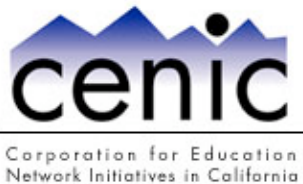


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# **Northwest California Network Infrastructure Analysis: Del Norte and Humboldt Counties**

*Prepared for*  
**Corporation for  
Education Network Initiatives  
in California**



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*Performed under*  
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## 1. EXECUTIVE SUMMARY

Science Applications International Corporation (SAIC), a San Diego-based research and engineering company, was retained by the Corporation for Education Network Initiatives in California (CENIC), to perform an assessment of the need for broadband network capabilities in Humboldt and Del Norte counties and the existing network infrastructure, and to identify alternatives for increasing the availability of high speed connectivity in the region.

The findings of the review of the northwest California counties of Humboldt and Del Norte are examples of the “Digital Divide” at work. Humboldt and Del Norte counties, as with many other rural or sparsely populated areas, do not have the regional communication infrastructure to enable area residents to benefit from 21<sup>st</sup> century technologies enjoyed by other areas of the state. Because the telecom industry makes capital investments based on expected rates of returns, areas such as Humboldt County and Del Norte County usually are ranked in a manner that puts them on the trailing edge of new product, service, or technology rollouts.

The bandwidth drought that currently affects Humboldt County customers’ ability to purchase new services will improve, according to information provided by SBC Communications (SBC). By fall, SBC should have more than adequate bandwidth to serve the basic voice communications needs as well as to fulfill both the current pending orders and unmet data bandwidth needs projected in this analysis for the near term.

While this solution will lead to enhanced networking infrastructure within the region because of the extension of the high-speed network backbone into Humboldt County, it does not change three very important issues for educational initiatives in Humboldt and Del Norte counties.

The first issue is the need to provide fiber infrastructure to Del Norte County, via a connection to the SBC provided fiber in Humboldt County or another approach.

The second is the requirement for redundancy for high bandwidth connections to Humboldt and Del Norte counties. Fiber connectivity to Eureka will be limited to a single path provided by SBC. Redundancy is necessary to ensure the reliability of the network and quality of service at the level enjoyed by the other counties in the state. While SBC plans to retain the current microwave systems as a redundant path, the capacity of the microwave systems is considerably less than the capacity of the to-be-installed fiber infrastructure, and is not likely to have the capacity to ensure quality of service for some of the applications that may be in use within schools. Teachers’ ability to depend on network delivered resources is a major factor in teachers’ willingness to utilize online resources. Additional analysis is recommended to ensure that redundancy requirements will be met.

The third issue is “last mile” fiber links that allow customers at local sites to connect to the new high-speed backbone. As SBC improves the capabilities of the backbone to Humboldt, enhanced fiber in the local loop can be expected to follow. Enhanced fiber in

the local loop must be deployed in a timely manner to ensure that the local fiber loop does not become the next bandwidth bottleneck.

The following analysis shows that education-related networking requirements, the domain of CENIC, represent a significant portion of the current and projected bandwidth markets in these counties. However, significant demands exist in other sectors, and economic development of the counties can only improve if the infrastructure of the area improves. The analysis suggests that the key to promoting network-driven economic development in the two-county region may be a united effort amongst the stakeholders to develop consensus on an approach for providing infrastructure that can be shared across education and other interests.

All interested parties, including CENIC and other education entities need reliable, redundant connections to both Humboldt and Del Norte counties. If the private sector cannot, based solely on traditional investment models, provide such capabilities, CENIC, in collaboration with the providers and interested community members in this region of the state, should explore alternatives to augment basic planned network connections from service providers.

The wide range of alternatives that were identified suggests that solutions can be found to meet the educational bandwidth needs in Humboldt and Del Norte counties. Due to the complexity of the issues involved with each of the alternatives, further discussions and analysis is needed with stakeholders in the region. As a neutral third party that has access to significant technical resources, CENIC should continue its efforts to facilitate such discussions and continue to support the exploration of the various alternatives.

## 2. INTRODUCTION AND STUDY METHODOLOGY

Science Applications International Corporation (SAIC), a San Diego-based research and engineering company, was retained by the Corporation for Education Network Initiatives in California (CENIC), to perform an assessment of the need for broadband network capabilities in Humboldt and Del Norte counties, and the existing network infrastructure, and to identify alternatives for increasing the availability of high-speed connectivity in the region.

### 2.1 Background

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As part of its Digital California Project (DCP) for nearly three years, CENIC has been attempting to connect Kindergarten through 12<sup>th</sup> grade schools, district offices, and county offices of education in Humboldt and Del Norte counties into the statewide education network known as the CalREN-DC. The county offices of education and roughly 71% of the district offices and schools in all other counties have connectivity to CalREN-DC, the commercial Internet or both at speeds of T-1 or greater, but Del Norte and Humboldt counties remain unconnected because of a lack of high-speed network infrastructure.

Despite all best efforts and even with local and county government assistance, CENIC has not been able to obtain the required commercial broadband services into these areas.

### 2.2 Purpose

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The purpose of this study is to document current unmet bandwidth needs in these counties, to report projected future bandwidth needs, and to identify the existing network infrastructure and alternative approaches for meeting current and future needs.

### 2.3 Methodology

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SAIC employed a direct interview methodology across a wide spectrum of the economic, education, and business communities of Humboldt and Del Norte counties. This included representatives from business, government, and education within the areas. Each interview was conducted using a uniform questionnaire to ensure uniformity. However, the areas explored were intentionally structured to be open-ended to encourage discussion and expression of needs and interests related to broadband communications. *Appendix A* contains the list of interviews, including contact information.

SAIC worked collaboratively with CENIC and several of their consultants to produce this integrated report. Consultant information that is incorporated in the report is attributed to the source in the respective report section.

In the case of Del Norte County, largely because of the size of the county, the initial collection effort was conducted at a town hall meeting. This meeting was advertised in the local newspaper (*The Triplicate*). Chris York, Director of Technology for Del Norte County Office of Education, assisted with other community outreach efforts. The day prior, our arrival was announced and the meeting agenda was presented at the local Rotary Club meeting. In addition to the Town Hall meeting and the direct interviews that resulted from that meeting, more than 30 telephone interviews were conducted to ensure an adequate sampling of the community as well as a thorough understanding of the needs of the residents.

In addition, major local service providers were interviewed to obtain their perspectives regarding broadband services, to get their perceptions of the consumer market's use of Internet, and to gather information regarding the presence of broadband service alternatives. Each of the business respondents was also requested to provide information about the type of Internet service they used for personal use at home.

Aside from direct information, SAIC also searched secondary information sources to obtain population, age, income, employment, business development, education, and other relevant demographic information pertaining to the areas of the study. The sources include the following:

- California Department of Employment Data
- California Department of Finance
- United States Census Bureau, 2000 statistics
- United States Census Bureau, 2001 Business Statistics.

### 3. STUDY FINDINGS

The findings section of this report provides a synopsis of the interviews conducted in each county, along with the secondary research into census demographics and trends used in the assessment of economic patterns and unmet area needs.

#### 3.1 Humboldt County Information

##### 3.1.1 Demographic and Geographic Information

Humboldt County is predominantly a rural county located on the northwest coast of California. The cities of Eureka and Arcata represent more than 35% of the County's total population. The County is located 110 miles south of the Oregon state border, and approximately 235 miles north of San Francisco. The County land mass is 2.3 million acres, of which more than 80% lies within the National Forest, protected redwood areas, and recreational areas.

The demographic information<sup>1</sup> for Humboldt County as compared to California as a whole is presented in *Table 3–1* through *Table 3–6*.

**Table 3–1. Population and Housing – Humboldt County**

Population and Housing	Humboldt	California
Population <sup>2</sup>	127,700	33,871,648
Projected Population Growth Rate	.667%	N/A
Total Housing Units	55,912	12,214,549
Vacant Housing Units	8.4%	5.8%
Owner Occupied Housing	57.6%	56.9%
Average Household Size	2.39	2.87

Of 58 counties in California, Humboldt County ranks 31<sup>st</sup> in number of households within the county and 23<sup>rd</sup> in population. Both home ownership and housing vacancy rates are slightly above the California average, while the average household size is somewhat smaller.

**Table 3–2. Ethnicity and Age – Humboldt County**

Ethnicity and Age	Humboldt	California
Median Age (years)	36.3	33.3
Percent Population 65 and over	12.5%	10.6%
Majority Ethnicity	84.7%	59.5%

<sup>1</sup> All age, income, education and employment information obtained from the United States Census Bureau, Census 2000 data at <http://factfinder.census.gov>. All income amounts represent 1999 data.

<sup>2</sup> Population data and growth rates obtained from California Department of Finance.

Humboldt County's average age and percentage of population 65 years of age and older are slightly higher than California averages. The County's majority population ethnicity is white, which is substantially higher than California averages.

**Table 3–3. Education Attainment – Humboldt County**

Educational Attainment	Humboldt	California
High School Graduate or higher	84.9%	76.8%
Bachelors Degree or higher	23.0%	26.6%

Overall educational attainment is higher in Humboldt County, as measured by the percent of population attaining high school or above education. The percentage of population attaining a four-year degree or higher is somewhat less than the California average.

Education is an important factor in the economy and culture of Humboldt County. There are 38,481 students enrolled in pre-school, K-12 schools, and higher education. This represents 30.1% of the county population. The use of instructional technology is advanced when measured by students per instructional, networked computer. Humboldt County averages 4.4 students per computer as contrasted to the California average of 5.7 students per instructional computer. Higher education enrollment at Humboldt State University and College of the Redwoods in Eureka is approximately 12,400 students. Many of the students hold residence outside the county, and thus may not be included in county population numbers.

Education entities in Humboldt County contribute significantly to the economy as a major employer in the region. Humboldt State University represents more than 3,000 total jobs. Approximately 1,400 of those positions are full-time staff at the University.

**Table 3–4. Income Levels – Humboldt County**

Income Levels	Humboldt	California
Median Household Income	\$31,226	\$47,493
Per Capita Income	\$17,203	\$22,711
Percent at/below Federal Poverty Level	19.5%	14.2%

Humboldt County ranks 51<sup>st</sup> of 58 counties in household income, and is significantly behind both California median household and average per capita income levels. Correspondingly, Humboldt County ranks 13<sup>th</sup> of 58 counties with populations at or below the federal poverty level.

**Table 3–5. Employment – Humboldt County**

Employment	Humboldt	California
Total Employed	55,426	14,718,928
Work at Home	5.6%	3.8%
Government Employment	23.1%	14.7%
Self Employed	12.9%	8.5%
Unemployment	5.2%	4.3%

During the time of the 2000 Census, Humboldt County was experiencing unemployment rates higher than the California average. The County also has significantly higher portions of the population engaged in work at home and identified as self-employed. The influence of Humboldt State University increases the portion of the population engaged in government employment when compared to California averages.

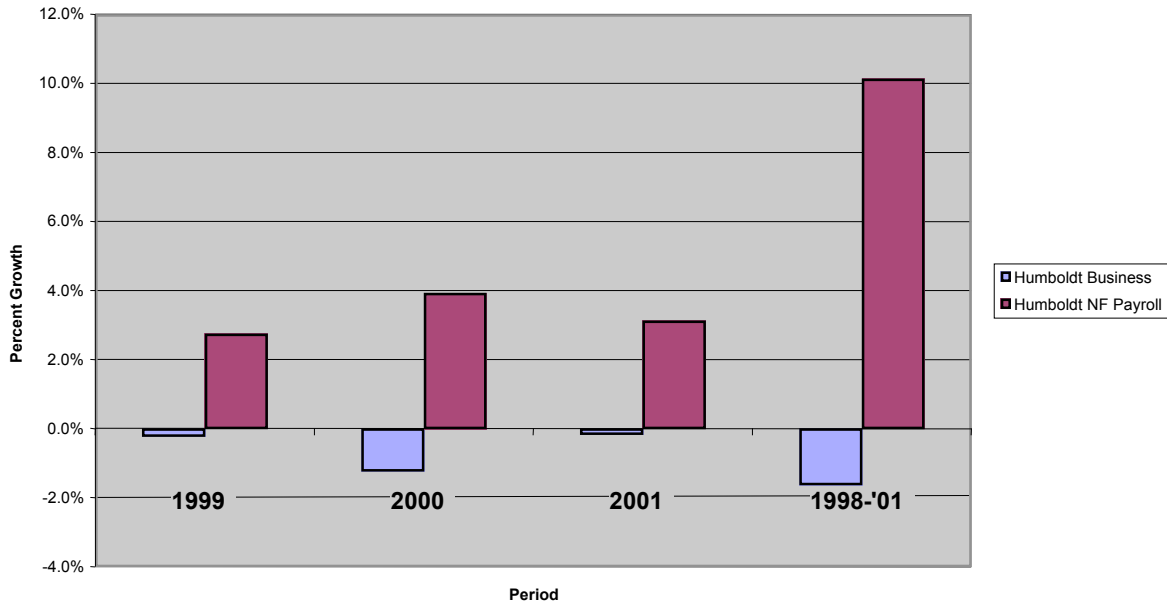
**Table 3–6. Employment by Industry – Humboldt County**

Employment by Industry	Humboldt	California
Ag, Forestry, Fishing, Hunting, and Mining	4.9%	1.9%
Construction	5.8%	6.2%
Manufacturing	8.7%	13.1%
Wholesale Trade	3.1%	4.1%
Retail Trade	12.5%	11.2%
Transportation Warehousing and Utilities	3.8%	4.7%
Information	1.9%	3.9%
Finance, Ins, Real Estate, and Rental/Leasing	5.1%	6.9%
Professional, Scientific, Management	6.9%	11.6%
Educational, Health, and social services	26.6%	18.5%
Arts, Entertainment, Recreation, Lodging, Food	9.8%	8.2%
Other Services (except Public Administration)	5.2%	5.2%
Public Administration	5.7%	4.5%

Agriculture, retail, education, health, social services, entertainment and public administration represent higher than State average employment categories. Interestingly, Humboldt County employment in the emerging information industry is only less than one-half of the state average. Manufacturing, construction and transportation represent lower than average employment categories.

For the years 1998 through 2001, the Humboldt County business climate is a mixed picture. (See *Figure 3–1.*) While non-farm (NF) payroll amounts grew by 10% over the period, the number of functioning businesses declined by just under 2%<sup>3</sup>. It appears that growth within the government and education sectors may have offset job losses in other areas of the local economy.

<sup>3</sup> Source: U.S. Census Bureau NAICS, 2001 Major Industry statistics



**Figure 3-1. Humboldt County Business Growth**

Major employers in Humboldt County include (in alphabetical order):

- College of the Redwoods - Eureka
- Hoopa Valley Business Council - Hoopa
- Humboldt County - Eureka
- Humboldt County Office of Education - Eureka
- Humboldt State University – Arcata
- Mad River Community Hospital – Arcata
- Pacific Lumber – Scotia
- Simpson Timber Company – Korbek
- St. Joseph Hospital – Eureka
- Sun Valley Floral Farms – Arcata.

### 3.1.2 Economic Development

The Humboldt County economy is one in transition. Forest products and resources-based businesses have and continue to experience declines. Without exception, interviews conducted with area business and government leaders elicited identical and unprompted responses regarding the perceived problems that stand in the way of economic development and improved prosperity. Respondents repeatedly mentioned communications and transportation as being inadequate to support economic transition. This perception seems to be borne out by the data in *Table 3-6* that indicates a much lower percentage of information-related employment is present in the region when compared to the statewide average.

Transportation, as defined by the respondents, refers to both the highway and rail systems. Only two major roads link Humboldt County. U.S. Highway 101, winding along the coast, connects Humboldt County from the north and south. US Highway 299

extends east over the coastal range of mountains from McKinleyville to Interstate 5, and cannot support Federal-legal sized trucks. Neither highway provides cost-effective transportation corridors that might otherwise support substantial manufacturing and/or transport of raw material into or out of the area.

The Northwestern Pacific Railroad, a former short line of the Southern Pacific Railway, served to move raw materials, goods and services into and out of Humboldt County. The track line opened in 1914. The North Coast Railway Authority was created by the State of California in early 1998 to operate the line. However, in November 1998, the railroad ceased operations due to slides and degradation of track near the Eel River Canyon and other locations. Now, most of the track line lies in ruin and equipment has been idle for nearly five years. Estimates to reopen the rail line range from a conservative \$300 million to as much as \$650 million investment. The focus and purpose of this report is not on transportation, although area interviews frequently mentioned the subject. However, telecommunications and data connectivity will assist Humboldt and Del Norte counties to refocus economic development into areas of the information and knowledge-based economy, potentially offsetting or acting as replacement for physical transportation facilities.

Interviews with business and community leaders show they perceive the communications infrastructure in Humboldt County to be archaic and severely limited. Respondents mentioned that communications are sometimes interrupted or difficult during stormy weather. During these episodes respondents report often receiving fast busy signals when attempting to make simple long distance voice calls from regular telephone lines and cell phones. Because of limited broadband services and the lack of fiber optics, the community believes the area generally cannot support newer services.

Several regional economic development agencies report that work at home and small information-based enterprise are beginning to grow. The interest level of small business and individual entrepreneurs is high in training and education leading to formation and operation of businesses. The North Coast Small Business Development Center (SBDC) report of 2002 activities shows greatly increased levels of workshop demand, workshop attendance, and a five fold increase in SBA loans, equity investments, and sales increases.

While the SBDC reports standardized metric results of 120 new jobs created and 373 jobs retained for the county in 2002, the key measure is effectiveness in relationship to funding. These two measures show that Humboldt County economic development averages 7.43 and 17.79 times more effective when compared to the State average based on populations throughout the state. Humboldt County's efforts to develop and foster economic development are very effective in relation to the funding received. Efforts to attract businesses to the area are more uncertain. Companies that visit the area, but who do not relocate, tend not to expound on all of the reasons why they may not have chosen the area for relocation. It is unclear just how much more effective economic development could be if a strong communications infrastructure were in place.

In summary, the high level of interest in small business development indicates the economy of the region is changing in response to loss of employment and industrial activity in other resource-based segments.

### 3.1.3 Current Bandwidth Status

Current bandwidth information was derived from interviews with the primary service providers, as well as business and industry respondents. While service providers represent the supply side of bandwidth, users represent the demand side of the equation. Each category of respondents is discussed separately.

Primary bandwidth suppliers in the region are SBC Communications and Cox Communications (Cox). These are the only providers that offer high-speed (other than dial-up) services within the county. Other providers within the area include the following:

- Mallard Cablevision in Willow Creek
- Starstream Cable in Garberville
- Frontier (Citizens) in Ferndale and the Lost Coast area
- Verizon in Garberville, Redway, Willow Creek, and Hoopa.

None of these last four offer other than dial-up service, and in fact, Frontier doesn't offer dial up.

Cox is a national cable television service provider. In addition to analog and digital cable television service packages, Cox offers high-speed Internet services to consumers and business under the trade names of [COX@Home](#) and [COX@Work](#). Cox distributes the high-speed Internet services to customer locations over their existing hybrid fiber COAX (HFC) system. Cox serves nearly the entire county of Humboldt including more rural towns to the north and south of Eureka-Arcata. The cable industry measures market availability using the metric of "homes passed". In Humboldt County, Cox is capable of reaching approximately 95% of the homes with cable television and Internet over cable services. Cox further reports that their high-speed Internet service enjoys approximately a 10% take rate, which is at least 20 points below comparable system properties that Cox operates in other areas. The low percentage of homes and businesses that take or purchase the services is attributable to the lack of bandwidth that Cox has available, as explained below.

Cox does not have its own primary form of transport to an Internet point of connection for the Humboldt County system. Instead, Cox subscribes to and relies upon a Pacific Bell DS-3, 45 megabit service to connect their e-mail and authentication servers to the Internet outside the counties. Currently, Cox has a waiting list of customers for high-speed Internet service, but is unable to connect more customers because their single, existing DS-3 service is operating at maximum capacity. The majority of customers on the waiting list are dial-up Internet customers waiting to upgrade to high-speed services. Were they to add more Internet customers on cable modems, all their existing high-speed customers would suffer delays and the quality of service would be affected. Cox has an additional DS-3 service request on back order. However, Pacific Bell is unable to fill their order, for reasons discussed later. At the corporate level, Cox is also a supplier of voice telephone service combined with their cable television and Internet services. As a Competitive Local Exchange Carrier (CLEC), Cox competes with local telephone companies in other areas using its embedded network connections. However, Cox does not currently offer telephone services in the Humboldt County area.

SBC is, by definition, the Incumbent Local Exchange Carrier (ILEC). In that role SBC provides a range of services from basic dial tone lines supporting voice services up to sophisticated broadband services. Competition for local exchange services is almost non-existent. SAIC was unable to locate any alternative, facilities-based CLECs in

Humboldt County. Facilities-based carriers are important in that they have their own facilities and do not merely use the facilities or resell the services of a Local Exchange Carrier (LEC).

SBC utilizes a predominantly copper cable plant in the Eureka-Arcata area. The Eureka main Central Office building is located south and east of the main commercial area. DSL, which stands for "Digital Subscriber Line", is another newer technology for connecting consumers to the Internet. By comparison, dial-up modems deliver between 28 and 56 kilobits per second connections. DSL delivers 128, 256, 640, and higher kilobit connections, depending on the service package selected.

Telephone companies provide DSL service. DSL lines use a special line card at a nearby telephone central office and special DSL modem at the customers location. DSL doesn't change the phone line in the way it operates for voice calls. The DSL connection can be used at the same time the telephone is used. The DSL signal operates on frequencies higher than voice calls.

The SBC communications switch serving this area offers DSL high-speed Internet service in Eureka. However, DSL service is not available to all subscribers in Eureka because of technical limitations. DSL service has a practical distance limitation of 12-15,000 cable feet from the central office location, and is dependant upon the quality of the copper cable pairs. Customers located beyond two to three cable miles of the SBC Central Office do not qualify for DSL service. Those with DSL service generally connect to the Internet through a service provider. The unregulated division of SBC is Pacific Bell Internet (PBI), which is the main direct provider of the Internet access.

By reviewing the geographic layout of Eureka and the location of the SBC Central Office, it appears that 75% to 85% of the businesses may be eligible to purchase DSL service. The exact percentage is difficult to estimate because the location, routing, and condition of specific loop qualification that serves potential customer locations within Eureka are not known. SBC offers DSL services in Arcata through a separate central office.

In addition, SBC is deploying fiber in the local plant carrier serving area to remote terminals (RT). These RTs extend the effective range and therefore the number of customers who may be eligible for DSL services. No publicized reports exist that identify the number or percentage of Humboldt County customers that have purchased DSL services.

SBC reports that its digital communications switch at the Eureka location is of the very latest type, utilized as a high-low switch. High-low refers to an industry definition of a digital switch that performs two distinct functions. The first is to deliver dial tone and line side services to consumers through the low side. The high side refers to the switch functions as a Class 4 Tandem Switch. Tandem Switches, sometimes referred to as Local Access and Transport Area (LATA) Tandems, collect traffic from other area Class 5 switches and form the connection point for voice and data traffic destined for or connected to locations outside the local area. The SBC tandem collects traffic from other area local switches when a long distance voice connection is required.

SBC acknowledged that several DS-3, 45 megabit services are ordered but cannot be installed due to lack of bandwidth capacity on their existing microwave systems connecting Humboldt County. The California Department of Transportation (Caltrans), Cox, and others were mentioned as having pending orders. However, as mentioned below, SBC has recently reached agreement with Caltrans to allow SBC to complete

fiber to Humboldt. When this is completed, SBC will be able to satisfy the ordered services and meet additional demand as well.

Figure 3–2 shows the relationship and connections between local switches, the Eureka Tandem Switch functions, and the backbone microwave connections, all of which serve the voice connection needs of both counties. Voice calls originating in or terminating from outside the counties rely upon the trunk groups carried by the digital microwave. Separate bandwidth groups carried on the SBC microwave systems also carry all Internet or data communications into and out of the counties.

The Tandem Switch has more capacity than currently is being used, but it cannot deliver the required connecting bandwidth alone. The limiting factor in meeting demand is infrastructure and backbone capacity.

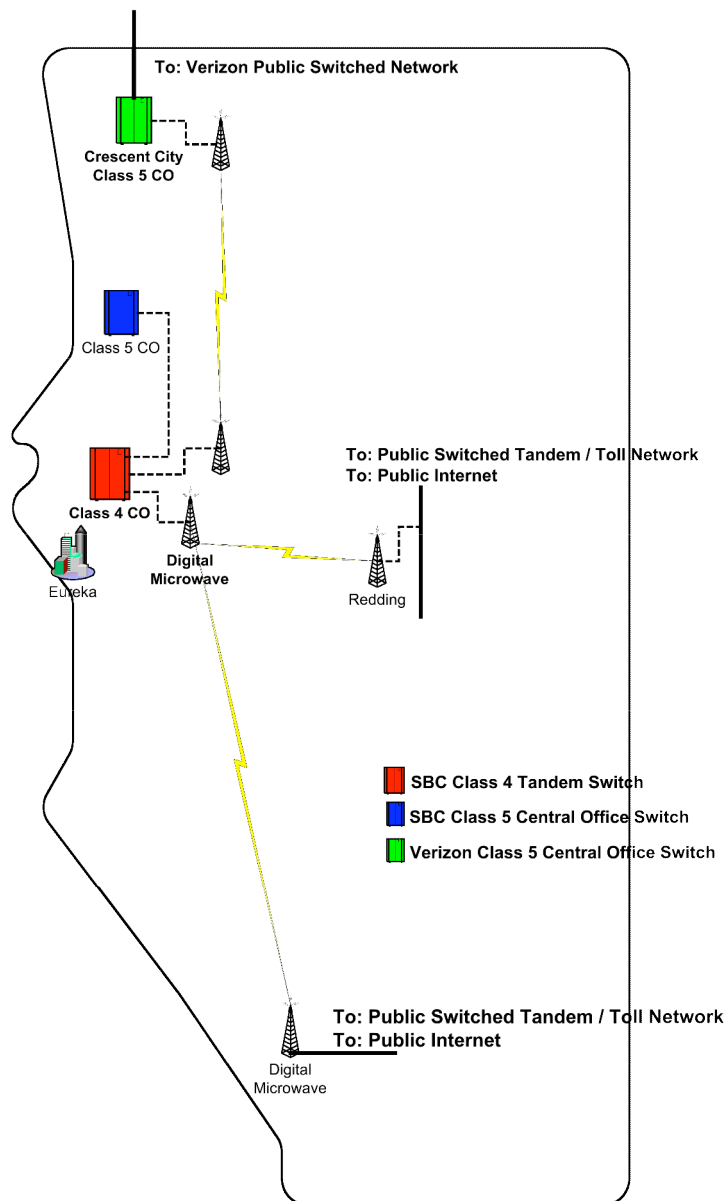


Figure 3–2. Local Switches and Eureka Tandem Switch Functions

SBC reports that the Eureka Tandem Switch also connects to Verizon-served territories in the north coast towns of Crescent City and Del Norte County. Therefore, all long distance traffic routes from Del Norte County through the Eureka center. SBC acknowledges that voice network traffic is saturated and that “all trunks busy” or fast busy signals and recorded announcements are growing. The “all trunks busy” conditions are true for Del Norte County as well.

SBC currently connects the Eureka and northwest coast area using two OC-3, Digital Microwave Systems. The first system, providing 155 megabits of capacity, extends south along the coast toward Santa Rosa, California. The second route, providing another 155 megabits of capacity, connects Eureka over the coastal mountains at Redding, California. Eureka and the northwest coast towns rely upon these two routes and a single supplier for all voice long distance and high-speed Internet connections to areas outside the northwest coast. SBC has been in the process of constructing an optical fiber route from the south into Eureka over the past 24 or more months. Construction is complete on the route with the exception of one 18-mile segment and one 3-mile segment of fiber optic cable involving three bridge crossings. The conduit or structure needed to cross the bridges is in place. However, construction was stopped for a significant period of time due to a dispute between SBC and Caltrans pertaining to compensation for encroachment and rights-of-way use. The dispute did not arise out of any technical or environmental issues. Caltrans made a request for compensation payable to the state for use of the rights-of-way involving the uncompleted segments. SBC was unwilling to pay the cost for the rights-of-way claiming they were not requested at the time of construction, that such payments assessed upon the “supplier of last resort” are contrary to the spirit and intent of the Telecommunications Act of 1996, and by their payment would establish a precedent for future payments.

Following the county interview process, SAIC received information that a tentative solution to the fiber installation issue had been reached. In a press release, SBC announced that construction of the fiber segments linking Eureka to Santa Rosa will resume under a funds escrow agreement pending the results of litigation. Permits have been issued and construction of the remainder of the fiber links will begin shortly. According to SBC, new services should be available when the fiber link is finished in early Fall 2003.

Emotions run high on the topic of fiber optic connections for the region. Business, industry and representative groups perceive the completion of the fiber optic cable as one of the few means available to advance the cause of changing the economic fortunes of the area. Prior to the recent settlement between SBC and Caltrans, local, county, and educational leaders weighed in with state legislators and the Governor’s Office regarding the importance of getting fiber to Del Norte. These groups have felt that lack of fiber is an impediment to development efforts to make the area attractive and appealing for business relocations. Many of the interviewed people involved in economic development could not point to specific examples of lost opportunities. However, they said that several contacts with prospective relocation clients involved discussions of communications, and that simply stated, these contacts elected to take their businesses elsewhere. Rarely do regional development authorities get feedback from prospective clients on specific reasons why their area is not chosen.

During the interviews, SBC estimated that now that an interim solution has been found, approximately four months is needed to complete construction of the fiber optic and begin offering more capacity services. In SAIC’s opinion, SBC will be able to offer

broadband services using its existing Asynchronous Transfer Mode (ATM) network, with service speeds ranging from 3 megabits per second, up to 45 megabits per second. However, speeds faster than 3 megabits per second will still require a direct fiber link between the SBC Eureka Central Office and the customer location. Such higher speed services are not available using copper cable loops. SBC currently does not offer a tariff-based gigabit, native Internet Protocol (IP)-based transport aside from existing ATM tariffs, but has indicated they plan to do so as soon as the fiber project is completed. In addition, SBC does intend to operate the digital microwave and the new fiber optic links simultaneously for a period of time, presumably as a redundant backup in the event of a failure in either system.

### 3.1.4 Market Demand

Education, health care, financial services, Native American Tribal operations, and work at home industries are the most impacted by the lack of bandwidth in Humboldt County.

- Humboldt State University currently uses a 40 megabit per second, Asynchronous Transfer Mode service from SBC to connect into the University System. While the bandwidth supports connection to the CalREN-DC and the resources of the Internet and Internet2, there are significant applications that either will not or cannot be placed onto the current network bandwidth. HSU maintains an Environmental Test Range project. A significant portion of sensitive northwest coastal area is environmentally monitored. A huge amount of information is constantly collected by means of a Geographical Information Systems (GIS)-based system. The distribution of the information occurs regularly as part of the monitoring and evaluation activities. Transmitting the information over the network was considered and rejected, as the size of the data content would require approximately two and one-half times the current bandwidth that is not available to the University. Currently, the information is transported by means of courier and ground transport.
- The Northern Humboldt Union High School District in McKinleyville is awaiting connection of a DS-3 45 megabit service from SBC. Currently, the kindergarten through 12th grade schools must operate on a much slower connection.
- Northwest Clinics have considered Electronic Medical Records (EMR) and some telemedicine applications. EMR supports centralized billing and improved patient care. They have high potential for reducing costs and improving the quality of health care delivery directly to patients. However, implementation of such best practices requires broadband connectivity between clinics and business offices. Clinics have not been able to acquire DSL or T1, for reasons of high cost or lack of service availability, to support such applications.
- St. Joseph Hospital has been unable to obtain anything greater than T1 services. Tele-radiology, potential diabetic ophthalmologic eye screenings, and other telemedicine applications are not being used or considered because of inadequate bandwidth in the area. St. Joseph Hospital was not prepared to list specific remote medical applications and teaching accreditation applications that have been considered and rejected because of insufficient network connections to larger teaching hospitals or University Medical Centers outside of the Humboldt area.
- Humboldt State Bank is reported to be taking jobs outside Humboldt County in order to meet business needs.

- The Yurok Native American Reservations is located in Northern Humboldt and southern Del Norte counties. As the largest Native American tribe in California, much of the Reservation is without telephone service and Internet access. In her testimony report, dated May 14, 2002, before the Senate Subcommittees of Commerce and Indian Affairs, Susan Masten, Chairwoman of the Yurok Tribe, documented the complete lack of telephone and power to the upper Reservation area. Needless to say, the lack of telephone, power or utility infrastructure isolated the Reservation from any form of bandwidth connectivity. In a sense, the Reservation is a microcosm of the most deprived bandwidth areas of the county. However, assistance is forthcoming. North Coast Congressman Mike Thompson announced recently that \$3M in funding has been granted to the Yurok Tribe for developing and improving energy and telephone services within their Reservation. The funding was provided through the U. S. Department of Agriculture (USDA) Rural Development's High Energy Cost Program.
- Work at home is a rapidly growing segment of the economy. By most industry estimates, it represents a substantial portion of the 170% year after year growth in Internet traffic volumes. As the knowledge-based economy grows, significant available bandwidth must be available outside traditional commercial centers, as they are known today. Where people choose to live no longer bears the strong relationship to where they elect to work. Lifestyle decisions of people are more likely to influence where bandwidth demand occurs, rather than historic bricks and mortar construction.

### 3.1.5 Potential

Unmet demand, as estimated for purposes of this study, is a summation of only the needs uncovered and stated during the interview process. The estimate does not include pricing or price level sensitivity with respect to current services. The unmet bandwidth was calculated using direct input from large area customers as they reported either needs or capabilities they are unable to meet today. Consumer demand was calculated by using the difference between current and typical market penetrations of high-speed services. While *Table 3-7* is not a complete market analysis, it shows there is significant unmet demand for services if offered at competitive rates.

**Table 3-7. Current Unmet Demand for Services**

Unmet Market Demand	Megabits
Higher Education	60
Educations (K-12)	125
Consumer	2,863
HealthCare	20
Service Providers	90
State Government	45
Financial Services	20
<b>Sub Total</b>	<b>3,223</b>
<i>Three Year Growth</i>	656
<b>Total</b>	<b>3,879</b>

Over the next three years, there is the potential for an estimated four gigabits of new data transmission connections from Humboldt County connecting to locations outside of the area. Accounting for growth in voice traffic, which already is at capacity, this represents as much as 100 times the total bandwidth currently connecting Humboldt County.

## 3.2 Del Norte County

### 3.2.1 Demographic and Geographic Information

Del Norte County is predominantly a rural county located at the extreme northwest corner of the California Northwest Coast. Crescent City is the largest city or incorporated area, representing more than 26% of the county’s total population. The County is located south and adjacent to the Oregon state border. Humboldt County borders Del Norte County on the south. The county covers 1003 square miles.

The demographic information<sup>4</sup> for Del Norte County is presented in *Table 3–8* through *Table 3–13* for the purpose of contrasting variations in criteria between Del Norte County and the State of California.

**Table 3–8. Population and Housing – Del Norte County**

Population and Housing	Del Norte	California
Population <sup>5</sup>	27,507	33,871,648
Projected Population Growth Rate	N/A	N/A
Total Housing Units	10,434	12,214,549
Vacant Housing Units	12.1%	5.8%
Owner Occupied Housing	63.8%	56.9%
Average Household Size	2.58	2.87

Del Norte County ranks 49<sup>th</sup> in the state in number of households. Both home ownership and housing vacancy rates are significantly above the California average, while the average household size is somewhat smaller. Del Norte County ranks 51<sup>st</sup> in population.

**Table 3–9. Ethnicity and Age – Del Norte County**

Ethnicity and Age	Del Norte	California
Median Age (years)	36.4	33.3
Percent Population 65 and over	12.5%	10.6%
Majority Ethnicity	78.9%	59.5%

Del Norte County average age and percentage of population 65 of years of age and older are slightly higher than California averages. The County’s majority population ethnicity is white, which is substantially higher than California averages.

<sup>4</sup> All age, income, education and employment information obtained from the United States Census Bureau 2000 data at <http://factfinder.census.gov>. All income amounts represent 1999 data.

<sup>5</sup> Population data and growth rates obtained from California Department of Finance.

**Table 3–10. Educational Attainment – Del Norte County**

<b>Educational Attainment</b>	<b>Del Norte</b>	<b>California</b>
High School Graduate or higher	71.6%	76.8%
Bachelors Degree or higher	11.0%	26.6%

Del Norte County educational attainment falls below the California averages both in high school graduates, as well as percent of population holding four-year degrees or higher.

**Table 3–11. Income Levels – Del Norte County**

<b>Income Levels</b>	<b>Del Norte</b>	<b>California</b>
Median Household Income	\$29,642	\$47,493
Per Capita Income	\$14,573	\$22,711
Percent at/below Federal Poverty Level	20.2%	14.2%

Del Norte County ranks 54<sup>th</sup> of 58 counties in household income, and is significantly behind both California median household and average per capita income levels. Correspondingly, Del Norte County ranks 9<sup>th</sup> highest percentage of population at or below the federal poverty level.

**Table 3–12. Employment – Del Norte County**

<b>Employment</b>	<b>Del Norte</b>	<b>California</b>
Total Employed	8,959	14,718,928
Work at Home	3.6%	3.8%
Government employment	35.1%	14.7%
Self Employed	9.9%	8.5%
Unemployment	4.9%	4.3%

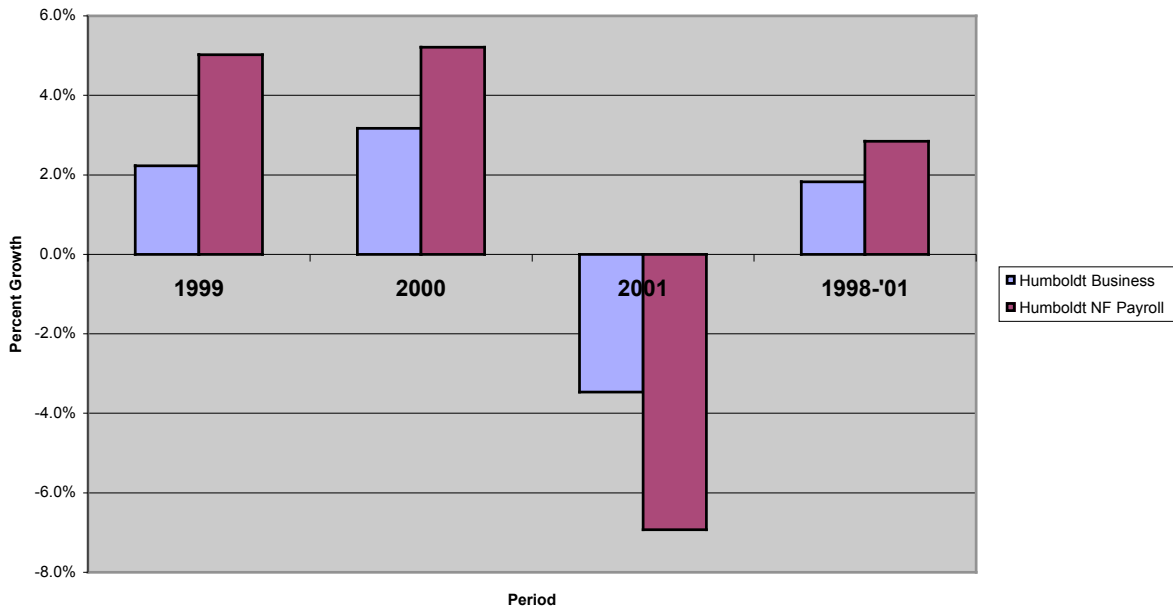
During the time of the 2000 Census, Del Norte County was experiencing unemployment rates that are higher than the California State Department of Employment Development reports. In fact, by the time of California Employment Development Department (EDD) reported for 2002 and year-to-date 2003 reports, unemployment rates grew to 9.2% and 9.3%, respectively for Del Norte County, according to the California EDD data. Differences between census data and EDD data may also be attributed to Del Norte County’s highly seasonal employment levels. Through the interview process, we believe the EDD unemployment percentages are more representative of actual average county conditions. Del Norte County ranks 2<sup>nd</sup> in the State on the measure of the percentage of the population engaged in government employment.

**Table 3–13. Employment by Industry – Del Norte County**

Employment by Industry	Del Norte	California
Ag, Forestry, Fishing, Hunting, and Mining	6.2%	1.9%
Construction	5.4%	6.2%
Manufacturing	4.4%	13.1%
Wholesale Trade	2.1%	4.1%
Retail Trade	10.7%	11.2%
Transportation Warehousing and Utilities	2.9%	4.7%
Information	1.2%	3.9%
Finance, Ins, Real Estate, and Rental /Leasing	2.3%	6.9%
Professional, Scientific, Management	3.3%	11.6%
Educational, Health, and social services	23.4%	18.5%
Arts, entertainment, recreation, lodging, food	13.0%	8.2%
Other services (except Public Administration)	5.1%	5.2%
Public Administration	20.0%	4.5%

Agriculture, education, health, social services, entertainment and public administration represent higher than the State average employment categories. Del Norte County employment in the emerging information industry is less than one-half of the statewide average. All other categories of employment range from moderately to very significantly less than State averages.

The business economic climate, as measured by non-farm (NF) payrolls and number of operating businesses, shows some growth over the period of 1998 through 2001. (See *Figure 3–3.*) The growth in non-farm payroll correlates closely with the number of operational enterprises. There is not an identifiable specific event or business failure for Year 2001 to account for the significantly negative numbers. Overall, and excluding the events of 2001, Del Norte County experienced an average 2 to 4 % growth rate.



**Figure 3-3. Del Norte County Business Growth**

Major employers in Del Norte County include (in alphabetical order):

- California Department of Corrections
- City of Crescent City
- Crescent City Convalescent Hospital
- Dahlstrom & Watt Bulb Farm, Inc.
- Del Norte County
- Del Norte County Unified Schools
- Elk Valley Casino
- Lucky 7 Casino
- Sutter Coast Hospital
- Wal-Mart.

### 3.2.2 Economic Development

Del Norte County and Crescent City are known as the survivors of the 1964 tsunami. While doing a terrific job of rebuilding the communities from that devastation, Del Norte has had a much rougher time addressing the economic decline in the fishing and timber industries in the area. Transportation of goods to support and promote economic development, as with Humboldt County, is a significant issue. Weather also was identified as a detriment to economic development by those interviewed. With these three strikes against the County, there's a more significant need for reliable and adequate telecommunications to support business and economic development. Without exception, every individual interviewed who was familiar with or associated with the economic development of the County shared the opinion that lack of reliable, adequate bandwidth is a direct deterrent to new business development.

U.S. Highway 101 continues its route north from Humboldt County to Del Norte County and eventually to Oregon. While improvements are being made, this tributary becomes more difficult to travel as one enters Del Norte County and the Redwood Forest. The difficult road and the frequency of fog along the route makes transporting goods into Del Norte County time-consuming and expensive. Unlike Humboldt County, there is no railway to support the communities.

Customers with both dial-up and cable modem connections described repeated cases of dropped connections, difficulties reconnecting, corrupted files and “fast busy” (dial-up). It certainly can be assumed that some of these problems are weather-related. But it also can be concluded that the communication infrastructure is old and deteriorated, and that these factors are contributing to the service problems. Regardless of the cause, it reduces the attractiveness of the county for new businesses.

Work at home and small information-based enterprise growth were found to be occurring in Del Norte County. Several interviewees shared a similar story of moving from industrial areas (or Silicon Valley) to the more attractive and serene Del Norte County area to start small businesses. All shared the same concern that while surviving for now with the slow dial-up and cable modem connections, they fear that as their business grows, they will have to leave the area for better communication resources to support their needs. Some mentioned the possibility of moving to Humboldt County once their fiber issue is resolved and completed. One small but international mapping and imagery business spends hundreds of dollars per month sending files (on CDs) via FedEx because of the tremendous time delay of trying to send them over a dial-up connection.

### 3.2.3 Current Bandwidth Status

Current bandwidth information was derived from interviews with the primary service providers, as well as business and industry respondents. While service providers represent the supply side of bandwidth, users represent the demand side of the equation. Each category of respondents is discussed separately.

By most standards, the bandwidth availability within Del Norte County is extremely limited. Current service providers delivering bandwidth to Del Norte County customers are Verizon Communications (telephone), Charter Communications (cable provider), and, on a smaller scale, Harborside Internet provides wireless and dial-up capabilities.

Per above, Charter Communications is the local cable provider. Charter offers both analog and digital cable television service packages as well as high-speed Internet services. Residential cable modem service is available in three different download speeds or levels. They are defined as follows in *Table 3–14* and are designed to customer needs.

**Table 3–14. Cable Modem Service Download Levels/Speeds**

Plan	Down Link	Up Link
Level 1	256 Kb	128 Kb
Level 2	528 Kb	128 Kb
Level 3	1.5 Mb	128 Kb

Charter's Web site (<http://www.chartercom.com/order/order.asp?prod=pipe>) describes these services and offers Web-based ordering services. For commercial customers, Charter offers an up link speed of 512 KB with the same down link speeds as above.

Charter's area of service extends from Nesika Beach, Oregon, south to Crescent City, California (approximately 60 miles) and includes the areas of Smith River and Fort Dick just north of Crescent City. Their services extend east as far as Adam's Station and Gasquet, California, a distance of 18 miles from Crescent City on Highway 199. Charter does not offer services south of Crescent City (i.e., Klamath). While these are the boundaries for Charter's services, most of Charter's Del Norte customers are within Crescent City. It should also be noted that as with any rural area, there are limitations. While Charter does define their service area as described above, they state that availability of products and pricing may vary depending on the current rebuild status in individual areas. This is certainly not uncommon for this type of rural area.

Charter uses a hybrid fiber coax (HFC) system to provide services to their customers. There are two exceptions to this. Charter has extended fiber optic cable to both the College of the Redwoods and to the Del Norte County Office of Education for the purpose of Distance Learning. While we know there are more than 10,000 housing units, we're not sure what percentage of these homes are passed by the Charter HFC distribution system. That information was considered sensitive. We assume it's a fairly large percentage, but don't know for sure. Charter has increased support to the area by installing a 36-count fiber cable from Crescent City north into Oregon (Coos Bay).

Charter routes outbound traffic north to Brookings, Oregon, where the traffic is handed off to Verizon on an OC-48 connection. This routes them to their primary Internet entry point (Tier I/Tier II connection), which is in Medford, Oregon. Per Charter, more bandwidth is available from Verizon as business justifies. Charter appears to have sufficient bandwidth to support current and future high-speed cable modem customers.

Charter is a CLEC in the state of Oregon and at some point in time would like to provide digital phone service to Del Norte County.

Verizon Communications, the ILEC for Del Norte County, provides only basic dial tone services and is the only provider in the County. Verizon doesn't offer DSL for their customers in Del Norte County.

All voice traffic leaves Del Norte on five DS-3, 45 megabit microwave systems connected to SBC at Eureka in Humboldt County. The five DS-3 systems are currently operating at full capacity with no allowance for future growth.

One additional DS-3 circuit is used by CENIC to connect the Del Norte County Office of Education to the Humboldt County Office of Education. When CENIC acquires bandwidth to Humboldt County, this DS-3 will provide a basic level of connectivity to Del Norte County to meet educational needs.

Verizon has already purchased hardware for three additional DS-3 microwave systems, and is currently working to obtain permits for construction and operation of the new systems. The three new systems, if and when implemented, are already committed to customers, Sprint, AT&T, and the Del Norte County Office of Education.

While Verizon has recently installed a new 160-count fiber cable going north from Crescent City to Coos Bay, Oregon, there are tariff issues that prevent them from using these high-capacity circuits for outbound traffic. The purpose of this fiber connection is not clear. Because Crescent City is located in a Northern California LATA, and Coos

Bay is in located in a southern Oregon LATA, Verizon could be planning to re-home long distance voice traffic northward into one of their own Tandem Switches. Local telephone companies are currently permitted by Federal Communications Commission (FCC) LATA rules to carry internal traffic across LATA boundaries. As local telephone companies obtain regulatory relief from prohibitions against offering long distance and interLATA services, this fiber could be used to more directly connect Verizon customers.

Many of the interviewees reported several problems with the Verizon service. The following primary problems were addressed:

- Not able to get a connection, when dialing. This is referred to an “all circuit busy” condition and is an indicator that the shortage of bandwidth is preventing voice traffic (as well as data) from getting through.
- After a call has been connected, it drops. This may be an issue of poor infrastructure of the Verizon network within Del Norte, or weather interfering with and affecting the transmission of the radio signals causing connections to be lost.
- No more T1 circuits are available for service: obviously a lack of bandwidth situation. It should be noted that the pricing of current T1s was also mentioned as being expensive. Interviewees indicated they were paying from \$1200 to \$1800 per T1 per month. This is very expensive compared to pricing in densely populated areas of the State. For a better understanding of the pricing for the service providers within California, refer to *Appendix B*, where graphs from the CENIC Last Mile Report illustrate the disadvantages suffered by rural areas.

### 3.2.4 Market Demand

In collecting the information for Del Norte County, there were a total of 36 interviews conducted. This total came from a town hall meeting, face-to-face interviews and telephone interviews with interested individuals who weren’t able to meet with us while we were visiting Del Norte County. The occupations of the interviewees represented state, local and city agencies, financial industry, small owner/vendor businesses, health organizations (including doctors), service providers, educators, and retirees.

From the data collected, it can be clearly determined that a large part of the population desperately need and want increased bandwidth capabilities. There is a dichotomy in Del Norte County, however, in that some of those interviewed are content with the bandwidth they currently have. Most of these individuals were the smaller bandwidth users or the smaller businesses. It may be a case of “not knowing what they can’t know”. In other words, having ever experienced the true advantages of higher bandwidth, higher than dial-up or choked-down cable modem, these individuals may not be able to predict how higher bandwidth capabilities could make their lives better and/or their business more profitable.

Significant findings from the interviews conducted in Del Norte are summarized in the following categories:

- Economic Development
  - Interviewees such as the city manager and the chairman for Economic Development for the Chamber of Commerce stated there were specific cases where the lack of adequate and reliable bandwidth within Del Norte County was the primary reason new businesses elected not to locate to Crescent City or Del Norte.

- Small Business
  - Two cases of distress for small business within Del Norte follow:
    - A small software business is forced to support customer needs with a dial-up connection making it impossible for providing online support or software upgrades. This business is forced to send updates to their customers via FedEx/Mail, spending hundreds of dollars each month doing so. If, at a minimum, cable modem capabilities were available for this situation, these FedEx expenses could be eliminated.
    - A small but international aerial mapping and imagery business works with nothing but large files (10Mb and up). As above, their capabilities are limited to a dial-up connection and again must use surface mailings to support their customer need.
- Distance Learning
  - There are students who could be participating or preparing for advanced placement classes or preparing for SATs via the Web, but who cannot because of current bandwidth conditions.
  - Teachers, nurses, lawyers, highway patrolmen, and others who were interviewed stated they could use higher bandwidth capabilities for continuing education or certifications.
- Health Care
  - Telemedicine
    - Health care professionals continue to experience unnecessary travel for continuing education accreditation and an inability to conduct telemedicine sessions in various fields: radiology, psychiatry, and specialty consultations/interviews, etc. Specialty physician consultations and transmission of diagnostic radiological imaging requires broadband speeds not available in the area.
    - Lack of bandwidth prevents the hospital from utilizing “electronic medical records” which would allow doctors the ability to remotely review records and offer consultations.
- Law Enforcement
  - One interviewee from the California Highway Patrol was adamant about needing more than the government subsidized T1 that they currently have. The increased bandwidth would greatly improve their ability to protect the community and provide critical information desperately needed in a timely fashion (such as information related to an “Amber Alert”).

These are just a representative sample of the unmet capabilities presented during the visit that are directly related to the less than adequate bandwidth situation with Del Norte County.

One interviewee made the comment that “adequate bandwidth would improve the culture of the County.” This statement may best reflect what was mentioned above; “you don’t know what you can’t know.” Without the opportunities to experience the

advantages of better technologies, it is difficult, if not impossible to move forward. At a minimum one must be able to move forward at a similar rate as your contemporaries.

### 3.2.5 Potential

Unmet demand, as estimated for purposes of this study, is a summation of the needs uncovered and stated during the interview process. The estimate does not include pricing or price level sensitivity to current services. While *Table 3–15* is not a complete market analysis, it shows there is significant unmet demand for services if offered at competitive rates. See *Section 3.1.5* for how unmet demand was calculated.

**Table 3–15. Current Unmet Demand for Services**

Unmet Market Demand	Megabits
Higher Education	45
Consumer	534
HealthCare	20
Service Providers	135
State Government	45
Education	45
Financial Services	20
Rancherias	90
<i>Sub Total</i>	<i>844</i>
Three Year Growth	442
<b>Total</b>	<b>1,286</b>

Comparing these results with those from Humboldt County, it can be seen that the unmet demand for Del Norte County is approximately one-third that of Humboldt County. While Humboldt is five times larger than Del Norte County, the relationship between the two counties is not simply a correlation based on size. It appears that the current bandwidth inadequacies that currently exist in Del Norte County are driving factors in the larger than expected ratio of need when comparing the two counties.

## 4. ALTERNATIVE TECHNICAL SOLUTIONS

The existing fiber infrastructure does not reach Del Norte and does not provide for the same levels of redundancy to provide reliability enjoyed by other counties in the state. To satisfy the educational needs for high-speed connection into Del Norte and to provide some degree of high-speed redundancy, new means of funding telecommunications fiber infrastructure is needed. In order to satisfy these needs, because of the sparse population, solutions should be explored that would identify new sources of funding for infrastructure and that would combine the needs of educational and other communities.

In looking for infrastructure and funding solutions for Humboldt and Del Norte counties, several possibilities were identified. The following sections address the resources available for possible development of alternative telecommunication solutions for both counties.

### 4.1 *Fiber Optic*

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Fiber optics transmission offers the highest potential for bandwidth with the widest flexibility in configuration to meet future bandwidth growth requirements. With the advent of sophisticated electronics, future channels of bandwidth can be created within light spectrum on a single fiber strand. Wave Division Multiplexing offers up to 36 unique frequencies or color of light each capable of transmission of 1, 2.5, or 10 gigabits of information transfer over a single pair of fiber optic strands. The life cycle of fiber optics ranges between 15 and 25 years depending on the installation method and supporting structure (i.e., conduit versus aerial cable).

SBC is currently constructing a fiber optic route to Eureka from the south. SBC will be using their networking utility Synchronous Optical Network (SONET) standard equipment. SONET allows SBC flexibility in building voice, video and data within different but unique transmission groups, as well as the ability to carry other transmission protocols (i.e., IP) within a discrete virtual path.

Fiber optics has some distinct disadvantages. Initial cost of fiber optic cable construction can vary significantly from \$18,000 to \$65,000 per route mile, depending on terrain, density and supporting structure costs. Annual maintenance of the fiber itself is normally low and is incurred for repairing relatively infrequent manmade or weather related damages. The terminating electronics, which include the laser light sources, represent the highest maintenance cost.

There is fiber optic cable in Humboldt and Del Norte counties, but that fact is not widely advertised. This is because most of the fiber is dark (unlit with no hardware at either end) and not ready for use by most customers or the owner of the cable installed it for their use. However, in all cases, when fiber is installed many more pairs are installed than are needed by the owner. This means that there are fiber pairs available; assuming that negotiations with the owner surrounding the use of those fibers is successful.

There are several different owners of the fiber optic cable in the two counties. The owners installed their cable for their personal use. Because of this, there in no

“continuous” run of cable to suit the homogenous telecommunication needs of the two counties. By “piecing together” segments from each of these owners, connectivity can be achieved to support the needs of CENIC and the citizens of Del Norte and Humboldt counties. The *Section 4.1.1* and *Section 4.1.2* identify the current segments or spans of fiber that might be able to be used.

In summary, there are viable dark fiber solutions to providing connectivity into the north coast counties using a combination of fiber and duct from Level (3) Communications [Level (3)], WiITel, AT&T, SBC, Charter, Cox, and others. Actual cost estimates could only be determined after an actual network design and an order of magnitude for the level of service was determined. Initial contact with some of these providers in soliciting their support for possible build out of their infrastructure has been positive.

A separate consultant, Victor Braud of Fiber Channels, Inc, under contract to CENIC, developed much of the following information.

#### 4.1.1 Humboldt County

The following is a list of the existing fiber optic cable owners in Humboldt County:

- **Cox Communications**

The only dark fiber available in the Eureka/Arcata area belongs to Cox, the local cable provider. They currently have fiber going north of Eureka to Orick (20 miles), east to Blue Lake (20 miles), and south to Scotia (30 miles). Most of their fiber is on Pacific Gas & Electric (PGE) poles with Right of Way (ROW) leases. This fiber carries inter-city traffic, and does not connect Humboldt to locations outside the County.

- **SBC**

SBC and Caltrans have recently reached a tentative agreement that will allow SBC to complete its new fiber overbuild from the south into Eureka which will provide connectivity back to SBC's Santa Rosa (POP location).

- **WiITel**

WiITel has a route on which dark fiber is available. The route goes from Fort Bragg to Ukiah, and from Ukiah to Sacramento via Lakeport. They have a partially complete diverse route on which fiber will be available from Ukiah to Sacramento via Santa Rosa and Rohnert Park (located just south of Santa Rosa).

WiITel also has fiber on a diverse route on which fiber is available from Bandon, OR to Eugene, OR via Florence, OR.

- **AT&T**

AT&T has a fiber route on which dark fiber is available that goes north from San Francisco through Rohnert Park, Santa Rosa, Ukiah, Lakeport, and Weaverville. This route continues north (it passes within 54 miles of Crescent City via Route 199) on its way to Bandon OR, the international cable head for AT&T, WiITel, and others. From Bandon it connects through Roseburg, OR into Eugene, OR. Level (3) (see below) has a Point of Presence (POP) in Eugene, which means this is a location where the AT&T and Level (3) routes could be joined.

AT&T has a POP served by fiber from the north and south to which Cox in Eureka/Arcata would like to connect. The possibility exists that a system could be built to connect the Eureka/Arcata POP to the fiber link in Weaverville. It is

101 miles via Route 299 through the Shasta Trinity National Forest from Weaverville to the Eureka/Arcata area.

- **Level (3) Communications**

Level (3)'s route, on which dark fiber is available, travels the I-5 corridor north in California, from Sacramento through Colusa, Orland, Corning, Red Bluff, Redding (Palo Cedro), Burney, Tionesta, and Tulelake. From there it continues into Oregon where it eventually arrives in Eugene. CENIC has already purchased 20-year rights to use two fibers along this route between Corning and Sacramento.

#### 4.1.2 Del Norte County

The following is a list of the existing fiber optic cable owners in Del Norte County and a potential expansion route:

- **Verizon Communications**

The ILEC for Del Norte County is Verizon and they have a new, 160-count fiber cable going north from Crescent City to Coos Bay, OR.

- **Charter Communications**

The CATV franchisee in Crescent City is Charter Communications, and they have a new 36-count fiber going north from Crescent City to Coos Bay. There is a gap in their connectivity between Port Orford, OR and Langlois, OR. To provide complete connectivity, they currently use leased fiber from Verizon.

The Charter fiber passes through Bandon, OR from which there is fiber available via diverse routes to Eugene, OR from either AT&T or WiTel.

Charter has fiber optic cable from their head-end facility in Crescent City to both the College of the Redwoods Campus and the Del Norte County COE.

- **New Construction**

Building new fiber from Crescent City via Route 199 to intercept the AT&T fiber in Cave Junction, OR between San Francisco, CA and Bandon, Or is possible but would be very expensive, difficult construction. Initial estimates placed the cost of construction for this 54-mile segment at \$1.7 million. However, as a result of recent interviews with Caltrans, we have determined this would have to be increased to approximately \$3.5 million due to Caltrans special permitting fees of approximately \$35,000/mile which are intended to deter construction on scenic byways and result in overall costs nearly double that which would normally be required.

## 4.2 Microwave

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SBC provides connection to Humboldt and Del Norte using digital microwave operating in the 6 gigahertz licensed band. The two OC-3 radio systems connect into Humboldt and Del Norte County providing a total of approximately 310 megabits of bandwidth. Microwave systems can be a cost-effective alternative to fiber optic installations. While lower in initial cost, microwave requires more annual maintenance and certification cost for operations.

Under contract to CENIC, Mr. Kenneth Richter of the Kern County Office of Education has determined that a feasible microwave path exists to the east of Eureka, using Redding or Chico California as a connection point into the Digital California Project nodes. Mr. Richter has completed the preliminary engineering but site location and powering systems would need to be evaluated. This alternative could be useful especially if only education's bandwidth needs are to be addressed by CENIC. As a potential OC-3 radio system, CENIC could derive 155 megabits of bandwidth to serve higher education and K-12 education entities' needs.

### **4.3 Other(s)**

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There are two other plausible forms of service delivery. Satellite service is available in DS-3 45 megabit and OC-3 155 megabit services. Satellite tends to be very expensive, subject to weather changes, and has significant transmission delays (known as latency). Latency can negatively affect certain applications used in bi-directional exchange of information.

The other alternative is managed services available from the telephone companies. SBC, and to a lesser extent, Verizon offer ATM transport services in multi-megabit configurations. These services usually offer both a committed information rate (CIR) bandwidth, as well as a burst rate equivalent to the maximum bandwidth. Managed Services require fiber optic connections from customer locations to the telephone company Central Office. From the Central Office, the telephone companies connect and combine all user traffic onto a higher capacity backbone circuit. Traffic is switched through the telephone company network to its final connecting destination using virtual circuits and tributaries. Depending on location and tariff costs, ATM services can be a reasonably economical alternative to dedicated, point-to-point fiber optic services.

### **4.4 Potential Scenarios**

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Since 1492, population growth, commerce, and communications have typically progressed from east to west and from south to north across the United States. This was true with the Overland Stage, the Pony Express, the railroads, the telegraph, the telephone, cable television and the digital age of telecommunications. Therefore, it is not surprising that the north coast communities of California are the last in California to benefit from the technological advances in telecommunications. The same forests, rivers, mountains, canyons, and deserts that challenged the evolution of these earlier modes of communications have, for years, conspired to retard the advance of telecommunications technology into Humboldt County and Del Norte County.

Due to a combination of geographical, regulatory, political, sociological, and fiscal constraints, no single organization has proven able to solve the telecommunications challenges that result from these constraints. Due to regulatory constraints governing interLATA service, neither SBC, or Verizon, the ILECs, can unilaterally solve the problem. Due to fiscal constraints resulting from small population spread over large geographic territories, neither CATV provider, Cox nor Charter, has been able to justify the heavy investment required to bring broadband communications ubiquitously to the north coast communities they are franchised to serve. To date, construction of new telecommunications infrastructure from the south (Santa Rosa) or east (Redding or Yreka) has proven prohibitively expensive due to a combination of extremely difficult

physical terrain and large permitting costs levied by the owners or managers of the public and private rights-of way. However, a recent agreement reached by SBC and Caltrans is “bringing some light” to this situation in the form of a new optical fiber cable plant being constructed by SBC along Caltrans rights-of way from the south between Santa Rosa and Humboldt County. Additionally, Verizon and Charter installed high-count optical fiber cable into Del Norte County from Oregon. However, to date, neither has elected to install the high-bandwidth optronics necessary to leverage its full potential for the community.

Exhibits in *Appendix C* include a map of existing optical fiber routes, and routes currently funded and under construction for completion later this year. Also included is a tabular summary of the various telecom providers and right-of-way owners, along with the potential communities that would be better served by enhanced telecommunications infrastructure in the north coast (and inland) communities of California. What they are intended to show is that it will require the combined effort of multiple incumbent telecom carriers, right-of-way owners, regulatory agencies, educators, commercial entities, and the communities in general, to totally overcome the geographic, regulatory, fiscal, and political barriers to ubiquitously-available broadband communications for the north coast communities. Barring atypical cooperation from the ILECs and CATV carriers, regulatory relief from the FCC and PUC, financial relief from the large permitting costs, and a Herculean effort from some catalytic influence such as CENIC, or the research and education community, such combined efforts typically never take place. However, with such cooperation, the technical, regulatory, and fiscal solutions are definitely feasible, as has been outlined in the attached tabular summary of potential solutions and scenarios.

## 5. ALTERNATIVE ORGANIZATIONAL STRATEGIES

CENIC may address the issue of reaching its educational goals and objectives by acquiring broadband capabilities through one of more approaches and technologies. The following describes the several primary methods of business arrangements available:

### 5.1 *Free Enterprise*

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Most customers rely on dominant service providers for local telephone or television service, high-speed Internet and data connections. Local exchange telephone companies and cable television companies are the primary sources of high-speed services. The general exception is large customers with sufficient volume who generally can and will economically justify private network infrastructure to serve their own needs.

Free enterprise has and continues to serve communication needs of consumers, government and business well. However, rural and low-density areas historically have been the last to receive the benefits of new technologies. High-speed Internet is certainly influenced by densities of areas. Costs per customer are significantly higher in less dense areas, resulting in lower profit margins for investments in low-density areas.

Free enterprise is an excellent choice of procuring services if those services are plentiful and there are not any long schedule delays waiting for network investments to construct the necessary connections.

Collaboration with current providers should continue in an ongoing effort to meet the needs of Humboldt and Del Norte counties.

### 5.2 *Public Development Authority*

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Community-based organizations (CBO) or a joint powers authority could be formed to address the broadband needs that the free enterprise system has not yet met. Market failures, as defined for the purpose of this analysis, include instances that may occur when service providers either do not or cannot provide advanced, high-speed services, or when prices charged for services are held artificially high because a single supplier controls the availability of connections. CBOs are similar to utility districts formed for the specific purpose of delivering infrastructure services in the interest of the common good.

The regulatory environment makes it necessary for any entity that elects to sell or resell service commercially to hold a “carrier status”. This regulatory status known as CLEC status can represent a significant overhead and cost for newly created authorities. However, customers who elect to provide their own network facilities are not considered carriers, as long as they do not resell their services to the public.

Federal, state, and local government make up a substantial portion of commerce within these counties, with education entities leading the way. This suggests that a possible consortium of governments may hold the highest potential for success.

### **5.3 Public-Private Partnerships**

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Public-private initiatives are favored when capital investment and joint interests and benefits can be exploited. However, most LECs like SBC and Verizon, as dominant local carriers, do not commonly participate in such arrangements. Dominant carriers do not commonly participate in such arrangements.

The current situation in Humboldt and Del Norte counties would only seem to favor such arrangements with alternate or non-dominant carriers.

## 6. POTENTIAL FUNDING SOURCES

Potential sources of funding that may have applicability to the development of advanced services in Humboldt and Del Norte counties have been identified, and are discussed below.

### 6.1 Existing Customer Expenditures

Existing large consumers of bandwidth, including commercial, consumer and service provider customers, represent the largest single source of funding for the use of potential alternative technologies or services. As key stakeholders, each has specific needs. Taken as a group, there may be significant synergies that emerge that will contribute to funding of potential solutions.

### 6.2 U.S. Department of Agriculture Broadband Funding

In 2002, the U.S. Department of Agriculture (USDA) instituted the Rural Broadband Access Loans and Loan Guarantees Program. Eligible participants include legally organized entities for wireless ISPs, rural power utilities, and communities building their own fiber networks.

The following is a description of the new program:

- Name:** RUS Broadband Loans and Loan Guarantee Program
- Web Site:** <http://www.usda.gov/rus/telecom/broadband.htm>
- Purpose:** To provide loans for construction, improvement, and equipment for broadband service in eligible rural communities.
- Launched:** January 31, 2003
- Value:** Approximately \$2B/year over six years
- Details:** The following are the key points of the program:
- 15 to 20 year loans, including refinancing (except for USDA broadband pilot program grants, which it appears that no California entity was awarded).
  - In FY-2003, \$1.45B is available
  - \$1.295B for direct cost-of-money loans
  - Most rural, economically-challenged with no broadband (BB)
  - \$80M for direct 4% loans
  - \$80M for private lender loan guarantees
  - Minimum \$100,000; Maximum for direct 4% is \$5M
  - Normally, January 31st is the funding deadline for the state allocation system; however, since FY-2003 budget wasn't

finalized until January 30, 2003, this year all applications must be postmarked by July 31, 2003. Applications received after July 31, 2003 will be considered in the following fiscal year cycle. In future years, California applications for the state allocation system will conform to the January 31<sup>st</sup> application date.

- Future years California applications for the state allocation system with a deadline of January 31<sup>st</sup>.
- State allocations are based on the number of communities with a population of 2500 or less. The Federal Register notice, January 30, 2003, indicates that based upon 2000 U.S. Census data, California has 296 qualifying communities, and it's 1.84% share equals \$26,767,708.
- Loan application criteria include the following:
  - Rural = population up to 20,000
  - 200 Kb minimum – both ways
  - One proposal per community will be funded; priority is determined by the placement in the queue for analysis. Multiple applications will be considered on a first in, first out basis.
  - If broadband service exists, not eligible for priority consideration
  - Funds can be used for equipment located in non-rural areas if it is necessary to provide service to rural areas.
  - A state or local government shall be eligible for a broadband loan only if, normally not later than April 30<sup>th</sup>, no other eligible entity is already offering service.

Additional information may be obtained by contacting the Rural Utilities Service General Field Rep for California, Arizona & Nevada, as follows:

**Address:** Harry M. Hutson  
P.O. Box 519  
Litchfield Park, Arizona 85340

**Telephone:** (623) 535-5450

### **6.3 Distance Learning and Telemedicine Grant/Loan Programs**

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Another USDA program, the Distance Learning and Telemedicine (DLT) Program is a combination grant and loan program. A comprehensive application guide, including sample documents, is available at the USDA Web site listed below.

The following is a description of the USDA Rural Utilities Services funding option:

**Name:** Distance Learning and Telemedicine Program  
**Web Site:** [http://www.usda.gov/rus/telecom/dlt/pdf\\_files/dltloan-grant-app-guide-2003.pdf](http://www.usda.gov/rus/telecom/dlt/pdf_files/dltloan-grant-app-guide-2003.pdf)  
**Purpose:** To provide financial assistance to enhance learning and health care opportunities for rural communities.

- Value:** For FY 2003, \$27M in grants and \$300M in loans.
- Details:** The following are the key points of the program:
- \$17M was available for 100% DLT grants in FY-2003.
    - Applications were due May 2, 2003.
    - In FY-2002, two awards were made to California: Southern California Tribal Chairmen's Association, \$479,235; and Yosemite Community College District, \$500k.
  - \$200M is available for 100% loans, and \$100/\$10M is available for 100% combination loan-grants (\$10 loan to \$1 grant).
  - Maximum loan size: \$10M
  - Minimum loan size: \$50K
  - Applications are accepted year round until July 31, 2003.
  - Applications are processed as received on a first come, first served basis, and based on available funds.

Additional information may be obtained by contacting the Rural Utilities Service General Field Rep for California, Arizona & Nevada, as follows:

**Address:** Harry M. Hutson  
P.O. Box 519  
Litchfield Park, Arizona 85340

**Telephone:** (623) 535-5450

## **6.4 Rural Development**

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### **6.4.1 U.S. Department of Commerce**

The U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA) Office of Telecommunications and Information Applications (OTIA) assists state and local governments, educational and health care entities, libraries, public service agencies, and other groups in effectively using telecommunications and information technologies to better provide public services and advance other national goals. This is accomplished through the administration of the Technology Opportunities Program (TOP) and the Public Telecommunications Facilities Program (PTFP).

The Technology Opportunities Program (TOP) awards grants through an annual competition. On March 17, 2003, the Commerce Department's National Telecommunications and Information Administration (NTIA) announced the fiscal year 2003 grant round for TOP. For FY 2003, approximately \$12.4 million is available for matching grants. The deadline for submission was Wednesday, April 23, 2003. The grant round is now officially closed. (<http://www.ntia.doc.gov/top/grants/application.htm>)

### **6.4.2 Federal Communications Commission, Universal Service Fund**

The goals of Universal Service, as mandated by the 1996 Telecommunications Act, are to promote the availability of quality services at just, reasonable, and affordable rates; increase access to advanced telecommunications services throughout the Nation;

advance the availability of such services to all consumers, including those in low income, rural, insular, and high cost areas at rates that are reasonably comparable to those charged in urban areas.

In addition, the 1996 Act states that all providers of telecommunications services should contribute to Federal universal service in some equitable and nondiscriminatory manner; there should be specific, predictable, and sufficient Federal and State mechanisms to preserve and advance universal service; all schools, classrooms, health care providers, and libraries should, generally, have access to advanced telecommunications services; and finally, that the Federal-State Joint Board and the Commission should determine those other principles that, consistent with the 1996 Act, are necessary to protect the public interest.

## **6.5 California Teleconnect Fund**

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The California Public Utilities Commission established the California Teleconnect Fund (CTF) in 1994. It provides discounted telecommunications services for qualifying schools, libraries, hospitals, and CBOs. The following information is taken directly from the CTF Web page.

The CTF is funded by an all-end-user surcharge billed and collected by telecommunications carriers that, in turn, remit the surcharge monies to a financial institution as directed by the Commission or its representatives. Procedures for the administration of CTF are set forth in the Adopted Universal Service Rules adopted by the Commission in D.96-10-066. The carriers are reimbursed by way of claims against the fund for discounts granted.

The following entities are eligible for consideration and discounts under the program:

- Public or nonprofit schools that provide elementary or secondary education and that have endowments under \$50 million
- Only those libraries that are eligible for participation in state-based plans for funds under Title III of the Library Services and Construction Act (20 USC, Section 335c et seq.).
- Hospitals and health clinics owned and operated by qualifying municipal and county governments; CBOs that are tax exempt and offer health care, job training, job placement, or educational instruction. Tax exempt refers to organizations described in Section 501(c) (3) or 501 (d) of the Internal Revenue Code, Title 26 of the United States Code.

Any discounts, if approved, will take effect from the date that the application is received by the Public Utilities Commission.

CBOs, as well as qualifying schools, libraries, and hospitals, are entitled to a discount rate for all measured business service lines, switched 56 lines, ISDN, DSL, T-1, DS-3 and up to and including OC-192 services or their functional equivalents. The discount rate for these services will be 50% below the rates charged to other business customers for those same services.

These discounted rates may not be resold to, or shared with, any other non-qualifying entity or person. Also, nothing in this rule precludes a carrier from offering a larger discount than what is provided for in this rule.

The following office may be contacted for more information:

Donna Silvestre  
Los Angeles Outreach Office CPUC  
320 West 4th Street, Suite 500 Los Angeles, California 90013  
Telephone: 213-576-7058

## 6.6 JP Morgan Chase

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JP Morgan Chase invites applications for grants to support faith-based institutions embarking on their first community development project or those entering into a new type of project, either on their own or in collaboration with other organizations. Grants of up to \$25,000 will be made in the form of a one-time grant to be used for capital expenses related to the selected community development projects. Economic development projects and those addressing the Digital Divide will be considered. Among other eligibility requirements, faith-based institutions must be either: (1) a religious community or congregation with 501(c)(3) tax exempt status from the Internal Revenue Service, or (2) a separate tax exempt 501(c)(3) entity associated with an organized religious congregation. Applications are due July 31, 2003. More information, including a complete listing of eligible communities, is available at the following Web site:

<http://www.jpmorganchase.com/cm/cs?pagename=Chase/Href&urlname=jpmc/community/grants/programs/cdhs/faith>.

## 6.7 Legislative Possibilities

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There are several other funding avenues that could be explored, but would require legislation, including the following:

- Amending the Public Utilities Code to allow the High Cost Fund A and High Cost Fund B accounts within the CTF to cover costs of fiber infrastructure and circuits to provide an access point to advanced telecommunications services in rural counties where such services are not currently available to schools. Initially provide one time funding to prototype such infrastructure investment for Del Norte County.
- Modifying the CTF regulations for Del Norte and Humboldt counties so that telecommunications circuits are eligible for discounts in proportion to the eligible use as a percentage of total usage. This would both align the CTF regulations with comparable federal E-rate regulations, and would remove a disincentive from cost effective circuit sharing between CTF-eligible and CTF-non-eligible organizations in the region.
- Authorizing the establishment of a special entity for the two-county region similar to the entity created in the Monterey area to address issues related to the closure of Fort Ord and base reuse plans, that would have the authority to levy assessments, reassessments, or special taxes and issue bonds to finance regional telecommunications infrastructure in accordance with any of the following:
  - *The Benefit Assessment Act of 1982* (Chapter 6.4 (commencing with Section 54703) of the Government Code).

- *The Landscape and Lighting Act of 1972* (Part 2 (commencing with Section 22500) of Division 15 of the Streets and Highways Code).
- *The Integrated Financing District Act* (Chapter 1.5 (commencing with Section 53175) of Division 2 of Title 5 of the Government Code).
- *The Mello-Roos Community Facilities Act of 1982* (Chapter 2.5 (commencing with Section 53311) of Part 1 of Division 2 of Title 5 of the Government Code).
- *The Infrastructure Financing District Act* (Chapter 2.8 (commencing with Section 53395) of Division 2 of Title 5 of the Government Code).
- *The Marks-Roos Local Bond Pooling Act of 1985* (Article 4 (commencing with Section 6584) of Chapter 5 of Division 7 of Title 1 of the Government Code).

## 7. CONCLUSIONS AND NEXT STEPS

The ideal geographic marketplace for local carriers and service providers consists of high density residential and business; favorable prevailing land features; proximity of connections to wireless and InterExchange carriers; upscale income, employment, and educational demographics; and ample economical access through joint use conduit or aerial systems. These types of factors not only satisfy return on investment and payback periods for service providers, but also change the “utility” perception of investors and shareholders into one of high technology service companies. Unfortunately, Humboldt and Del Norte counties meet none of these criteria.

The FCC publishes an annual Broadband Deployment report, which tracks the year progress of broadband services to consumers and businesses. At the end of 2001, broadband deployment in the highest density areas did not appreciably increase. In the least dense areas (ZIP codes), the percentage of broadband availability rose from 28% to 43%. This contrast growth rate indicates saturation in dense areas resulting in capital investment being redirected and prioritized into the less dense areas.

Humboldt and Del Norte counties have higher home ownership resulting in greater population stability. Broadband deployment has begun, but customer purchases have been impeded because network backbone connections cannot support additional sales. As backbone connectivity increases, the availability of broadband in the community and customer take rate will increase. Higher future penetration of broadband for homes and business can be anticipated when backbone capacity is increased. DSL and Cable Modem services can be expected to resume aggressive growth.

In addition, there appears to be another phenomenon at work. Internet use and adoption tend to be more important to people in less dense areas. Lower income levels do not translate into fewer households with Internet Service. Despite the counter-intuitive appearance, Internet use by business and residence is more important as a source of information, transactional services, news, or communications,

Interest and attention to broadband services and alternative suppliers runs high in Humboldt County. To a lesser extent, Del Norte County shares the same interests. These factors favor both the adoption of new services when available, as well as interest in alternative supplier options.

The availability of fiber to Eureka is a significant step forward in meeting the broadband needs of the county. Backbone bandwidth, although available to Humboldt County in early fall 2003, does not appear to be fully diverse. A possible failure or break in the SBC Santa Rosa to Eureka link could leave Humboldt and Del Norte County functioning temporarily on microwave systems that have already proven to be inadequate from a capacity standpoint. Service providers and large customers must view this network vulnerability seriously. Moreover, the installation of fiber into Humboldt County does not address fiber to Del Norte County.

Existing built fiber routes, possible rights-of-way access, and new potential microwave paths offer the opportunity to create possible partnerships that would result in having diverse and redundant economical access to complete the DCP network connections.

Specifically, CENIC needs to expeditiously pursue the following next steps:

1. Inform members of the communities of the findings of this analysis.
2. Develop charter and project plans for completion of planning and collaboration.
3. Form a consortium planning group consisting of local county leaders, local educational representatives, local Service Providers, CENIC, and networking experts who wish to participate and potentially fund development in the county areas. Work collaboratively to maximize broadband deployment throughout the counties.
4. Develop and issue a summary area development plan that specifies if and under what circumstances either individual, consortium, or governmental solutions can blend with technological alternatives to be implemented.
5. Ultimately form or facilitate implementation of solutions.

Unfortunately, technology solutions require detailed planning followed by even more detailed implementation. CENIC represents the largest single stakeholder interest in the counties, and needs to begin and sustain a process toward resolving the issues.

## Appendix A – List of Interviews

## Humboldt County

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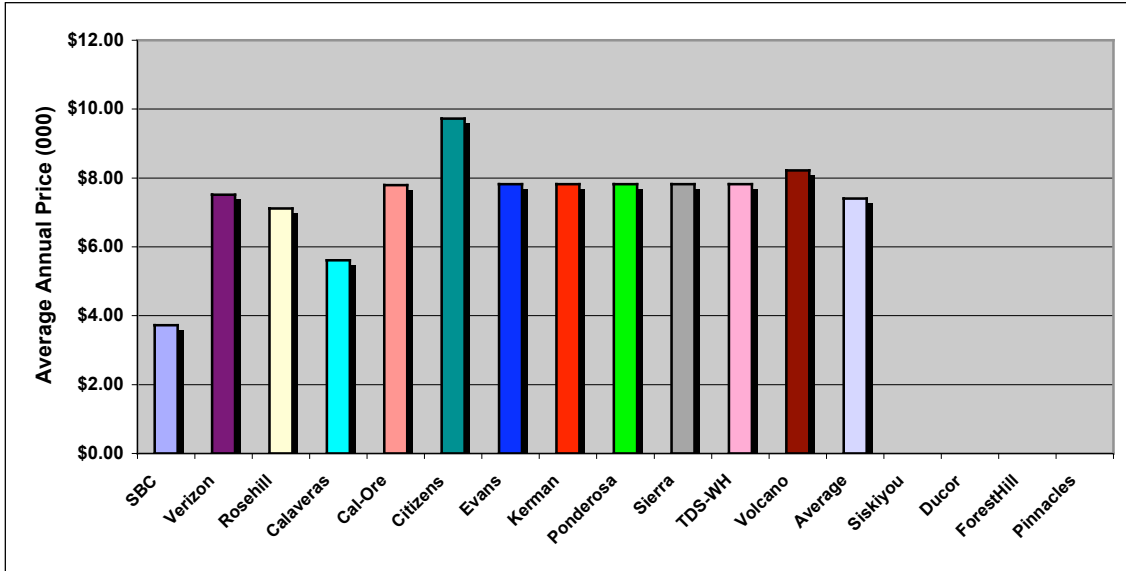
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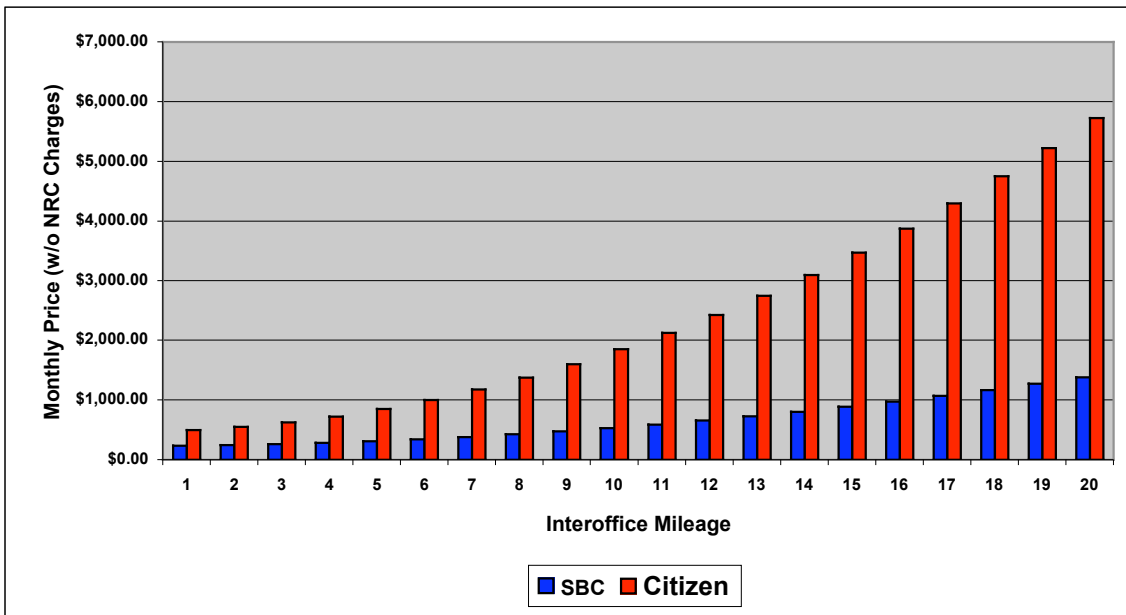
## **Appendix B – Last Mile Study Pricing Charts**

**Figure B-1** shows there are considerable differences in cost depending on the carrier providing service. The data in **Figure B-1** are taken from the Cal-Net schedules for T-1 (1.544 Mbps) service. Costs are annual costs with a one-time installation charge averaged over 3 years. It should be noted from **Figure B-1** that all non-SBC providers are considerably more expensive than SBC. These larger differences will skew any “average” calculations that could be made.



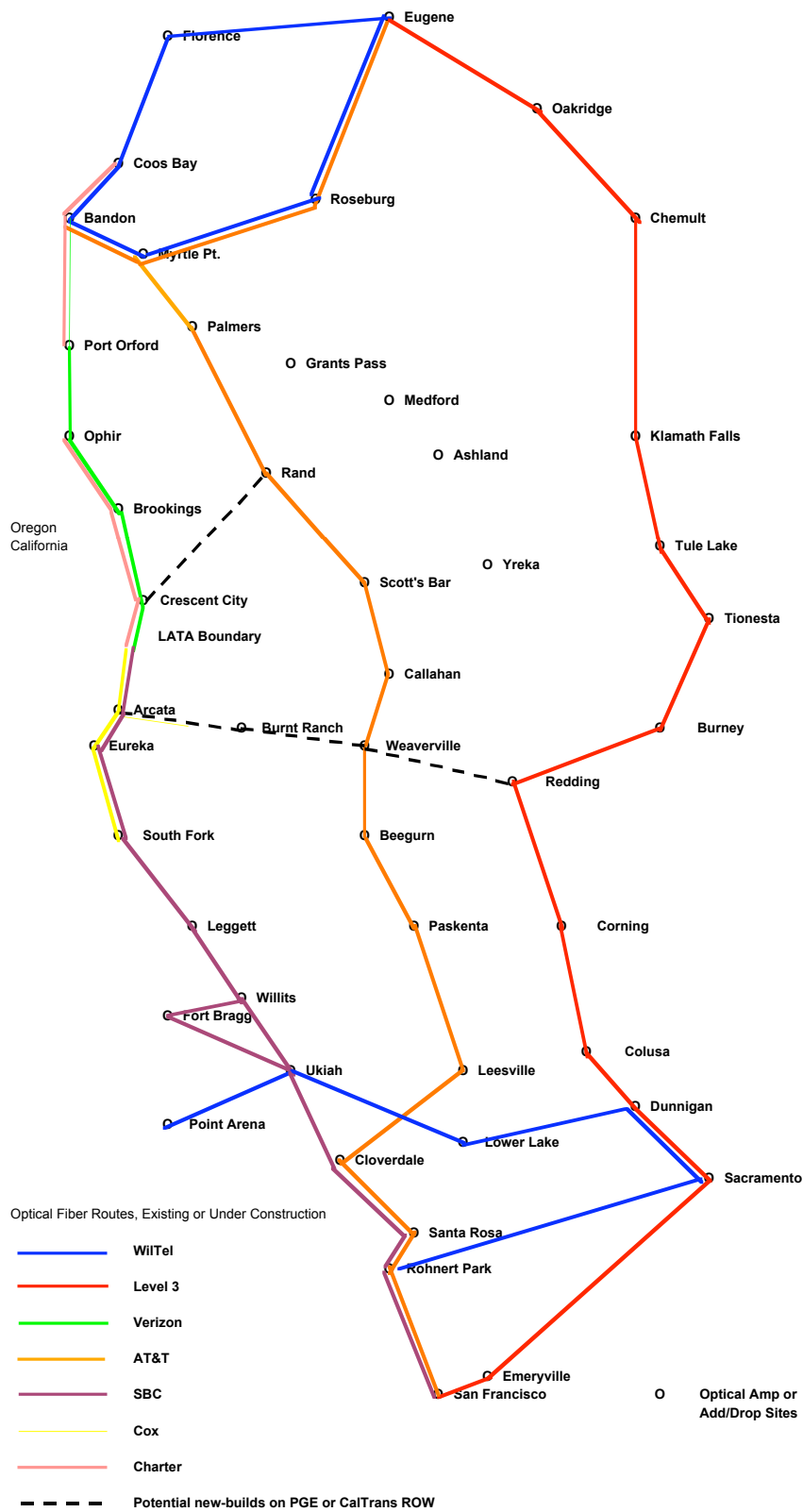
**Figure B-1**

To vividly illustrate this pricing difference, SBC and Citizens were chosen for **Figure B-2** to demonstrate of the largest difference for circuit costs. As the figure shows, the distance between circuits can have a significant impact on the cost of service. This analysis was performed for T-1 (1.544 Mbps) services using the lowest and highest indicated costs from the Cal-Net contract schedules.



**Figure B-2**

## Appendix C – Scenarios



Courtesy: Victor Braud, of Fiber Channels, Inc.

**Figure C-1. Optical Fiber Routes, Existing and Under Construction**