



National Telecommunications and Information Administration

Broadband Technology Opportunities Program
Evaluation Study

Order Number D10PD18645



Case Study Report

MCNC

Comprehensive Community Infrastructure

Submitted March 4, 2014

ASR Analytics, LLC
1389 Canterbury Way
Potomac, MD 20854

Federal TIN: 20-1204680
DUNS: 15-108-3305
GSA Schedule #: GS-10F-0062R

Submitted to:

Shelita Saint-Louis, Contracting Officer
Cassandra Sterba, Contract Specialist
Acquisition Services Directorate
National Business Center
Department of the Interior

Table of Contents

- Executive Summary 1
- Section 1. Introduction 6
- Section 2. Impacts..... 14
 - 2.1 Education and Training 14
 - 2.2 Workforce and Economic Development..... 17
 - 2.3 Healthcare 19
 - 2.4 Digital Literacy..... 20
 - 2.5 Government Services..... 21
- Section 3. Grant Implementation 23
 - 3.1 Implementation..... 23
 - 3.2 Open Access Policies 24
 - 3.3 Results 24
 - 3.4 Sustainability 25
 - 3.5 Successful Tools, Techniques, and Strategies 25
- Section 4. Conclusions..... 26
 - 4.1 Improve Access to Unserved and Underserved Areas of the Country 26
 - 4.2 Broadband Education, Awareness, Training, Access, Equipment, and Support 27
 - 4.3 Public Safety Agencies 27
 - 4.4 Demand for Broadband, Economic Growth, and Job Creation..... 28
- Section 5. Next Steps for the Evaluation Study 30
- Notes..... 31
- Glossary..... 41
- Bibliography 43

List of Tables

Table 1. Community Anchor Institutions Located in the Service Area	3
Table 2. Counties in Service Area	6
Table 3. Number of Broadband Providers Available in North Carolina	7

List of Figures

Figure 1. Map of CAIs	7
Figure 2. Maximum Speed Ranges Available for the Service Area Population	8
Figure 3. CAI Subscribers by Connection Speed	9
Figure 4. Direct Jobs Created by MCNC	19

Executive Summary

About BTOP

The American Recovery and Reinvestment Act of 2009 (Recovery Act) appropriated \$4.4 billion in federal funding to the National Telecommunications and Information Administration (NTIA) to implement the Broadband Technology Opportunities Program (BTOP) in order to spur job creation, stimulate economic growth, and increase access to broadband services.¹ BTOP projects are intended to support increased broadband access and adoption, provide broadband training and support through community organizations, and stimulate the demand for broadband. NTIA distributed grant funding to 233 projects, benefiting all 50 states, 5 territories, and the District of Columbia. The types of projects BTOP funded include Public Computer Centers (PCC), Sustainable Broadband Adoption (SBA), and Comprehensive Community Infrastructure (CCI). CCI projects deploy new or improved broadband Internet facilities to connect households, businesses, and community anchor institutions (CAI) such as schools, libraries, hospitals, and public safety facilities.² CCI projects funded by BTOP are predominantly middle mile projects, although a small number of last mile projects were awarded.³

Comprehensive Community Infrastructure projects deploy new or improved broadband Internet facilities to connect households, businesses, and community anchor institutions such as schools, libraries, hospitals, and public safety facilities.

About the Evaluation Study

This case study report is one of twelve case studies performed by ASR Analytics, LLC (ASR) on CCI projects. It is part of a larger mixed-methods evaluation of the social and economic impacts of the BTOP program.

The purpose of this case study is to:⁴

- Identify how the grantee maximized the impact of the BTOP investment.
- Identify successful techniques, tools, materials, and strategies used to implement the project.
- Identify any best practices, and gather evidence from third parties, such as consumers and anchor institutions, as to the impact of the project in the community.

The information presented in this report intends to capture the social and economic impacts of the grant, and is not an evaluation of MCNC, its partners, or its subgrantees.

This case study is primarily qualitative. Social and economic impacts are categorized by the five focus areas described in *Interim Report 1*, with the addition of the Government Services focus area.⁵ Section 2 includes the presentation of these impacts by focus area.

The evaluation study team collected information to evaluate the social and economic impact of the MCNC project during field visits. From September 9 to 13, 2013, the evaluation study team met with representatives of MCNC and CAIs connected by the project. In total, the evaluation study team performed twenty-three site visit interviews and focus groups. ASR transcribed these discussions and used this information, along with other information and reports provided by the grantee, to supplement Quarterly Performance Progress Reports (PPR), Annual Performance Progress Reports (APR), and other publicly available information. The information presented here is intended to

capture the social and economic impacts of the grant, and is not an evaluation of MCNC, its partners, or its subgrantees.

About the Grantee



Located in Research Triangle Park in Durham, North Carolina, MCNC was founded in 1980 to stimulate economic development through technology research and initiatives. Under a state mandate, MCNC began to construct an advanced communications network and completed the initial framework by 1985. This network was the first version of what is now known as the North Carolina Research and Education Network (NCREN). MCNC owns and operates NCREN. By 1993, broadband connections to all North Carolina's public universities, most private universities, and nonprofit research institutes were constructed.

From these initial connectors, NCREN now extends to all public school districts in the state along with sixty-nine charter schools, forty-three colleges and universities, fifty-eight community colleges, and numerous research institutes and foundations. In addition, the North Carolina Telehealth Network, which links nonprofit hospitals and other health entities throughout the state, also receives broadband service through MCNC. At the completion of MCNC's BTOP Round 1 award, the network included 1,443 miles of owned and leased fiber.⁶

MCNC completed the North Carolina Rural Broadband Initiative project at the end of September 2013, after spending \$104,854,663.

On August 1, 2010, NTIA awarded MCNC a BTOP Round 2 CCI grant for \$75,757,289 to implement the North Carolina Rural Broadband Initiative project, known as the Golden LEAF Rural Broadband Initiative (GLRBI). MCNC and project partner Golden LEAF Foundation pledged \$30,034,187 in matching funds.⁷ MCNC completed the project under budget by July 31, 2013 after spending a total of \$104,854,663.

Project Proposal and Status

MCNC's GLRBI project planned to expand on the work of its \$28,225,518 BTOP Round 1 award by adding 1,700 miles of middle mile fiber and operating an optical network capable of speeds up to 100 Gbps. This report focuses on the Round 2 grant, although references to the Round 1 grant are included where necessary. MCNC proposed the following with results shown:⁸

- Construct more than 1,300 miles of new fiber in the sixty-nine county service area.⁹ As of July 31, 2013, MCNC had constructed 1,301 miles of new fiber and acquired indefeasible rights of use (IRU) for 336 miles of fiber.¹⁰
- Connect more than 170 CAIs, including 58 K-12 schools, 52 higher education institutions, 54 public libraries, and 12 public safety entities. MCNC connected 175 CAIs by July 31, 2013.¹¹
- Facilitate improvements in public health and electronic health records (EHR). The North Carolina Telehealth Network (NCTN), served by NCREN infrastructure, links statewide healthcare institutions. MCNC connected two hospitals through NCTN during the award period.¹² The grant also improved network reliability by establishing redundant paths for healthcare institutions already connected to NCTN.¹³

MCNC accomplished the following from its proposed goals:

- Installed 1,301 miles of fiber
- Connected 175 community anchor institutions
- Improved reliability of NCTN by establishing redundant paths for participating healthcare

- Improve broadband accessibility and affordability for up to 2.3 million households and 160,000 businesses by providing Internet service providers (ISP) the opportunity to connect to more than 2,000 interconnection points on the open access network. As of July 31, 2013, MCNC had signed new agreements with seven providers and was in negotiations with five additional providers.¹⁴ The number of business and residents connected by local ISPs is not publicly available. Section 3.2 of this report describes MCNC’s approach to open access in more detail.

As shown in Table 1, MCNC connected 175 CAIs.¹⁵ Approximately one-third of the CAIs connected at the time of the site visit are K-12 school districts, followed by universities, colleges, or other postsecondary institutions as the second most frequent CAI type (3 percent).¹⁶

Table 1. Community Anchor Institutions Located in the Service Area

Type	Goal		Served by Grantee		All of Service Area
	#	%	#	%	#
School Districts (K-12)	58	33%	57	33%	77
Library	54	31%	52	30%	76
Medical/Healthcare	0	0%	2	1%	11,319
Public Safety	12	7%	11	6%	999
University, College, or Other Postsecondary	52	30%	52	30%	140
Other Community Support	0	0%	1	1%	NA*
All	176		175		12,610
*No comprehensive publicly available data source was found to match Other Community Support organizations.					

MCNC connected fifty-seven K-12 school districts to the middle mile portion of the network, one fewer than its goal of fifty-eight. Each school district has connected its local school buildings and facilities to NCREN through a connection point typically located at the school district’s administrative offices. MCNC provided connections ranging from 100 Mbps to over 1 Gbps depending on the projected needs of each school district. MCNC monitors these connections in real time and upgrades connection speeds based on school district demand. MCNC connected fifty-two out of a planned fifty-four libraries and eleven out of a planned twelve public safety organizations. MCNC connected more hospitals and university or community colleges than planned. This includes connecting two hospitals through the NCTN and fifty-two higher-education institutions. As the CAIs use their new Internet connections, MCNC monitors their usage and raises the broadband speeds when the CAI consistently uses 65 percent of its assigned speed capacity. MCNC expects last mile providers will connect additional CAIs as their current service contracts expire or new money is allocated locally for Internet services.

Major Outcomes and Impacts

Through interviews and data collection from a number of sources, the evaluation study team observed qualitative and quantitative outcomes and impacts of the grant. The list below highlights these outcomes and impacts, with additional detail provided in Section 2.

- Connectivity to school districts has improved significantly. The school districts are now connected through fiber connections with speeds ranging from 100 Mbps to 4 Gbps. The faster speeds allow

many of the districts to upgrade to cloud-based services for learning management, finance and accounting, and office automation.

- Higher-education institutions are expanding their distance learning opportunities for students. Increased bandwidth for K-12 districts and higher education institutions connecting to NCREN has supported growth in the use of web-based instructional tools.
- The MCNC project provided rural areas with a carrier class network with open access policies. NCREN is the only open network extending into rural western North Carolina. The network is helping to stimulate economic development in rural communities with the opening of a cluster of data centers, pharmaceutical companies, and expansion of furniture manufacturing.
- Wireless providers are planning to connect to the MCNC network through wholesale providers that have purchased fiber from MCNC. These connections are in response to incentives through the Cell Tower Deployment Act, which allows local governments to regulate the construction of wireless towers and the state to lease property for tower construction.¹⁷ The new law will make it easier for wireless providers to build towers in North Carolina, resulting in more potential customers for MCNC.
- The MCNC network affected healthcare services in North Carolina in several ways. Medical education programs use the network to train medical professionals in telehealth. This includes courses and clinical experiences for medical and health care students in medicine, dentistry, nursing, and other fields. The grant helped expand and enhance the NCTN, which was initially funded through the FCC Rural Healthcare Pilot Program and connects over 130 healthcare providers to a private and secure IP-based network.
- MCNC accomplished the Recovery Act goal to provide broadband education, awareness, training, access, equipment, and support. MCNC collaborates with local initiatives to ensure its network connectivity provides reliable and adequate service to help CAIs offer innovative digital literacy programs. The network enables the CAIs to diversify access points to the Internet and their services through mobile devices, wireless devices, public computer labs, and related training classes.

Through BTOP, the project achieved the following community impacts:

- Increased educational opportunities for K-12 and higher education institutions
- Spurred economic development in rural areas
- Increased telemedicine opportunities for healthcare providers

Conclusions

Without the grant to fund the GLRBI project, MCNC would have faced many challenges to serve CAIs with a reliable and scalable fiber-based high-speed broadband network. An MCNC executive observed that it was becoming difficult for MCNC to provide affordable service to CAIs outside of the core network service area, which extends from Research Triangle Park to Charlotte. It was expensive for MCNC to serve CAIs in rural areas. MCNC reported that without the BTOP grant it would have to serve rural CAIs with short-term leases to connect to the NCREN network. It was not able to purchase dark fiber to improve these connections to CAIs. This was a particularly significant issue for building out the NCREN network in eastern and western North Carolina. Executives from MCNC and partners responsible for building the network in western North Carolina agreed that without the BTOP grant it would not have been economically feasible to build through the mountains in

Community anchor institutions interviewed reported that their networking costs declined and capacity increased after connecting to MCNC. School districts, in particular, benefit from MCNC's pricing structure, which is a flat rate that does not increase if additional bandwidth is requested.

one of the most rural areas of the United States. Community anchor institutions interviewed reported that their networking costs declined and capacity increased after connecting to MCNC. School districts, in particular, benefit from MCNC's pricing structure, which is a flat rate that does not increase if additional bandwidth is requested. Data provided during interviews show that the average increase in capacity at CAIs was over 400 percent.

Section 1. Introduction

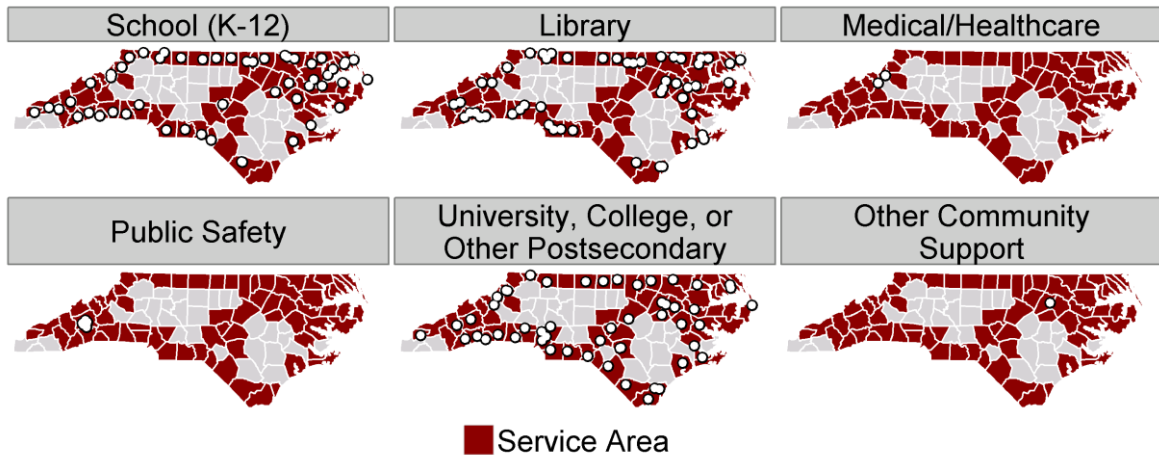
The goal of MCNC's Golden LEAF Rural Broadband Initiative (GLRBI) was to improve broadband access in underserved rural areas of North Carolina by expanding the existing North Carolina Research and Education Network (NCREN). The project proposed to serve more than 170 CAIs including public safety agencies, public libraries, K-12 schools, and institutions of higher education.¹⁸ The grant's service area encompassed 69 of North Carolina's 100 counties. Table 2 includes the counties in MCNC's service area.

Table 2. Counties in Service Area

Alleghany	Gaston	Pasquotank
Anson	Gates	Perquimans
Ashe	Graham	Person
Avery	Granville	Pitt
Beaufort	Halifax	Polk
Bertie	Harnett	Richmond
Brunswick	Haywood	Robeson
Buncombe	Henderson	Rockingham
Cabarrus	Hertford	Rutherford
Caldwell	Hyde	Scotland
Camden	Jackson	Stokes
Carteret	Lee	Surry
Caswell	Lincoln	Swain
Chatham	McDowell	Transylvania
Chowan	Madison	Tyrrell
Cleveland	Martin	Union
Columbus	Mecklenburg	Vance
Craven	Mitchell	Wake
Cumberland	Moore	Warren
Currituck	Nash	Washington
Dare	New Hanover	Watauga
Edgecombe	Northampton	Wilson
Franklin	Onslow	Yancey

As of July 31, 2013, MCNC had connected 175 CAIs. Figure 1 displays a map of the service area highlighted in red with the locations of the connected CAIs, broken out by type, plotted on top.

Figure 1. Map of CAIs



The American Community Survey (ACS) Five Year Summary for 2007 to 2011 shows that the total population in the service area accounts for more than 65 percent of the population of North Carolina, or nearly 6.2 million people. Race and income statistics for the service area are indicative of statewide averages. Approximately 69 percent of residents in these counties are White, and nearly 22 percent of the service area population is African American. Seventy percent of the population in the rest of North Carolina is White and twenty-one percent of the population is African American. More than half of the service area population (52 percent) has a household income of less than \$50,000 per year, and 15 percent are in poverty. In the rest of North Carolina, 55 percent of the population has a household income of less than \$50,000 and 16 percent are in poverty.¹⁹ Using publicly available data, the evaluation study team identified 14,654 CAIs in the service area, including 76 libraries, 11,319 medical/healthcare facilities, 999 public safety institutions, 2,120 K-12 schools, and 140 universities, colleges, or other postsecondary institutions.

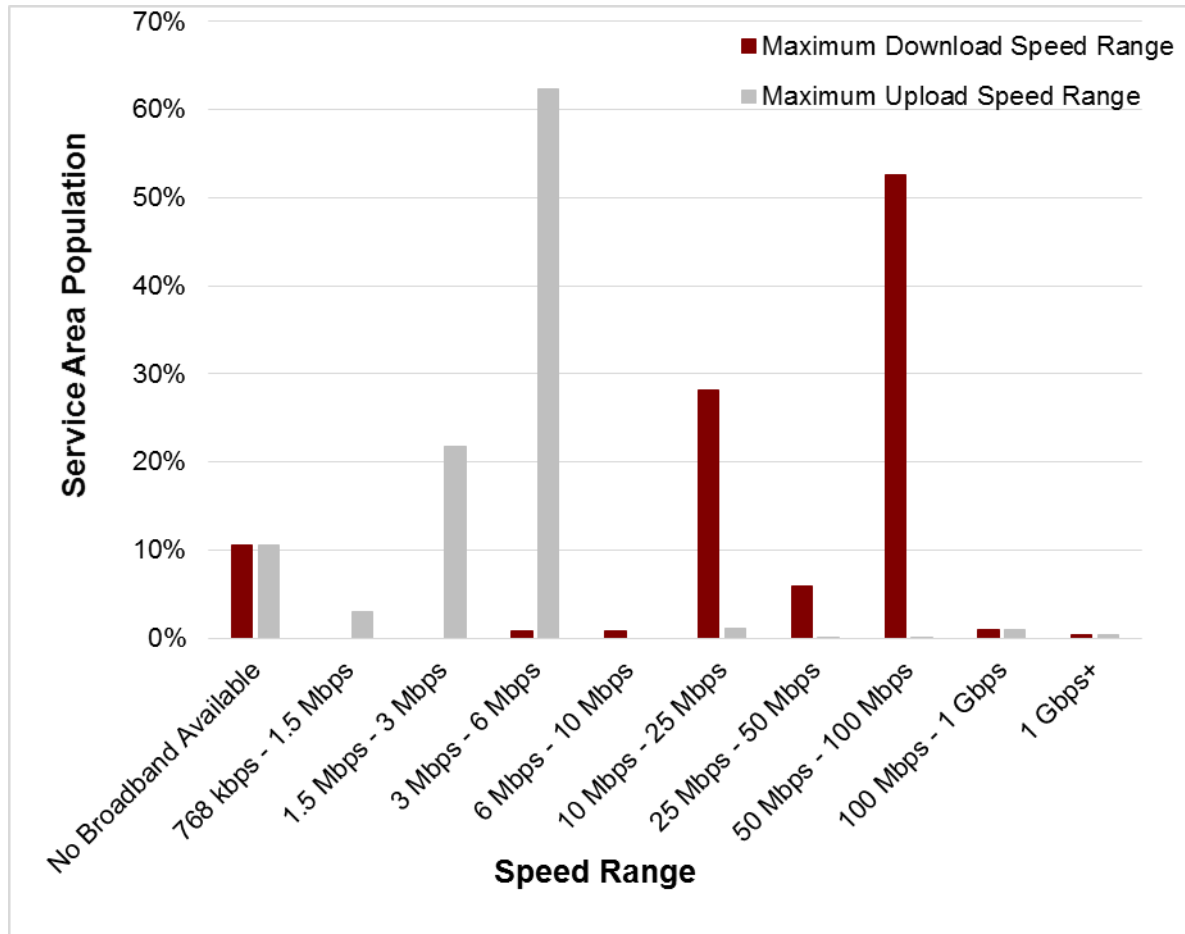
Table 3 shows the percentages of the populations in the service area and the rest of North Carolina by the number of broadband providers available according to data and speed thresholds defined by the National Broadband Map (NBM).²⁰ Nearly 11 percent of the service area population does not have access to a broadband provider compared to slightly more than 9 percent of the rest of the state's population. Nineteen percent of service area residents have only one broadband provider available, compared to approximately 28 percent of the rest of North Carolina. According to the NBM, the majority of both the service area population and the population of the rest of North Carolina have access to maximum download speeds of 50 to 100 Mbps (53 percent of the service area compared to 49 percent of the rest of North Carolina).²¹ All provider and speed statistics use the June 2011 release of the NBM and 2010 population data from GeoLytics.

Table 3. Number of Broadband Providers Available in North Carolina

Number of Providers	Service Area	Rest of North Carolina
0	10.57%	9.43%
1	19.26%	28.21%
2	40.61%	46.84%
3	28.26%	14.50%
4	1.26%	1.00%
5	0.05%	0.01%

Figure 2 shows the percentages of the service area population with respect to the fastest download and upload speed range available to them.²² According to the NBM, twenty-eight broadband providers offer service somewhere in the service area. Maximum download speeds range from 3 Mbps to 1 Gbps, while maximum upload speeds range from 768 kbps to 1 Gbps.

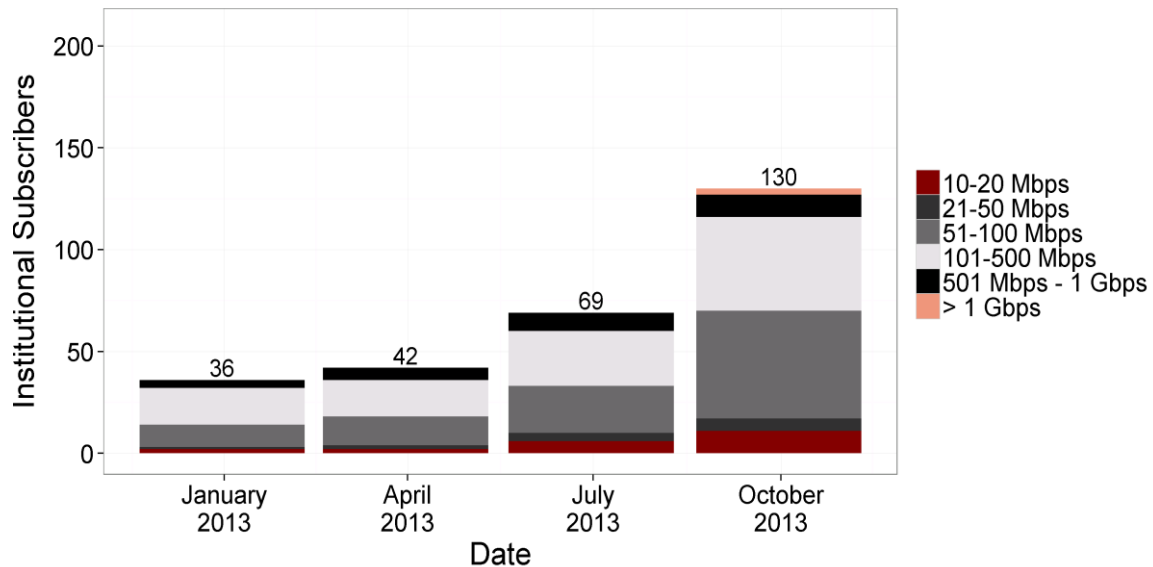
Figure 2. Maximum Speed Ranges Available for the Service Area Population



Broadband subscribership rates are also higher in the service area than across the state. Federal Communications Commission (FCC) data from June 2012 show that nearly 65 percent of the service area population subscribes to an Internet service that has at least 768 kbps download speeds and 200 kbps upload speeds.²³ Approximately 60 percent of the state's population subscribe to an Internet service with the same minimum thresholds.²⁴

Figure 3 presents the number of CAI subscriptions at different speed tiers since MCNC first reported CAI subscribers and their speed tiers in the last quarter of 2012.²⁵ In the most recently available quarter of data, third quarter of 2013, the largest speed tier by number of subscribers connected through GLRBI is the 51 to 100 Mbps range.

Figure 3. CAI Subscribers by Connection Speed



The evaluation study team met with MCNC staff, project partners, and service providers. These interviews helped the team understand the grantee’s approach to project implementation and the strategies used to create demand for the broadband service. Additional interviews with key CAIs throughout North Carolina focused on describing the impact on CAIs in relation to several factors, including the quality of service of the upgraded network, especially speed, reliability, flexibility, and cost. The analysis in this report focuses on outcomes and impacts to CAIs. Interviews conducted include the following:

- Grant Partners
 - **Broadplex, LLC** is a competitive local exchange carrier (CLEC) based in Morganton, North Carolina. Broadplex is a vendor of dark fiber infrastructure and provides limited construction services for small-scale fiber installation projects. Broadplex assisted MCNC in developing cost estimates during the proposal process for the GLRBI grant. Broadplex also leased Indefeasible Rights of Use (IRU) to MCNC as part of the grant-funded network expansion. As a result, some of MCNC’s network runs on Broadplex fiber. Broadplex has executed an IRU with MCNC for the entire expanded MCNC fiber backbone funded by the project.
 - **CommScope** is a privately held multinational telecommunications company based in Hickory, North Carolina. Established in 1976, the company has developed technology solutions for the delivery of cable television and broadband services. CommScope offers optical fiber, hybrid, radio frequency, and wireless technology solutions to deliver broadband to commercial carriers, enterprise clients, and the broadband cable market. The company has over 12,000 employees and serves customers in more than 100 countries.²⁶ CommScope supplied physical materials for the project, including conduit and fiber they manufactured, and acted as a distribution facility for other project vendors. CommScope also played a key role in managing the logistics of the project’s construction phase by shifting production and supply among its three facilities to accommodate changing construction schedules.
 - **ECC Technologies, Inc. (ECC)**, founded in 1995, is a technology and communications consulting group that has worked on over \$1 billion worth of development projects around the world. ECC works with owners, architects, and engineers to design and implement technological infrastructures that include computer networks, telephone systems, public address systems, sound and video systems, and security systems. The company specializes in creating systems for multi-building organizations or communities. Originally operating exclusively in New York State, ECC expanded its programs to North Carolina in 2011 to

partner with MCNC on the GLRBI project. ECC serves as the project's marketing agent for the network.

- **ERC Broadband** (ERC) is an arm of the Education and Research Consortium of the Western Carolinas, a nonprofit organization committed to economic development in western North Carolina and northern South Carolina. ERC owns and operates its own network in western North Carolina. The ERC network provides Internet access, data center operations, weather data collection, and dark fiber leases for research and education organizations, health care facilities, public safety agencies, and government entities. The network has an interconnection point to NCREN and three fiber rings in Buncombe County, as well as points of presence (POP) in Burnsville, Cullowhee, Pisgah, and Marshall. As a sub-recipient, ERC was able to expand its network through the GLRBI project. The ERC network provides services to CAIs in the ERC service area. The network in this area is operated by ERC. ERC and MCNC buy and sell varying degrees of services, including dark fiber, to one another.
- The **Golden LEAF Foundation** (Golden LEAF) is a nonprofit economic development organization created by the North Carolina Legislature in 1999. Golden LEAF was initially charged with distributing the private share of the state's allocation from the Tobacco Master Settlement Agreement. The foundation awards grants to government organizations, education institutions, economic development councils, and other community development organizations. As of October 2013, Golden LEAF has funded 1,216 grants equaling over \$538 million.²⁷ Golden LEAF provided \$24 million in matching funds for the GLRBI project.²⁸
- **NC Broadband** is a division of the North Carolina Department of Commerce and funded through a separate NTIA grant program, the State Broadband Initiative. The NC Broadband team focuses on mapping and data collection to contribute to NTIA's National Broadband Map (NBM). It also conducts broadband adoption research and develops programming to address broadband affordability and digital literacy skill building. NC Broadband helps create relationships between MCNC and last mile providers to make connections to CAIs. NC Broadband initiatives are intended to add value and improve sustainability to broadband projects in North Carolina such as GLRBI.
- **Shannon Tufts, PhD** acts as the principal investigator (PI) for a Golden LEAF-funded research study of the social and economic impacts of the GLRBI project on the state. Dr. Tufts is an assistant professor at the University of North Carolina (UNC) at Chapel Hill and the director of UNC's Center for Public Technology.
- Service Providers
 - **Blue Ridge Electric Membership Corporation** (Blue Ridge) is a member-owned cooperative based in Lenoir, North Carolina that serves 75,000 customers in 7 counties.²⁹ **RidgeLink, LLC** is a subsidiary of Blue Ridge Electric that uses the fiber network originally put in place to facilitate operations of the electrical plant. Using this infrastructure, RidgeLink provides IP-based data, video, and voice communications to Blue Ridge's offices, businesses, and CAIs. RidgeLink does not provide end-user services to residences. Blue Ridge also uses RidgeLink's fiber infrastructure as a smart grid to provide automated metering services for more than 4,000 of its electric customers.³⁰ RidgeLink interconnects with the ERC network in Spruce Pine, North Carolina and is a provider of dark fiber IRUs to ERC.
 - **Yadtel Telecom** is a telecommunications cooperative that serves North Carolina's Yadkin Valley as a CLEC. Since its inception in the 1950s, Yadtel's service offerings have expanded from telephone landlines to include long distance telephone service, Internet access, TV, wireless telephone service, networking, PC repair, and business systems.³¹ Yadtel has made fiber connections to all K-12 schools in Yadkin and Davie Counties. Yadtel is developing a fiber-to-the-home project and hopes to use MCNC's network for transport.
- Higher Education
 - **Blue Ridge Community College** (BRCC) is a state-run, two-year community college founded in 1969 as Henderson County Technical Institute. BRCC's main campus is a 13-building, 128-acre complex located in Flat Rock, Henderson County.³² The Transylvania County campus, completed in 2008, occupies two large facilities on nine acres in Brevard. Both campuses

offer continuing education and Associate degrees. BRCC improved its NCREN connectivity through the GLRBI project in May 2013, from 100 Mbps to 1 Gbps.³³

- **East Carolina University (ECU)** is a public four-year institution in the University of North Carolina (UNC) system. ECU offers undergraduate, master's, and doctoral programs. ECU's Main, Health Sciences, and West Research Campuses are all located in Greenville. ECU had 27,836 students in the 2011-2012 school year, including distance education enrollees.³⁴ ECU was already connected to NCREN prior to the GLRBI project. The grant-funded project allowed ECU to obtain greater bandwidth by a factor of ten, increase network dependability, and expand the availability of wireless local area network (LAN) connectivity on its campus.
 - **Nash Community College (NCC)** is a public comprehensive educational institution founded in 1967. NCC is located midway between Nashville and Rocky Mount, North Carolina. The student body is mostly composed of students from Franklin, Halifax, Nash, Wake, and Wilson Counties. NCC offers nearly 100 different academic programs, including college transfer programs and vocational programs. In the 2011-2012 school year, NCC served 4,888 curriculum students and 7,230 continuing education students.³⁵ NCC connected to NCREN through the GLRBI project, upgrading its fiber connection from 50 Mbps to 250 Mbps.
 - **North Carolina State University (NCSU)** is a public four-year institution in the UNC system. Located in Raleigh, the university comprises ten schools and colleges, including a veterinary school and a graduate school. The university serves over 34,000 students and employs nearly 8,000 faculty and staff.³⁶ Seventy percent of NCSU faculty and 2,500 students are engaged in sponsored research. NCSU was connected to NCREN prior to the grant-funded project. The project allows NCSU to obtain greater bandwidth and faster speeds at no additional cost, and drastically reduced build-out costs for the university to make fiber connections to its remote research facilities.
 - **Richmond Community College (RCC)** was founded in 1964 as Richmond Technical Institute in Hamlet, North Carolina. The college offers more than sixty degrees, diplomas, and certificates. In addition to traditional curricula, RCC offers non-traditional studies through its Workforce and Economic Development Department, including general equivalency degree (GED) programs and industry-specific vocational training. In the 2012-2013 school year, RCC served 3,179 traditional students and 6,759 Workforce and Economic Development students.³⁷ The project enabled RCC to connect to the NCREN network and increase capacity from 100 Mbps to 1 Gbps.
 - The **University of North Carolina at Pembroke (UNCP)** is a public, co-educational, historically American Indian liberal arts university. A part of the UNC system, UNCP is located in the town of Pembroke in Robeson County. UNCP is a master's level degree-granting university and one of seventeen schools that constitute the University of North Carolina system. In the spring 2009 semester, the school had an enrollment of 6,433 students, including 5,699 undergraduate students and 734 graduate students. The school also has 326 full-time faculty. GLRBI did not affect the capacity of UNCP's primary network. Rather, it increased the capacity of its backup network from 500 Mbps to 1 Gbps.
 - **Wake Forest University (WFU)** is a private, independent four-year institution in Winston-Salem. Founded in 1834, the university offers degree programs through its Undergraduate College, Graduate School, School of Business, School of Divinity, School of Law, and School of Medicine.³⁸ In the fall 2012 semester, WFU served 4,815 undergraduate students and 2,617 graduate students.³⁹ **Wake Forest Baptist Medical Center (WFBMC)** is an academic medical center in Winston-Salem that houses the hospital and other facilities managed under the brand Wake Forest Baptist Health, including the WFU School of Medicine. WFBMC manages its own equipment and network for telehealth activities, ensuring compliance with the Health Insurance Portability and Accountability Act (HIPAA). WFBMC's connection to NCREN allows for communication with the main WFU campus, which is located five miles away. WFU and WFBMC were connected to NCREN prior to the GLRBI project, however, the grant allowed them to obtain faster speeds and more capacity because of the 100 Gbps upgrade to the network backbone.⁴⁰
- K-12 Institutions

- **Edgecombe County Public Schools (ECPS)** is a pre-K-12 school system comprised of thirteen schools and a central office in Tarboro. Edgecombe County is among the forty most economically distressed counties in the state, with one of the highest unemployment rates. Seventy-five percent of ECPS's 7,100 students receive free or reduced lunch.⁴¹ Prior to the GLRBI grant, ECPS had fiber connections in place. However, connections were only utilized at 10 Mbps. After upgrades to the ECPS wide area network (WAN) and school LANs, ECPS connected to NCREN and was able to make better use of its existing fiber by increasing connection speeds.
- **Lee County Schools (LCS)** is a public school district of sixteen schools with central offices in Sanford. Lee County is mostly rural with persistent unemployment and poverty. LCS serves over 9,700 students and has a 63 percent free or reduced lunch rate.⁴² Before the GLRBI project, LCS had fiber connections to all schools. They received 100 Mbps service for approximately \$10,000 per month.⁴³ After connecting to NCREN, LCS received a 250 Mbps connection, scalable to 500 Mbps, at a fraction of the price it had previously paid.
- **Mooresville Graded School District (MGSD)** is a public K-12 school district in Mooresville, the largest city in Iredell County. MGSD is comprised of seven schools, including the N.F. Woods Advanced Technology and Arts Center at Mooresville High School. The district serves approximately 5,500 students, 40 percent of whom are eligible for free or reduced lunch.⁴⁴ Before connecting to NCREN, MGSD had a 40 Mbps connection. The project allowed MGSD to obtain a 100 Mbps connection, which has been scaled gradually to 500 Mbps at no additional cost.⁴⁵
- **Rutherford County Schools (RCS)** is a public pre-K-12 school district comprised of nineteen schools, three administrative and technical offices, and one shared site at a community college. RCS serves approximately 9,000 students at a 70 percent free and reduced lunch rate.⁴⁶ Before the GLRBI project, RCS schools had poor connectivity. Some locations had bandwidth as low as 3 Mbps. A nonprofit organization began constructing fiber connections to the schools in neighboring Polk County, which were extended to RCS. This allowed for a 40 Mbps connection to RCS's central office. After connecting to NCREN through the grant-funded project, most RCS schools have 1 Gbps connections and the central office has a 500 Mbps connection. Remaining schools are connected at 100 Mbps.⁴⁷
- **North Carolina Department of Public Instruction (DPI)** is responsible for implementing education policies and procedures in North Carolina's public schools. DPI manages 115 local school districts, more than 100 charter schools, and 3 residential schools for hearing- and visually-impaired students. It develops curricula, distributes funding, and regulates teacher and administrator licensure. DPI's IT team is responsible for tracking network utilization, and for helping schools obtain discounts for purchasing technology equipment and services through the federal E-Rate program. Utilization data collected by DPI's network analysts are used to ensure network scalability and to plan upgrades. Networks currently operate at a combined capacity of about 48 Gbps compared to 25 Gbps one year ago.⁴⁸ DPI estimates that connecting schools through NCREN has cut costs by a combined \$100,000 per month, or \$1.2 million per year.
- **Healthcare**
 - **North Carolina Telehealth Network (NCTN)** was established through the FCC's Rural Health Care Pilot Program to build a statewide telehealth network.⁴⁹ Today, the NCTN team is continuing to expand the network to add capabilities for sharing electronic health records (EHR). NCTN is a fiber broadband network dedicated for use by healthcare organizations, meaning that traffic does not reach the Internet or share fiber lines with other organizations. These measures ensure that NCTN is HIPAA-compliant. NCTN uses NCREN infrastructure and the North Carolina Office of Information Technology Services (ITS) network infrastructure for transport. MCNC connects healthcare sites through NCTN. During the grant period, MCNC connected two hospitals.⁵⁰
- **Public Safety**
 - **North Carolina State Highway Patrol (NCSHP)** is a division of the North Carolina Department of Public Safety. NCSHP employs over 1,600 state troopers who enforce traffic

laws and regulate traffic during emergencies such as hurricane evacuations or hazardous material spills.⁵¹ Troopers are responsible for patrolling more than 78,000 miles of roadway in the state. NCSHP operates the fourth-largest radio communications system in the country, connecting all police, fire, emergency medical service (EMS), transportation, and emergency management facilities in the state. All NCSHP communications are IP-based. NCSHP provides colocation space for MCNC equipment at three nodes and interconnects to the MCNC network at these locations. NCSHP plans to connect to MCNC at more than fifty sites. NCSHP began using the MCNC network just before the evaluation study team's visit, in August 2013.

Section 2 provides a summary of the outcomes and impacts the evaluation study team observed.

Section 2. Impacts

This section describes the outcomes and impacts of the MCNC project in relation to the five focus areas described in *Interim Report 1*, with the addition of the Government Services focus area.⁵²

2.1 Education and Training

Impacts within the Education and Training focus area are measured as changes to elements of educational content distribution and instruction. These impacts occur at K-12 institutions, community colleges, four-year institutions, universities, and other education providers. This focus area includes how the broadband Internet connections help the educational CAIs to perform activities that lead to helping students earn a certificate or diploma or receive training that is recognized as valuable for career advancement. Examples of certificates or diplomas include community college degrees, four-year college degrees, advanced degrees, general equivalency degrees, certifications in advanced software technologies such as network engineering, and other licenses or certifications that reflect knowledge of a particular subject at a level that would typically be taught at an educational institution.

Education was the primary focus area targeted by the grant. Fifty-seven, or approximately one-third, of the connected CAIs are K-12 schools. These schools spread across forty-nine counties in North Carolina. MCNC reported that most K-12 CAI connections were to school districts rather than individual schools. In these cases, schools have connections to their district facility and the district facility has a direct connection to NCREN. This made it impossible to match connected K-12 CAIs to publicly available datasets where information on the school level, size, and demographics could be explored.

In addition to K-12 institutions, MCNC connected fifty-two universities, colleges, or other postsecondary institutions. Forty-two of the higher education institutions connected by MCNC are public, 2-year schools. Four of these institutions are public, 4-year schools. Most of the higher education institutions connected by MCNC were small, with thirty-four of them reporting a student body between 1,000 and 4,999. In total, MCNC connected higher education institutions that serve more than 322,000 students, nearly 60 percent of whom are female.

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **Research has shown that computer use among students leads to improved academic performance, greater levels of educational attainment, improved school enrollment and graduation rates, and increased earning potential for students.**⁵³
 - The grant's PI, Dr. Shannon Tufts, cited case studies that show fewer instances of discipline and higher attendance rates in North Carolina public schools after the implementation of one-to-one computing initiatives. One-to-one initiatives focus on ensuring that each student has a computer or mobile device, either through school-provided equipment or Bring Your Own Device (BYOD) programs. Dr. Tufts observed an increase in English scores for the state's standardized exam after the schools connected to NCREN. She also noted that virtual school enrollment grew significantly during the grant period.⁵⁴ Leadership at MCNC and Golden LEAF echoed Dr. Tufts' observation that attendance rates have increased among students, and added that teachers' attendance rates have improved as well.⁵⁵
 - Greater connectivity has led to more computer use in the Lee County Schools (LCS) system. Since connecting to NCREN, students' achievement scores have risen and the county's graduation rate has grown from 68 percent to 88 percent.⁵⁶

- Computer-based math learning tools at Nash Community College (NCC) have increased the passing rate in developmental math courses, resulting in greater retention rates.⁵⁷
- Mooresville Graded School District (MGSD) administration believes their one-to-one computing initiative, supported by grant-funded connections to NCREN, has had significant impacts on student retention and performance. The graduation rate in MGSD has increased from 80 percent in 2008 to 93 percent in 2013, the second-highest district graduation rate in the state.⁵⁸ In addition, attendance rates have risen, standardized test scores have improved in every subject, and teachers remark that students are more engaged.⁵⁹
- **Distance learning opportunities allow schools to broaden the variety of courses offered. They also represent an educational resource for nontraditional or disabled students, or those living in geographically remote or poor areas.**⁶⁰
 - A representative of NCC reported that distance learning opportunities at NCC have increased with improved connectivity. A faster, more reliable connection eliminates lag times, minimizes disconnections, and ensures video and audio are synchronized. Videos are recorded as the lecture is transmitted. These recordings enable students with poor Internet access at home to view the recorded lecture once they access a better connection. Increased capacity at the campus allows NCC to hold two to three video sessions concurrently without issue. NCC also holds online continuing education training sessions using interactive video via Movi-Jabber, a video conferencing software that is part of the NCREN video platform.
 - LCS one-to-one computing initiative facilitates distance education as students with Internet access outside of school can retrieve cloud-based education resources after school. LCS is working to push as much content to students' devices or to cloud-based services as possible, enabling students who are homebound or who miss a day of school to access content at home. LCS hopes to equip one of its school buses with Wi-Fi, which will allow students with long commutes to study and complete assignments on the way to and from school.
 - The University of North Carolina at Pembroke (UNCP) is the third largest provider of online education out of the UNC system in terms of the number of courses offered.⁶¹ UNCP offers a business entrepreneurship degree taught entirely online. Some on-site classes engage in interactive video communication with Richmond Community College (RCC) and other community colleges for collaborative distance learning activities. While UNCP had capacity that was adequate to support online instruction, grant-funded connections to NCREN made partnerships with community colleges possible.
 - Broadband needs at Wake Forest University (WFU) center on intra- and inter-campus communication. Fiber links were already present between WFU's main campus and medical campus at the Wake Forest Baptist Medical Center. However, the grant allowed WFU to benefit from a 100 Gbps upgrade to the NCREN backbone, allowing for more traffic on the network.⁶² WFU also offers a collaborative physician assistant (PA) program with Appalachian State University (ASU), which received connectivity through the grant project. Eighty miles separate the two campuses, so they rely heavily on interactive video communication supported by the increased bandwidth and new connection to ASU.
 - The North Carolina State Highway Patrol (NCSHP) has transitioned office training from a traditional classroom setting to video-based training. Conducting training via video allows officers to participate in training from any NCSHP location, eliminating the need for travel. As a result, NCSHP does not suffer from staffing shortages due to officers' absence during training as they have in the past. NCSHP also no longer incurs travel and lodging expenses for its staff during training.
- **The use of digital tools enabled by broadband can save staff time, allowing them to devote more effort to instruction.**⁶³
 - Rutherford County Schools (RCS) now has fiber running from its district office to each school, simplifying WAN management. In addition, increased bandwidth has allowed RCS to move Angel, its learning management platform, to a cloud-based setup. As a result, technical staff are free to support teachers.

- LCS's connection to NCREN has resulted in time savings for both technical and instructional staff. Increased bandwidth has facilitated the use of cloud-based applications, which eliminates the need for physical installations of software on students' devices. As a result, technical staff are free to support instructional activities. A representative of LCS also expressed that the reliability of the new connection eliminates the need for teachers to spend extra time writing backup lesson plans in case their Internet-dependent plans fail.
- **Broadband gives teachers a wide range of media through which to facilitate lessons. The integration of technology into classroom activities creates the opportunity for interactive and personalized educational experiences for students.⁶⁴**
 - Connections to NCREN give K-12 schools the capacity to support one-to-one computing initiatives, which are bandwidth-intensive programs because wireless networks must support simultaneous device use by multiple students. Schools are charged a flat rate for their connection, which does not increase when more bandwidth is requested. In order to obtain increased capacity, the district need only demonstrate that network utilization is approaching capacity. NC Broadband reported that the number of schools deploying one-to-one computing programs is increasing each year. One driver for this trend is a bill signed by the governor, which mandates that all public school textbooks will be in digital format by 2017.⁶⁵
 - MGSD had a one-to-one Macbook program in place prior to the grant, but the program has benefitted from the district's upgrade received through the grant. Students in grades three through twelve have their own district-issued Macbook. In total, the district issued about 4,000 laptops. Grades four and higher are allowed to take their laptops home each evening. At the onset of the Macbook program, MGSD had a 100 Mbps connection to NCREN. As of July 31, 2013, it had a 500 Mbps connection. The upgrade accommodates increased network traffic associated with the deployment of additional laptops each year.
 - LCS is in its fourth year of a one-to-one computing program that provides laptops to students in grades three through twelve. In the 2013-14 school year, LCS shifted from laptops to tablets for its high school students. The use of cloud-based applications, enabled by increased network capacity gained through the grant, makes it easy to deploy new devices each year. LCS is considering supplementing its one-to-one initiative with a BYOD program.
 - A representative of RidgeLink remarked that the schools they serve have accelerated the deployment of personal computing devices. Upgraded and expanded WAN infrastructure provided to them through the grant has made mobile computing possible. Similarly, a representative of Yadtel, which provides fiber connections to Yadkin County Schools (YCS), reported that YCS will be implementing a one-to-one tablet program in the future. The program will require more bandwidth, which will be supplied through NCREN at no additional cost.⁶⁶
 - RCS teachers learn how to leverage new connectivity during staff development programs. Workshops focus on integrating technology into instructional activities rather than substituting technology for traditional tasks. The connection to NCREN has led to more productive Internet use among teachers. Teachers now use online educational resources to create lesson plans, to facilitate instruction, and to collect and evaluate students' online assignments.
 - After connecting to NCREN, NCC has the bandwidth and infrastructure to support expanded use of broadband-enabled resources such as educational video streaming. Math and English classes use Pearson MyLab, a web-based customizable teaching and learning tool. NCC has also leveraged its NCREN connection with the construction of its Math Tank, a \$250 million computer lab with fifty-seven interactive screen stations and individualized tutorial assistance.⁶⁷
 - Edgecombe County Public Schools (ECPS) will leverage its connection to NCREN by opening media centers after normal school hours to hold computer-based GED training. Media centers will also offer adult literacy training through programs that encourage parents and children to read together using digital tools.
- **School administrations leverage broadband infrastructure to carry out internal operations. Broadband represents a rapid, reliable channel of communication to improve interactions among administrators, teachers, parents, and students.⁶⁸**

- The grant-funded project was instrumental in enhancing connectivity and network resiliency for K-12 and higher education entities. RCC's campus now has a triple-redundant fiber ring of 10 Gbps lines.⁶⁹ Grant-funded construction was necessary to build links from NCSU's main campus to its remote research campuses.⁷⁰ RidgeLink connected several educational institutions through the grant including the Ashe County Board of Education, Avery County Schools (ACS), and ASU. ACS had no fiber interconnectivity before the grant and relied on a few T1 lines provided through AT&T. RidgeLink built fiber lines between the schools and the district office through which NCREN provides service. RidgeLink's build to ASU has enhanced the university's path diversity, improving network reliability by establishing a redundant path where one did not previously exist.⁷¹
- LCS has developed a complete cloud solution for all administrative activities, including its student information system and faculty e-mail service provided through Google. Using the cloud saves the district money by eliminating the need for physical installation of software. LCS has not purchased any software licenses that require a physical installation in two years, reducing the need to hire additional technical staff.⁷²
- MGSD purchased cloud-based content to eliminate the need to purchase local servers. This includes the use of the Education Value-Added Assessment System (EVAAS), an application developed by SAS that identifies student performance trends and can predict future trends. Teachers view EVAAS data daily and administrators view data quarterly. The data are used to arrange class rosters and make instructional decisions. It is also intended to encourage teachers with high-performing students to share teaching strategies with teachers who have low-performing students. This data-driven approach necessitates a level of bandwidth that was not attainable prior to the grant.
- Some four-year universities are leveraging enhanced connectivity obtained through the grant-funded project to provide services and connectivity for smaller institutions. ECU has started working to build connections to community colleges in the Outer Banks, including Dare County Community College, Manteo Community College, and Nags Head Community College, through its connection to the Coastal Studies Institute. WFU has partnered with the North Carolina School for the Arts and Winston-Salem State University to provide low-cost connectivity through economics of scale due to the institutions' proximity to one another.
- Broadband represents a rapid, reliable channel of communication to improve interactions among administrators, teachers, parents, and students.⁷³ Most school districts interviewed already use a learning management platform. All public K-12 schools in the state are moving to the use of a state-provided learning management system (LMS) called Home Base.⁷⁴ Home Base will function as a resource for students, parents, teachers, and administration. It will serve as schools' student information system, provide student assessments, and track instructional progress. Some school districts, such as ECPS, have plans to conduct LMS training for parents.
- Increased bandwidth at East Carolina University (ECU) has supported the implementation of its emergency management communications system, InformaCast. The InformaCast system is the university's primary means of communication with ECU students and staff during emergencies. The system sends emergency notifications via e-mail, text message, and campus building loudspeakers.

2.2 Workforce and Economic Development

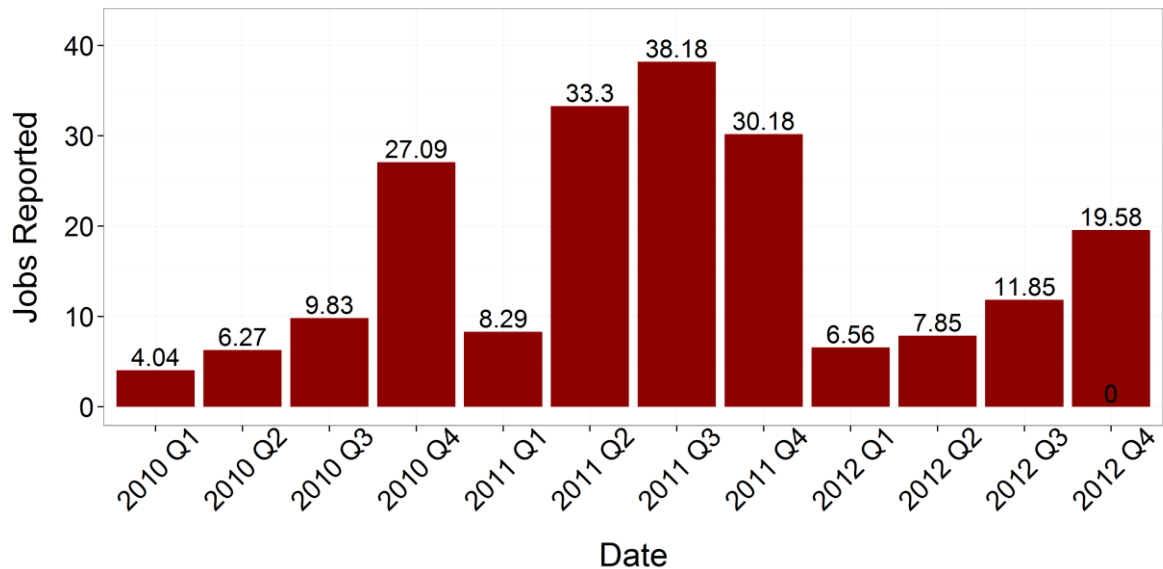
Impacts within the Workforce and Economic Development focus area can occur through activities intended to increase overall employment of the target population, or to assist employed members of that population in finding jobs that offer increased salaries, better benefits, or a more attractive career path, including self-employment. This focus area also includes activities to attract new businesses to locate along the fiber path or to expand the economic activity of existing businesses connected to the network. While this focus area primarily describes jobs, it also includes other economic impacts such as wages, property values, and the number of firms in a region.

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **Access to computers and broadband helps to reduce unemployment by enabling job seekers to engage in training programs, facilitating job seekers' ability to search and apply for open positions online, and reducing geographic limitations associated with employment search.**⁷⁵
 - Dr. Tufts' 2011 evaluation report found that the employment rate in North Carolina was positively correlated with broadband availability. After controlling population density, industry mix, and wealth measures, the effect was still significant.⁷⁶
- **Broadband access improves the ability of rural communities to compete for low- and high-end service jobs, the area of highest economic growth.**⁷⁷
 - A representative of NC Broadband estimated that the economic impacts of the grant project would not be fully realized for years. In the interviewee's opinion, the most significant economic impact at the time of the site visit was the potential for economic growth. Smaller ISPs have begun to show an interest in obtaining increased bandwidth through MCNC and expanding their market to serve rural areas. Small regional providers are now able to compete with major broadband providers.⁷⁸ Fiber installed through the GLRBI has enough capacity to support private business subscribers. As a result, connectivity in rural areas can help communities attract new business.
 - ECC Technologies, Inc. (ECC), the GLRBI project's formal marketing arm, develops fiber solutions for communities with few or no ISPs. ECC uses geographic information systems (GIS) technology to map fiber assets in the area and to identify economic development sites on which communities should focus their efforts. ECC then contacts ISPs about the possibility of serving the area. A representative of ECC estimated that the GLRBI project has already attracted more than \$500 million in proposed fiber that will be constructed off the backbone, all by private sector enterprises.⁷⁹ ECC could not disclose the details of these proposals at the time of the site visit.
 - A cluster of high-tech companies is beginning to develop in rural western North Carolina, including data centers, pharmaceutical manufacturers, and software companies. Having diversity and redundancy in networks attracts these types of firms to the state. A representative from RidgeLink noted that with Apple, Google, and Facebook operating nearby data centers, there is potential for similar facilities to open up in the area due to the clustering effect, which could become growth opportunities for RidgeLink.⁸⁰
- **The availability of infrastructure in a community enables firms reliant on broadband services to relocate or open additional locations. Local businesses are able to obtain improved access to inputs and markets.**⁸¹
 - ECC works with local governments and economic development councils to identify economic development zones and market them to companies that are interested in relocating or expanding. It also encourages local governments, which are prohibited by state law from competing with broadband providers, to partner with gas and electric companies to bring broadband connectivity to their areas. These companies are typically willing to collaborate, as they benefit from new or relocating companies' needs for gas and electric services. A representative from ECC reported that about a dozen of these partnerships were in existence as of July 31, 2013, and that nearly thirty would be in effect by the summer of 2014.⁸²
 - According to NC Broadband, expansion of middle mile infrastructure in the state has created opportunities for increased mobile deployment. A bill passed by the North Carolina General Assembly in June 2013, called the Cell Tower Deployment Act, will make it simpler for providers to make adaptations to cell towers.⁸³ NC Broadband expects that the new law will result in additional fiber connections to cell towers. AT&T, in particular, has invested a significant amount of money in North Carolina already.⁸⁴

As required by the Recovery Act, MCNC reported the number of jobs created quarterly as a direct result of the project. Figure 4 shows the number of full-time equivalent (FTE) positions funded by the grant during the award period.⁸⁵ This figure does not report cumulative job creation, but rather the number of FTE positions funded by MCNC each quarter. MCNC created an average of 16.13 FTE positions per quarter.⁸⁶ However, the number of FTE positions varied from 4.04 FTEs to 38.18 FTEs per quarter based on the phase of the project. The construction phases required the greatest number of FTEs, while the planning, environmental assessment, and close out phases were staffed with the fewest number of FTEs. It is important to note that this only includes direct jobs created, and does not include indirect or induced job creation.

Figure 4. Direct Jobs Created by MCNC



Some grant partners and participants were able to hire additional employees because of their roles in the project. The ECU IT department has hired additional technical staff due to expanded departmental responsibilities that arose from the GLRBI project’s impact on their network. They typically hire participants in their internship program, which recruits interns from ECU science, technology, engineering, and mathematics (STEM) programs and local community colleges. ERC also hired extra employees after the project, including a network engineer, a network administrator, and a fiber plant employee.

2.3 Healthcare

This focus area includes activities intended to increase elements of the provision and administration of healthcare services, including health information technology, e-Care, electronic health records (EHR), telehealth, and mobile health. Impacts in the Healthcare focus area include broadband-enabled activities aimed at improving personal health or that of someone else. This definition includes not only sophisticated tasks, such as viewing medical records online, but also more common activities that might not involve a medical provider at all. Healthcare impacts might be observed at primary care physicians’ offices, hospitals, or in areas served by nurse practitioners.

Connecting healthcare CAIs was not the primary focus of the GLRBI project. However, MCNC connected two healthcare institutions by March 31, 2013.⁸⁷ Created through the Rural Health Care Pilot Program, the North Carolina Telehealth Network (NCTN) project connects healthcare institutions by dedicated fiber through NCREN and North Carolina Office of Information Technology Services (ITS) to provide highly reliable, cost-efficient services. The first phase of the project focused

on connecting public health sites, free clinics, and rural health centers. The second phase connected nonprofit hospitals. As of July 31, 2013, NCTN has connected 130 public health and healthcare sites, including the two sites that were connected through GLRBI.⁸⁸

The NCTN serves healthcare institutions by offering a high-bandwidth, low-latency network that allows them to pursue a range of broadband-enabled activities including EHR and other health IT applications, telemedicine consultations, distance learning activities, and emergency management.⁸⁹ NCTN traffic does not reach the Internet and does not share fiber with other traffic. This ensures that NCTN meets HIPAA regulations and is not susceptible to delays or reliability problems caused by outside traffic.⁹⁰

The GLRBI project connected hospital partners through NCTN. By connecting to NCREN, NCTN established redundant network paths for most of the healthcare organizations connected to the network. This redundancy has greatly improved network reliability for the telehealth network.⁹¹

2.4 Digital Literacy

This focus area is fundamental to all of the others. “Digital Literacy” defines a set of skills and abilities that enable an individual to interact with the digital aspects of culture, and to maintain a digital identity. In the National Broadband Plan, the Federal Communications Commission (FCC) defines digital literacy as “the skills needed to use information and communications technology to find, evaluate, create, and communicate information.”⁹² Impacts within this focus area include the attainment of skills needed to obtain an education, search for employment, learn job-related skills, accessing government information, and more.⁹³

Access to broadband enables users to engage in a wide range of digital literacy activities, generating benefits to individuals, businesses, and communities. Digital literacy is fundamental to all other focus areas, and includes set of skills and abilities that enable an individual to interact with the digital aspects of culture, and to maintain a digital identity. Possessing the skills necessary to complete basic digital functions, such as using a computer with a modern operating system, use e-mail, and obtain information using Internet search tools, enhance an individual’s ability to realize the benefits of broadband connectivity.

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team’s observational evidence supporting either the realization of impacts or their potential to occur.

- **Access to broadband and digital literacy skills provide individuals with increased job opportunities, increased employment opportunities through telework, higher salaries, increased economic security, and promote the recruitment of job seekers, especially in rural areas.**⁹⁴
 - LCS has emphasized digital literacy development among instructional staff since the deployment of its one-to-one laptop program. The county has a team of technology trainers with master’s degrees in Instructional Technology. There is 1 trainer per 100 teachers. Teachers received their laptops a year before student devices were deployed. During this time, teaching staff underwent fourteen hours of training in groups of ten to fourteen, facilitated by two trainers per class. LCS teachers are required to participate in monthly technology training.
 - RCS provides digital literacy training for its teaching staff. Their training focuses on integration of technology into instructional activities. The county partners with ExploreNet, a company specializing in professional development for educators, to deliver training in dedicated space called the Success Center. RCS is phasing in a requirement that will stipulate that each member of the instructional staff must participate in at least three units of technology training.

- ECPS offers digital literacy support for its teachers through instructional facilitators. Instructional facilitators collect feedback from staff regarding professional development needs and create training content based on responses. In addition, they visit teachers during their planning periods to provide one-on-one technology training. ECPS instructional facilitators have also developed a series of short videos that demonstrate how to use different functions of the county's LMS.
- **Broadband access enables individuals to increase participation in everyday economic, social, and community life.⁹⁵ Connectivity enables individuals with digital literacy skills access to a wide variety of entertainment and the opportunity to pursue lifelong learning opportunities.⁹⁶**
 - Higher education digital literacy initiatives focus on providing access rather than training. This is largely accomplished by the provision of public computer labs and wireless networks. College representatives remarked that a great deal of traffic on these networks related to personal use including social media, e-mail, and entertainment. Nearly all reported an upward trend in wireless network utilization over the past few years, which they attributed to the increasing popularity of mobile devices. Connecting to NCREN has allowed these institutions to obtain greater bandwidth to accommodate increased levels of traffic that they may not have been able to afford otherwise. This is particularly true for colleges in rural areas where Internet providers are sparse.

2.5 Government Services

One of the five core purposes established by the Recovery Act was to “improve access to, and use of, broadband service by public safety agencies.”⁹⁷ The Government Services focus area identifies how broadband improves services provided by government organizations to the public and includes both the provision and administration of public safety activities. Examples of public safety agencies include law enforcement agencies, fire departments, and emergency medical services (EMS). Some potential government service impacts include enhanced government efficiency, improved ability to save lives and reduce injuries, prevention of criminal activity, and improved information sharing between citizens and public safety entities.

Sub-recipient ERC connected eleven local fire departments managed by the City of Asheville. All of the eleven fire stations connected by ERC are career departments. Career departments are fire departments where 100 percent of staff are paid employees rather than volunteers. Career departments represent less than 4 percent of the rest of the fire stations in the service area and less than 6 percent of the fire stations in the rest of North Carolina.⁹⁸ Asheville had a fiber network prior to BTOP that reached its public safety sites. However, operation eventually became unaffordable and the network was shut down. In the interim, the City of Asheville relied on a wireless microwave network for public safety communications that was more affordable than fiber but less reliable. The GLRBI project enabled ERC to provide service to Asheville fire departments on its fiber network at a price the city could afford, resulting in a more robust and reliable public safety communications infrastructure.

NCSHP supports the fourth largest radio system in the country, which connects all police, fire, EMS, transportation, and emergency management entities in the state. The network facilitates interoperability between public safety entities, a crucial emergency management strategy. MCNC and NCSHP have a mutually beneficial relationship through which NCSHP receives connectivity on the MCNC network and MCNC equipment is housed in NCSHP huts. At the time of the site visit, three major NCSHP nodes were connected to MCNC. Ultimately, NCSHP hopes to have approximately fifty sites connected. NCSHP operates on the MCNC as a virtual private network (VPN) and uses these fiber connections to supplement its wireless microwave infrastructure. Their connection to the MCNC network gives NCSHP a level of connectivity between its three major nodes that would be much more expensive to duplicate otherwise. After connecting to MCNC, NCSHP has increased its bandwidth by a factor of ten at about a third of the cost they would have paid if they

received service from another provider. The fiber provides high-speed, real time connectivity without interruptions from call-blocking communications between responders across the state.

Section 3. Grant Implementation

This section presents MCNC's strategy to maximize the social and economic impacts of the BTOP grant. The following subsections describe MCNC's implementation strategies; MCNC's approach to open access; major results of MCNC's implementation strategy; an overview of sustainability efforts; and successful tools, techniques, and strategies identified during interviews with the grantee.

3.1 Implementation

MCNC has over thirty years of experience building and managing middle mile Internet networks serving educational institutions in North Carolina. MCNC's recent experience providing broadband Internet service is making an impact on CAIs in North Carolina by addressing the disparity in the cost of access between CAIs in urban and rural areas. In 2008, MCNC launched an initiative to extend NCREN to all public schools in the state. However, in underserved rural areas, CAIs tended to connect to NCREN via short-term leases, which led to disparities in price, capacity, and reliability of connections between rural and urban CAIs. MCNC tried to solve this problem by acquiring permanent ownership of dark fiber assets in rural areas, but had little success.⁹⁹ The BTOP grants that MCNC received in 2010, including the GLRBI grant, were instrumental in addressing this issue. GLRBI enabled MCNC to expand broadband access to school districts, community colleges, public libraries, and other CAIs throughout the state.

The GLRBI strategy was to connect the portions of the network that serve rural areas to the core network infrastructure serving urban areas in central North Carolina. MCNC's goals for the design and implementation of its infrastructure are maximizing network reliability, resiliency, and scalability, improving the capacity of the middle-mile connectivity, and enabling private sector providers to reach underserved areas in North Carolina. MCNC has an endowment built on proceeds it received from the sale of technology to JDS Uniphase in 2000 that it uses to support broadband growth in rural parts of the state.¹⁰⁰ This access to capital enabled MCNC to defray the access costs for CAIs that experienced significant budget cuts during the network build. As part of the GLRBI project, MCNC leveraged this endowment to provide approximately \$8 million in cash and \$3.76 million of in-kind contributions for capital investments and to recover operating costs from CAIs.¹⁰¹

NCREN, MCNC's flagship network, is comprised of both owned and leased dark fiber. The BTOP grant allowed MCNC to add redundant routes to the middle mile portion of the network and extend the network to CAIs in underserved areas. MCNC collaborated with middle mile provider ERC to provide wholesale broadband service to last mile providers in its service area. MCNC integrated a dense wave division multiplexing (DWDM) optical system on the new fiber network paths with the existing network. This strategy helps MCNC to reduce service costs while offering service that is comparable in quality to that of the existing network, with 99.999 percent uptime.

MCNC provided access service to connect the CAIs to the closest NCREN regional point-of-presence (RPOP) through a layer-2 metro carrier Ethernet network with circuits ranging from 10 Mbps to 10 Gbps.¹⁰² Layer-1 transport services allow CAIs connected to NCREN to transfer voice, video, and data traffic on dedicated bandwidth ensuring speed and privacy. MCNC offers these circuits ranging from 100 Mbps to 10 Gbps.¹⁰³ CAIs connected to NCREN can access commodity Internet and national research networks. Private peering is offered to K-12 school districts, higher education campuses, research and health care organizations, and government entities.¹⁰⁴ MCNC provides redundant fiber paths to multiple Internet service providers.

The MCNC Client Network Engineering team provided school districts with network design assessments of their local network infrastructure, comprised of WANs and LANs to develop strategies to improve their network performance and security when connecting to the NCREN backbone.¹⁰⁵ MCNC helps CAIs develop capabilities to improve how they use broadband access. MCNC is building a user community through the staff that provides outreach and training. MCNC

also supports users through technology forums, online discussions designed to support K-12 and higher education organizations with learning and sharing instructional technology information.

3.2 Open Access Policies

CCI projects funded by BTOP are predominantly middle mile projects, although a small number of last mile projects were awarded. These grants are intended to improve available broadband capabilities for CAIs, to facilitate the development of last mile services in unserved and underserved areas, and to promote economic growth. This investment through the BTOP grant is intended to “lay the foundation for the ultimate provision of reasonably priced end-user broadband services” through open and nondiscriminatory interconnection strategies to enable last mile providers to have open access to the network.¹⁰⁶

There is considerable debate on the impact of open access policies on the competitiveness of the broadband market.¹⁰⁷ Open access is implemented through a wide variety of strategies. “These can range from commercial or voluntary arrangements, between communication operators and third-parties, through to regulatory intervention aimed at promoting certain policy objectives, such as expanding broadband availability, increasing competition, or promoting investment that may otherwise not be economic, such as in the case of enabling the establishment and treatment of shared facilities.”¹⁰⁸ The impact of open access will be dependent upon how well the practices and policies help to reduce the time, cost, and difficulty for last mile providers to interconnect to the network.¹⁰⁹ The impact also depends on how well the policy mechanisms ensure competitive pricing for wholesale services in the event of the presence of a middle mile provider that may also be a last mile provider.¹¹⁰

MCNC has an open access policy that is implemented through its governance practices and policies on non-discrimination, interconnection, and network management. MCNC offered service to any CAI located in the service area of the GLRBI-funded network at competitive prices and quality of service terms. The network is provider-neutral, enabling all wholesale and last mile providers to connect to the network. MCNC’s policy ensures that all traffic on the network is treated the same for all content and applications. Providers are permitted to interconnect to the network to access the Internet or to exchange traffic from carrier to carrier.

One of the benefits of the MCNC’s open access policies is that it enables MCNC’s partners serving western North Carolina to offer last mile providers a solid network backbone to carry traffic to and from the Internet. This area of the state is mostly rural and mountainous, making it very expensive to provide fiber. MCNC’s network is the only open fiber network reaching into these areas. With MCNC’s pricing policy, middle mile partners offer the same wholesale pricing to any provider who wants to access the network. As an executive from RidgeLink observes, “We don’t limit anybody who comes to us saying they need fiber. We know the rates that MCNC and the BTOP grant have offered and we offer the same. They’re usually below market-type rates and we wouldn’t stop anybody if they needed access in this area. We’ve got the infrastructure to support that.”¹¹¹

3.3 Results

The evaluation study team observed two major results of the GLRBI project:

- The GLRBI project expanded a fiber-based middle-mile network into rural areas where fiber services were previously unavailable or unaffordable. In some cases, only older technologies, such as T1, wide area wireless, or DS-3, were available. Fiber services support broadband uses that would not have been possible using the older technology. These impacts are described in detail in Section 2.
- K-12 schools and higher education institutions greatly benefit from NCREN’s unlimited bandwidth model. Since the BTOP grant was awarded, aggregate network capacity among K-12 schools in

North Carolina has increased six-fold, while the cost incurred by school districts to connect to NCREN has remained flat. This model gives schools unlimited capability to support any broadband-dependent programming they implement without incurring additional operating costs for bandwidth increases. Section 2.1 details how K-12 schools and higher education institutions have begun to use increased bandwidth.

3.4 Sustainability

MCNC's decades of experience implementing and managing a fiber network is an important factor in the sustainability of NCREN and CAI connections fostered through GLRBI. MCNC's practice of provisioning additional bandwidth to connected CAIs when network utilization approaches 60 to 65 percent capacity will continue to ensure that growing demand among its customers is fulfilled. In addition, the unlimited bandwidth model is key for sustainability in school districts and higher education institutions. As mentioned above, this model allows school districts and higher education institutions to channel more funding into equipment and other resources necessary to expand broadband-enabled programming without budgeting for bandwidth increases.

Activity at the state level also affects the sustainability of the GLRBI project. Movements to reduce barriers to entry and to streamline permitting processes, such as the Cell Tower Deployment Act, will make it simpler for last mile providers to offer services on MCNC's network. After the BTOP award period, divisions of the North Carolina Department of Commerce, including NC Broadband, the Rural Infrastructure Authority, and the Economic Development Board, will collaborate to develop a ten-year strategic economic development plan that will focus in part on leveraging the state's broadband resources to attract, retain, and expand new business in the state.¹¹² In addition, NC Broadband has been developing and piloting broadband adoption and awareness programs throughout the state, including demand aggregation studies and digital literacy training programs. NC Broadband has found local adoption programs to be most successful. The NC Broadband team is working to make these programs scalable and relevant across a larger region.

3.5 Successful Tools, Techniques, and Strategies

This subsection describes successful techniques, tools, and strategies identified by the grantee and interviewees. Successes and challenges described in earlier sections are not repeated here.

- MCNC collaborated with local middle mile and last mile providers to engineer the network to meet local conditions. As MCNC focused on building the network, technical staff offered strategies and solutions to last mile providers and CAIs for deploying applications and services on the network. MCNC assisted local school districts with engineering their networks after central offices connected to NCREN.
- Golden LEAF is funding a longitudinal evaluation study to assess the impact of the GLRBI grant with Dr. Shannon Tufts acting as the PI. Dr. Tufts and her team collect quantitative and qualitative data and publish annual reports that describe project progress and outcomes.
- MCNC's fiber supplier, CommScope, provided critical logistical support for the construction of the network. CommScope focused on reducing the costs of warehousing and distributing the fiber cables, conduit, and other related material by using a just-in-time delivery system. As the construction progressed, CommScope used its trucks to deliver the material to the construction teams at their worksites. The production planning system was integrated with the delivery system, permitting CommScope to manufacture the fiber at one of its three facilities and deliver the material directly to the construction site. This system minimized the amount of time any material was stored in a warehouse and reduced inventory expenses and wait times for the construction contractors.

Section 4. Conclusions

The American Recovery and Reinvestment Act of 2009 (Recovery Act) instructed NTIA to implement BTOP to promote five core purposes:¹¹³

1. Provide access to broadband service to consumers residing in unserved areas of the country.
2. Provide improved access to broadband service to consumers residing in underserved areas of the country.
3. Provide broadband education, awareness, training, access, equipment, and support to:
 - a. Schools, libraries, medical and healthcare providers, community colleges and other institutions of higher learning, and other community support organizations.
 - b. Organizations and agencies that provide outreach, access, equipment, and support services to facilitate greater use of broadband services by vulnerable populations (e.g., low-income, unemployed, seniors).
 - c. Job-creating strategic facilities located in state- or federally designated economic development zones.
4. Improve access to, and use of, broadband service by public safety agencies.
5. Stimulate the demand for broadband, economic growth, and job creation.

This section summarizes how MCNC's implementation of BTOP has encouraged the fulfillment of the Recovery Act's goals.

4.1 Improve Access to Unserved and Underserved Areas of the Country

The first two goals of the Recovery Act encourage improved access for unserved and underserved areas:

- Provide access to broadband service to consumers residing in unserved areas of the country.
- Provide improved access to broadband service to consumers residing in underserved areas of the country.

Improving access and service for unserved and underserved areas of North Carolina, particularly in rural areas, was a goal of the GLRBI grant. The mountainous terrain and granite bedrock in the western part of the state made laying fiber particularly costly. Before the grant, MCNC's strategy for connecting CAIs in these areas to NCREN was using leased fiber lines obtained through short-term contracts. The GLRBI build connected existing fiber-based broadband networks that serve urbanized areas of central North Carolina with a new network connecting rural areas in the southeastern and western parts of the state. MCNC constructed 1,301 miles of new fiber, upgraded 60 miles of existing fiber, and executed IRUs to lease 336 miles of additional fiber.¹¹⁴ The middle mile expansion serves sixty-nine counties that were fully or partially underserved prior to the grant.¹¹⁵ The new middle mile network provides a more affordable and reliable means of connecting CAIs.

The GLRBI project increased capacity and enhanced redundancy for higher education institutions already connected to NCREN and made fifty-two new connections to higher education sites across North Carolina.¹¹⁶ As a result, universities have begun to expand online learning options and distance education programs.¹¹⁷ Dr. Tufts and her team observed significant growth in online education enrollment during the award period.¹¹⁸

The GLRBI grant focused on providing a middle mile broadband network for rural unserved and underserved areas and connecting K-12 and higher learning institutions throughout the state to NCREN. The project connected 175 CAIs to NCREN.¹¹⁹ For some CAIs, connecting through the grant-funded project allowed them to use fiber-based connections that are more scalable, less costly,

and higher quality than previous connections. Those that previously had fiber broadband connections now have greater network capacity and reliability. This includes higher learning institutions, all of which had broadband connectivity prior to GLRBI but now have significantly increased capacity and, in many cases, greater redundancy. Interviewees representing CAIs that connected to NCREN reported improved quality of service at a price that would be much higher otherwise.¹²⁰

MCNC worked with NCTN on the GLRBI project to improve the telehealth network. In addition to connecting two healthcare sites, the project created redundant connections to improve the reliability of the network.

4.2 Broadband Education, Awareness, Training, Access, Equipment, and Support

Most closely aligned with PCC and SBA grants, the next Recovery Act goal is for grantees to provide broadband education, awareness, training, access, equipment, and support to:

1. Schools, libraries, medical and healthcare providers, community colleges and other institutions of higher learning, and other community support organizations.
2. Organizations and agencies that provide outreach, access, equipment, and support services to facilitate greater use of broadband services by vulnerable populations (e.g., low-income, unemployed, seniors).
3. Job-creating strategic facilities located in state- or federally designated economic development zones.

CAIs connected to NCREN are now able to provide access to the Internet to meet the growing information needs of the public. Having adequate capacity to support wireless networks is a key need of higher learning institutions and public libraries, where many users come to the premises primarily to access the Internet on a mobile device.¹²¹ Some school districts are also leveraging their role as community hubs to provide broadband and computer access for the public through wireless networks, open lab time, and computer training sessions.¹²² As the CAIs continue to learn how to maximize the use of the new broadband connections, additional impacts will likely emerge. CAIs' connections to NCREN could reduce instances of independent, disjointed efforts by CAIs of similar types. As members of a common network, CAIs can leverage their broadband connections for greater coordination and collaboration at local, regional, and state levels.¹²³

The proliferation of one-to-one computing initiatives in the K-12 field also relies heavily on wireless connectivity. K-12 schools connected to NCREN now have adequate bandwidth to support students' devices, which has accelerated the deployment of one-to-one programs in the state. Deployment of one-to-one computing initiatives and cloud-based learning resources has also generated more attention on making last mile connections to students' homes. This has spurred greater action toward addressing broadband affordability and accessibility for North Carolina residents.¹²⁴

4.3 Public Safety Agencies

The fourth goal of the Recovery Act is to improve access to, and use of, broadband service by public safety agencies.

NCSHP established broadband connections to the MCNC network to connect its facilities. This also includes providing fiber backbones to haul data for its radio communications, which previously relied on a private statewide microwave network. The NCSHP network interconnects to NCREN in three locations.¹²⁵ In the future, they hope to interconnect at more than fifty sites. Connecting to NCREN gives NCSHP another path for network traffic, making their communications system more robust and resilient. Network resiliency is vital for NCSHP, whose radio network links all public safety and

emergency management entities in the state. The fiber network helps to ensure that communications among public safety entities are preserved during a natural disaster when other systems, such as their microwave network, may fail. In addition, increased bandwidth obtained through NCREN has allowed NCSHP to deliver video-based training in a distance learning setting to its officers. This eliminates the need for officers to travel and helps to ensure that an adequate number of officers are on patrol at all times.

Other public safety activities facilitated by the grant include the use of an emergency management communications system at ECU, public safety professional training at NCC, and the re-opening of fiber-based communication for public safety entities in the Asheville area. These activities would not have occurred without the infrastructure and bandwidth provided through the grant-funded project.¹²⁶

4.4 Demand for Broadband, Economic Growth, and Job Creation

The final Recovery Act goal is to stimulate the demand for broadband, economic growth, and job creation.

Dr. Tufts stated that without the grant, rural economies would be regressing and that small local providers may struggle to stay in business. Even larger providers were forced to roll back some services in North Carolina prior to the grant, such as AT&T U-Verse, which was offered for a short time and discontinued after usage did not meet expectations.¹²⁷

The middle mile expansion has drawn last mile providers to serve areas they did not historically serve, creating competition among providers in previously underserved areas. This includes new providers as well as incumbent providers that have expanded their market areas.¹²⁸ Small regional providers, in particular, have benefited. MCNC estimates that the GLRBI project has reduced access costs to broadband providers by 60 to 90 percent.¹²⁹ Now, smaller providers can afford to expand service to new markets and compete with major national providers.¹³⁰ As a result, the price of broadband service in these areas has already begun to decline.¹³¹ Competition has helped to expand service in areas where other ISPs may be leaving or not upgrading their services to offer higher-speed access to the Internet. The range and levels of services available for subscribers have improved.¹³² In some counties, such as Avery County, the grant made it feasible for MCNC to build the first fiber network in the county. The new connection has boosted economic development for its local tree farmers and is beginning to enable local government agencies to improve service delivery systems.

The middle mile build-out created broadband demand among CAIs by creating opportunities for obtaining broadband service that were not available prior to the grant. For K-12 school districts, the broadband network is supporting a statewide initiative to provide tablets and mobile computers to each student. As the school districts implement these programs, IT directors reported that they experience increasing levels of broadband use.¹³³ The districts are also beginning to deploy more cloud-based services such as learning management systems, instructional content, and office automation systems like Microsoft 365 and Google Business Services.

NC Broadband is working with DPI and school districts across North Carolina to promote the READY Anywhere initiative, which addresses the lack of availability and affordability of home Internet access. Although the proliferation of one-to-one computing programs has placed devices in students' hands, many lack Internet connectivity outside of school. The goal of READY Anywhere is to provide all students with 24/7 access to an Internet-connected device.¹³⁴ The initiative encourages partnerships between nonprofit organizations, ISPs, and advocates for the implementation of unlimited data plans for students' learning activities. MCNC, for example, partners with local ISPs in rural areas to develop strategies for reaching households with no broadband service.

Home broadband adoption is relatively low in Edgecombe County, making ECPS the primary anchor institutions for communities. As a result, the county is extending school media center hours to accommodate public use. Community members will have access to computer labs and public Wi-Fi

networks. Wireless access is important for one-to-one laptop program participants who do not have home Internet access. ECPS will also provide LMS training for parents and install kiosk computers in schools so parents can check their child's progress when they drop them off at school.

While most stakeholders agreed that the economic benefits of the network would not be fully realized for many years, the evaluation study team collected evidence of some early impacts. The GLRBI grant intended to spur economic development by offering middle mile solutions for last mile providers serving rural areas and extending to economic development zones and industrial parks that did not have fiber broadband access. Areas that once had a concentration of textile and furniture manufacturers are seeing the broadband network help the remaining companies reach markets and suppliers. High-tech pharmaceutical firms, which also rely heavily on broadband networks, are expanding their operations in former furniture manufacturing locations. The grant has helped preserve existing businesses and, in some cases, allowed them to expand their service offerings. The middle mile network has also attracted new business, including investments by large corporations such as Apple, AT&T, Disney, Facebook, and Google.¹³⁵ Apple, Disney, Facebook, and Google operate data facilities along western North Carolina's Route 74 Corridor, served by MCNC's middle mile fiber. AT&T has expanded its infrastructure in the state as well by constructing new towers connected to MCNC fiber. In the first half of 2013, AT&T invested more than \$250 million to expand wireless and wired networks in North Carolina.¹³⁶

Direct job creation attributed to the grant project peaked at thirty-eight full-time positions in the third quarter of 2011.¹³⁷ In addition, some interviewees stated that their organization hired additional technical staff as an indirect result of the grant.¹³⁸ Grant implementation activities stimulated the local economy by contracting project tasks out to North Carolina-based corporations, including CommScope, Broadplex, ERC, and ECC. CommScope, in particular, was able to maximize operational efficiency by tapping into previously underutilized production capacity during the project.¹³⁹

Section 5. Next Steps for the Evaluation Study

In early 2014, ASR will deliver *Interim Report 2* to NTIA. This report will include a summary of the site visits to twelve CCI projects. It will also include a summary of the second round of site visits to the fifteen PCC and SBA grants.

For the CCI projects, *Interim Report 2* will summarize the activities underway by twelve CCI grantees and the social and economic impacts of these projects. For the PCC and SBA projects, *Interim Report 2* will provide an update to and refinement of the analysis presented in *Interim Report 1*.

In September 2014, ASR will deliver a *Final Report* that quantitatively and qualitatively assesses the economic and social impact of BTOP grants (including CCI, PCC, and SBA grants). The centerpiece of the *Final Report* will be an assessment of how and to what extent BTOP grant awards have achieved economic and social benefits in areas served by the grantees. To the extent that such information is available, ASR will use results from studies performed by the grantees to round out the conclusions presented.

Notes

¹ National Telecommunications and Information Administration, *Broadband Technology Opportunities Program (BTOP) 16th Quarterly Program Status Report*, 2013, http://www.ntia.doc.gov/files/ntia/publications/ntia_btop_16th_quarterly_report.pdf.

² National Telecommunications and Information Administration, "About," *BroadbandUSA: Connecting America's Communities* (Washington, DC, June 11, 2012), <http://www2.ntia.doc.gov/about>.

³ The Notice of Funds Availability (NOFA) includes the following definitions:

- Last mile project – any infrastructure project the predominant purpose of which is to provide broadband service to end users or enduser devices (including households, businesses, community anchor institutions, public safety entities, and critical community facilities).
- Middle mile project – a broadband infrastructure project that does not predominantly provide broadband service to end users or to end-user devices, and may include interoffice transport, backhaul, Internet connectivity, or special access.

National Telecommunications and Information Administration, "Broadband Initiatives Program; Broadband Technology Opportunities Program Notice" (Washington, D.C., 2009), http://www.ntia.doc.gov/files/ntia/publications/fr_bbnofa_090709.pdf.

⁴ National Telecommunications and Information Administration, "Statement of Work for Broadband Technology Opportunities Program (BTOP) Evaluation Study," July 26, 2010, 6.

⁵ ASR Analytics, *Progress towards BTOP Goals: Interim Report on PCC and SBA Case Studies, Broadband Technology Opportunities Program Evaluation Study (Order Number D10PD18645)* (Potomac, MD, 2012), <http://www.ntia.doc.gov/report/2012/progress-towards-btop-goals-interim-report-pcc-and-sba-case-studies>.

⁶ MCNC, *Building a Sustainable Middle Mile Network for Underserved Rural North Carolina Third Quarter Performance Progress Report, 2013*, 2013, http://www2.ntia.doc.gov/files/grantees/nt10bix5570011_mcnc_ppr2013_q3.pdf.

National Telecommunications and Information Administration, "Building a Sustainable Middle Mile Network for Underserved Rural North Carolina Project Fact Sheet," 2010, http://www2.ntia.doc.gov/files/grantees/MCNC_BTOP_fact_sheet_LES_011910.pdf.

This figure includes the number of existing miles of fiber referenced in the BTOP Round 1 award fact sheet (685) plus the number of miles of newly constructed fiber (444) and of leased fiber (314) reported in the final PPR for the Round 1 award.

⁷ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12" (Washington, DC: Distributed by National Telecommunications and Information Administration, 2013).

⁸ National Telecommunications and Information Administration, "North Carolina Rural Broadband Initiative Project Fact Sheet," October 31, 2013, http://www2.ntia.doc.gov/files/grantees/fact_sheet_-_mcnc.pdf.

⁹ National Telecommunications and Information Administration, "North Carolina Rural Broadband Initiative Project Fact Sheet."

¹⁰ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹¹ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹² National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹³ Representative of North Carolina Telehealth Network, "Interview with Author," September 13, 2013.

¹⁴ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹⁵ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹⁶ Institute of Museum and Library Services, "Public Libraries in the United States Survey (FY2011)" (Washington, DC, June 2013), http://www.ims.gov/research/public_libraries_in_the_united_states_survey.aspx.

Centers for Medicare & Medicaid Studies, "National Plan and Provider Enumeration System (NPPES)" (Washington, DC, July 2013), http://nppes.viva-it.com/NPI_Files.html.

United States Fire Administration, "National Fire Department Census Database," August 08, 2013, <http://apps.usfa.fema.gov/census/>.

United States Department of Justice. Office of Justice Programs. Bureau of Justice Statistics, "Census of State and Local Law Enforcement Agencies (CSLLEA), 2008," *Directory of Law Enforcement Agencies Series* (Ann Arbor, MI: Inter-university Consortium for Political and Social Research, August 03, 2011), doi:10.3886/ICPSR27681.v1.

National Center for Education Statistics, "Elementary/Secondary Information System (ELSi)" (Washington, DC, August 15, 2013), <https://nces.ed.gov/ccd/elsi/>.

National Center for Education Statistics, "Integrated Postsecondary Education Data System (IPEDS)" (Washington, DC, August 15, 2013), <https://nces.ed.gov/ipeds/>.

National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

¹⁷ General Assembly of North Carolina, "Session Law 2013-185 House Bill 664," June 26, 2013, <http://ncleg.net/Sessions/2013/Bills/House/PDF/H664v6.pdf>.

¹⁸ National Telecommunications and Information Administration, "North Carolina Rural Broadband Initiative Project Fact Sheet."

¹⁹ United States Census Bureau, "2007-2011 ACS 5-Year Summary File," *American Community Survey* (Washington, DC, December 06, 2012), http://www.census.gov/acs/www/data_documentation/2011_release/.

²⁰ National Telecommunications and Information Administration, "State Broadband Initiative June 30, 2011" (Washington, D.C.: United States Department of Commerce, 2011), <http://www2.ntia.doc.gov/Jun-2011-datasets>.

²¹ National Telecommunications and Information Administration, "State Broadband Initiative June 30, 2011."

²² National Telecommunications and Information Administration, "State Broadband Initiative June 30, 2011."

²³ FCC Form 477 data includes information at the census tract level on the population that subscribes to broadband using the following speed thresholds: at least 768 kbps download speed

and at least 200 kbps upload speed. Because of this limitation, ASR is not able to filter for subscribers with download speeds of at least 3 Mbps and upload speeds of at least 768 kbps.

²⁴ Federal Communications Commission, "Local Telephone Competition and Broadband Deployment Form 477," June 2012, <http://transition.fcc.gov/wcb/iatd/comp.html>.

²⁵ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

²⁶ CommScope, "Who We Are," November 01, 2013, <http://www.commscope.com/About-Us/Who-We-Are/>.

²⁷ Golden LEAF Foundation, "About Us," October 31, 2013, <http://www.goldenleaf.org/about.html>.

²⁸ Golden LEAF Foundation, "The Golden LEAF North Carolina Rural Broadband Initiative (NCRBI)," November 01, 2013, <http://www.goldenleaf.org/grantdetail.php?id=FY2010-368>.

²⁹ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author," September 10, 2013.

³⁰ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author."

³¹ Yadtel Telecom, "About Us," October 31, 2013, http://www.yadtel.com/yadtel_telecom/about_us.php.

³² Blue Ridge Community College, "About BRCC," November 01, 2013, http://www.blueridge.edu/about_brcc/index.php.

³³ Representative of Blue Ridge Community College, "Interview with Author," September 10, 2013.

³⁴ East Carolina University, "Fact Book 2011-2012," 2012, <http://www.ecu.edu/cs-acad/ipar/customcf/DL/FB/FactBook11-12.pdf>.

³⁵ Nash Community College, "Nash Community College," November 01, 2013, http://www.nashcc.edu/index.php?option=com_content&task=view&id=53&Itemid=43.

³⁶ North Carolina State University, "Discovery Begins at NC State," October 31, 2013, <http://www.ncsu.edu/about-nc-state/>.

³⁷ Richmond Community College, "About RCC," November 01, 2013, <http://www.richmondcc.edu/about-rcc/>.

³⁸ Wake Forest University, "Academics," November 01, 2013, <http://www.wfu.edu/academics/>.

³⁹ Wake Forest University, "Common Data Set 2012-2013," November 01, 2013, <http://www.wfu.edu/ir/docs/cds2012wfu.pdf>.

⁴⁰ Representative of Wake Forest University/Wake Forest Baptist Medical Center, "Interview with Author," September 10, 2013.

⁴¹ Representative of Edgecombe County Public Schools, "Interview with Author," September 12, 2013.

⁴² Lee County Schools, "Fast Facts," October 31, 2013, <http://www.lee.k12.nc.us/Page/86>.

⁴³ Representative of Lee County Schools, "Interview with Author," September 11, 2013.

⁴⁴ Mooresville Graded School District, "About Our District," November 01, 2013, http://www.mgsd.k12.nc.us/MGSD/Our_District.html.

Alan Schwarz, "Mooresville's Shining Example (It's Not Just About the Laptops)," *The New York Times*, February 12, 2012, http://www.nytimes.com/2012/02/13/education/mooresville-school-district-a-laptop-success-story.html?_r=0.

⁴⁵ Representative of Mooresville Graded School District, "Interview with Author," September 09, 2013.

- ⁴⁶ Representative of Rutherford County Schools, "Interview with Author," September 10, 2013.
Rutherford County Schools, "Introduction to RCS," 2013, [http://rcsnc.org/district_information/Introduction to RCS/](http://rcsnc.org/district_information/Introduction%20to%20RCS/).
- ⁴⁷ Representative of Rutherford County Schools, "Interview with Author."
- ⁴⁸ Representative of the North Carolina Department of Public Instruction, "Interview with Author," September 13, 2013.
- ⁴⁹ MCNC, "Our Health Care Community - NCTN," November 15, 2013, <https://www.mcnc.org/our-community/healthcare>.
- ⁵⁰ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."
Representative of North Carolina Telehealth Network, "Interview with Author."
- ⁵¹ North Carolina Department of Public Safety, "North Carolina State Highway Patrol," November 01, 2013, <https://www.ncdps.gov/index2.cfm?a=000003,000014>.
- ⁵² ASR Analytics, *Progress towards BTOP Goals: Interim Report on PCC and SBA Case Studies*.
- ⁵³ British Educational Communications and Technology Agency, *Extending Opportunity: Final Report of the Minister's Taskforce on Home Access to Technology* (Coventry, UK, July 2008), <http://dera.ioe.ac.uk/8285/>.
- Robert W. Fairlie, "The Effects of Home Computers on School Enrollment," *Working Paper*, September 2003, http://cjtc.ucsc.edu/docs/r_schoolcomp6.pdf.
- Mizuko Ito et al., *Living and Learning with New Media Summary of Findings from the Digital Youth Project, The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning*, November 2008, <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>.
- Robert LaRose et al., *Closing the Rural Broadband Gap, Final Technical Report*, November 30, 2008, <https://www.msu.edu/~larose/ruralbb/>.
- Barbara Means et al., *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies* (Washington, DC: United States Department of Education, September 2010), <http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf>.
- Juan Moran et al., "Technology and Reading Performance in the Middle-School Grades: A Meta-Analysis with Recommendations for Policy and Practice," *Journal of Literacy Research* 40, no. 1 (January 2008): 6–58, doi:10.1080/10862960802070483.
- Don Passey et al., *The Motivational Effect of ICT on Pupils, RR523* (Lancaster, UK: University of Lancaster, April 2004), <https://www.education.gov.uk/publications/RSG/ICTSCH/Page1/RR523>.
- Nancy Protheroe, "Technology and Student Achievement," *Principal*, November 2005, <http://www.naesp.org/resources/2/Principal/2005/N-Dp46.pdf>.
- Shapley Research Associates and Texas Center for Educational Research, *Final Outcomes for a Four-Year Study (2004–05 to 2007–08), Evaluation of the Texas Technology Immersion Pilot (eTxTIP)*, January 2009, <http://www.tcer.org/research/etxtip/>.
- Gil Valentine et al., *Children and Young People's Home Use of ICT for Educational Purposes: The Impact on Attainment at Key Stages 1-4, RB672*, August 2005, <https://www.education.gov.uk/publications/RSG/ParentsCarersandFamilies/Page12/RB672>.
- Jörg Wittwer and Martin Senkbeil, "Is Students' Computer Use at Home Related to Their Mathematical Performance at School?," *Computers & Education* 50, no. 4 (May 2008): 1558–1571, doi:10.1016/j.compedu.2007.03.001.

Julius Genachowski, *Broadband: Our Enduring Engine for Prosperity and Opportunity* (Washington, D.C., 2010).

Digital Impact Group, "The Economic Impact of Digital Exclusion" 19104, no. 215 (2010).

Robert W. Fairlie et al., *Crossing the Divide: Immigrant Youth and Digital Disparity in California* (Santa Cruz, 2006), <http://cjtc.ucsc.edu/docs/digital.pdf>.

⁵⁴ Shannon Tufts, "Interview with Author," September 09, 2013.

⁵⁵ Representatives of MCNC and Representative of Golden LEAF, "Interview with Author," September 13, 2013.

⁵⁶ Representative of Lee County Schools, "Interview with Author."

⁵⁷ Representative of Nash Community College, "Interview with Author," September 12, 2013.

⁵⁸ Schwarz, "Mooresville's Shining Example (It's Not Just About the Laptops)."

Lindsay Wagner, "NC Schools and Districts Honored for High Graduation Rates," *The Progressive Pulse*, September 23, 2013, <http://pulse.ncpolicywatch.org/2013/09/23/nc-schools-and-districts-honored-for-high-graduation-rates/>.

⁵⁹ Representative of Mooresville Graded School District, "Interview with Author."

⁶⁰ Scott M. Andes and Daniel D. Castro, *Opportunities and Innovations in the Mobile Broadband Economy*, *The Information Technology and Innovation Foundation*, 2010, <http://www.itif.org/files/2010-mobile-innovations.pdf>.

Communications Workers of America, *Speed Matters: Benefits of Broadband* (Washington, DC, 2009), http://files.cwa-union.org/speedmatters/CWA_Benefits_of_Broadbandr_2010.pdf.

Linda Ann Hulbert and Regina C. McBride, "Utilizing Videoconferencing in Library Education: A Team Teaching Approach," *Journal of Education for Library and Information Science* 45, no. 1 (2004): 25–35, <http://www.jstor.org/stable/40323919>.

Carly Shuler, *Pockets of Potential: Using Mobile Technologies to Promote Children's Learning* (New York, NY: The Joan Gans Cooney Center, January 2009), <http://joanganzcooneycenter.org/Reports-23.html>.

⁶¹ Representatives of the University of North Carolina at Pembroke, "Interview with Author," September 11, 2013.

⁶² Representative of Wake Forest University/Wake Forest Baptist Medical Center, "Interview with Author."

⁶³ Jessica Briskin et al., "26B-K: Smart Apps: An Analysis of Educational Applications Available on Smartphones and the Implications for Mobile Learning (D&D)," in *Annual Meeting of the AECT Convention* (Hyatt Regency Orange County, Anaheim, CA: Association for Educational Communications and Technology, 2010), http://convention2.allacademic.com/one/aect/aect10/index.php?click_key=1&cmd=Multi+Search+Search+Load+Publication&publication_id=430393&PHPSESSID=jgkifdqag6qgtckajo0k657jc7.

⁶⁴ Ruth H. Moody and Michael P. Bobic, "Teaching the Net Generation without Leaving the Rest of Us Behind: How Technology in the Classroom Influences Student Composition," *Politics & Policy* 39, no. 2 (April 29, 2011): 169–194, doi:10.1111/j.1747-1346.2011.00287.x.

⁶⁵ Representative of NC Broadband, "Interview with Author," September 11, 2013.

⁶⁶ Representative of Yadtel Telecom, "Interview with Author," September 13, 2013.

⁶⁷ Representative of Nash Community College, "Interview with Author."

⁶⁸ The South Dakota Bureau of Information and Telecommunications, "Broadband Benefits for Rural Areas," February 01, 2011, <http://broadband.sd.gov/Benefits-Rural.aspx>.

- ⁶⁹ Representative of Richmond Community College, “Interview with Author,” September 11, 2013.
- ⁷⁰ Representative of North Carolina State University, “Interview with Author,” September 09, 2013.
- ⁷¹ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, “Interview with Author.”
- ⁷² Representative of Lee County Schools, “Interview with Author.”
- ⁷³ The South Dakota Bureau of Information and Telecommunications, “Broadband Benefits for Rural Areas,” February 01, 2011, <http://broadband.sd.gov/Benefits-Rural.aspx>.
- ⁷⁴ Representative of the North Carolina Department of Public Instruction, “Interview with Author.”
- ⁷⁵ Samantha Becker et al., *Opportunity for All: How the American Public Benefits from Internet Access at U.S. Libraries* (Washington, DC: Institute of Museum and Library Services, March 2010), <http://www.gatesfoundation.org/learning/Pages/us-libraries-report-opportunity-for-all.aspx>.
- Robert W. Crandall, William H. Lehr, and Robert E. Litan, *The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data, Issues in Economic Policy* (Washington, DC: The Brookings Institution, July 2007), <http://www.brookings.edu/research/papers/2007/06/labor-crandall>.
- Michael Ann Dean, “Using the Internet in the Job Search,” in *Employment Options for Foreign Service Family Members* (Washington, DC: Family Liaison Office, United States Department of State, 2001), 31–48, <http://www.state.gov/m/dghr/flo/c21652.htm>.
- Michael Ann Dean, “Using the Internet in the Job Search,” in *Employment Options for Foreign Service Family Members* (Washington, DC: Family Liaison Office, United States Department of State, 2001), 31–48, <http://www.state.gov/m/dghr/flo/c21652.htm>.
- ⁷⁶ Tufts, “Interview with Author.”
- ⁷⁷ USDA Economic Research Service, “Rural Digital Economy: Online Activities,” *Briefing Rooms*, August 13, 2009, <http://ers.usda.gov/Briefing/Telecom/demandservice.htm>.
- ⁷⁸ Cindy Beamon, “Internet Provider Competition Heats up,” *The Daily Advance*, January 13, 2013.
- ⁷⁹ Representative of ECC Technologies, “Interview with Author,” September 09, 2013.
- ⁸⁰ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, “Interview with Author.”
- ⁸¹ USDA Economic Research Service, “Rural Digital Economy: Online Activities.”
- Business Link, “Advantages and Disadvantages of Using Social Media,” *Online Business Networking and Social Networking*, August 28, 2012, <http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1081912566&type=RESOURCES>.
- ⁸² Representative of ECC Technologies, “Interview with Author.”
- ⁸³ General Assembly of North Carolina, “Session Law 2013-185 House Bill 664.”
- ⁸⁴ AT&T Press Release, “AT&T Invests More Than \$250 Million in North Carolina Wireless and Wireline Networks in First Half of 2013,” July 14, 2013, <http://www.att.com/gen/press-room?pid=24695&cdvn=news&newsarticleid=36895&mapcode=consumer|mk-att-wireless-networks>.
- ⁸⁵ The Recovery Accountability and Transparency Board, “Recovery API,” *Recovery.gov* (Washington, DC, March 20, 2013), <http://www.recovery.gov/FAQ/Developer/Pages/RecoveryAPI.aspx>.
- ⁸⁶ Recovery.org provides the following guidance and example for calculating grant-funded jobs:
1. If a normal full-time schedule is 40 hours a week, multiply 40 hours x 52 weeks = 2,080 Total Hours per year.

2. Divide 2,080 Total Hours by 4 to equal 520 regular quarterly hours.
3. If two full-time employees each worked 520 hours (1,040 hours) for the quarter and another half-time employee worked 260 hours, the Total Hours for the three employees is 1300 (520 + 520 + 260 = 1300).
4. Divide 1300 by 520 to equal 2.5 Recovery funded jobs during that quarter.

For more information, visit <http://www.recovery.gov/News/featured/Pages/Calculator.aspx>

⁸⁷ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

⁸⁸ Representative of North Carolina Telehealth Network, "Interview with Author."

⁸⁹ MCNC, "Our Health Care Community - NCTN."

⁹⁰ MCNC, "Our Health Care Community - NCTN."

⁹¹ Representative of North Carolina Telehealth Network, "Interview with Author."

⁹² Federal Communications Commission, *Connecting America: The National Broadband Plan*, 2010, <http://www.broadband.gov/plan/>.

⁹³ Julius Genachowski, "Remarks on Broadband Adoption," 2011, <http://www.fcc.gov/document/chairman-genachowski-broadband-adoption>.

⁹⁴ Maria E. Wynne and Lane F. Cooper, *Power Up: The Campaign for Digital Inclusion* (Office of Economic Development and Innovation, Microsoft Corporation, June 2007), http://www.digitalaccess.org/pdf/White_Paper.pdf.

Robert D. Atkinson and Daniel D. Castro, *Digital Quality of Life: Understanding the Personal and Social Benefits of the Information Technology Revolution* (Washington, DC: Information Technology and Information Foundation, October 01, 2008), <http://www.itif.org/files/DQOL.pdf>.

A.J.A.M. van Deursen, "Internet Skills: Vital Assets in an Information Society" (Enschede, The Netherlands: University of Twente, November 01, 2010), doi:10.3990/1.9789036530866.

The State of Michigan, "The Benefits of Broadband," August 27, 2012, http://michigan.gov/broadband/0,1607,7-250-48184_48185---,00.html.

PriceWaterhouseCoopers, *Champion for Digital Inclusion: The Economic Case for Digital Inclusion*, October 2009, http://www.parliamentandinternet.org.uk/uploads/Final_report.pdf.

⁹⁵ Andrew Scarvell, "Digital Literacy and Awareness in Australia' S New Global Frontier," in *First Media and Information Literacy Forum* (Fez, Morocco: UNESCO, 2011), http://scarvell.net/andrew/blog/?page_id=15.

Digital Impact Group, "The Economic Impact of Digital Exclusion."

⁹⁶ David Osimo, *Web 2 .0 in Government: Why and How?* (Seville, Spain: Institute for Prospective Technological Studies, 2008), <http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=1565>.

The State of Michigan, "The Benefits of Broadband."

⁹⁷ Rural Utilities Service and National Telecommunications and Information Administration, "Broadband Initiatives Program & Broadband Technology Opportunities Program," *Federal Register* 74, no. 130 (July 09, 2009): 33104–34, <http://www.gpo.gov/fdsys/pkg/FR-2009-07-09/pdf/FR-2009-07-09.pdf>.

⁹⁸ United States Fire Administration, "National Fire Department Census Database."

⁹⁹ MCNC, "North Carolina Rural Broadband Initiative Application Part 1," September 10, 2009, http://www2.ntia.doc.gov/files/grantees/mcnc_round1_infrastructure_application_part1.pdf.

¹⁰⁰ MCNC, "About MCNC," November 13, 2013, <https://www.mcnc.org/about.html>.

¹⁰¹ MCNC, "North Carolina Rural Broadband Initiative Application Part 1."

- ¹⁰² MCNC, "Access Service," October 16, 2013, <https://www.mcnc.org/services/access-service.html>.
- ¹⁰³ MCNC, "Layer-1 Network Transport Service," October 16, 2013, <https://www.mcnc.org/services/layer-1-network-transport-service.html>.
- ¹⁰⁴ MCNC, "Internet Service," October 16, 2013, <https://www.mcnc.org/services/internet-service.html>.
- ¹⁰⁵ MCNC, "Network Assessment," October 16, 2013, <https://www.mcnc.org/services/network-assessment.html>.
- ¹⁰⁶ National Telecommunications and Information Administration, "Broadband Technology Opportunities Program Notices" (Washington, DC, January 22, 2010), http://www.ntia.doc.gov/files/ntia/publications/fr_btopnofa_100115_0.pdf.
- ¹⁰⁷ Jonathan E. Nuechterlein and Philip J. Weiser, *Digital Crossroads: American Telecommunications Policy in the Internet Age* (Cambridge, MA: The MIT Press, 2005).
- ¹⁰⁸ OECD, "Broadband Networks and Open Access," *OECD Digital Economy Papers* no. 218 (March 04, 2013).
- ¹⁰⁹ William H. Lehr, Marvin Sirbu, and Sharon Gillett, "Broadband Open Access : Lessons from Municipal Network Case Studies," 2008.
- ¹¹⁰ Lehr, Sirbu, and Gillett, "Broadband Open Access : Lessons from Municipal Network Case Studies."
- ¹¹¹ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author."
- ¹¹² Representative of NC Broadband, "Interview with Author."
- ¹¹³ Rural Utilities Service and National Telecommunications and Information Administration, "Broadband Initiatives Program & Broadband Technology Opportunities Program."
- ¹¹⁴ MCNC, *North Carolina Rural Broadband Initiative Third Quarter Performance Progress Report, 2013*, 2013, http://www2.ntia.doc.gov/files/grantees/nt10bix5570120_mcnc_ppr2013_q3.pdf.
- ¹¹⁵ MCNC, "North Carolina Rural Broadband Initiative Application Part 1."
- ¹¹⁶ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."
- ¹¹⁷ Representative of East Carolina University, "Interview with Author," September 12, 2013.
 Representative of Nash Community College, "Interview with Author."
 Representative of North Carolina State University, "Interview with Author."
 Representatives of the University of North Carolina at Pembroke, "Interview with Author."
- ¹¹⁸ Tufts, "Interview with Author."
- ¹¹⁹ National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."
- ¹²⁰ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author."
 Representative of Broadplex, "Interview with Author," September 10, 2013.
 Representative of ECC Technologies, "Interview with Author."
 Representative of ERC Broadband, "Interview with Author," September 10, 2013.
 Representative of NC Broadband, "Interview with Author."

Representative of the North Carolina Department of Public Instruction, "Interview with Author."
Tufts, "Interview with Author."

¹²¹ Representative of East Carolina University, "Interview with Author."

Representative of Edgecombe County Public Schools, "Interview with Author."

Representative of Nash Community College, "Interview with Author."

Representative of Richmond Community College, "Interview with Author."

Representative of Rutherford County Schools, "Interview with Author."

¹²² Representative of Edgecombe County Public Schools, "Interview with Author."

Representative of Rutherford County Schools, "Interview with Author."

¹²³ Beamon, "Internet Provider Competition Heats up."

¹²⁴ Representative of NC Broadband, "Interview with Author."

¹²⁵ Representative of North Carolina State Highway Patrol, "Interview with Author," September 2013.

¹²⁶ Representative of East Carolina University, "Interview with Author."

Representative of ERC Broadband, "Interview with Author."

Representative of Nash Community College, "Interview with Author."

¹²⁷ Tufts, "Interview with Author."

¹²⁸ Tufts, "Interview with Author."

¹²⁹ Joe Freddoso and MCNC, "NC in Prime Position for New Broadband Economy," April 08, 2013, <https://www.mcnc.org/btop/progress/reports>.

¹³⁰ Beamon, "Internet Provider Competition Heats up."

¹³¹ Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author."

Tufts, "Interview with Author."

¹³² Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC, "Interview with Author."

Tufts, "Interview with Author."

¹³³ Representative of Edgecombe County Public Schools, "Interview with Author."

Representative of Lee County Schools, "Interview with Author."

Representative of Mooresville Graded School District, "Interview with Author."

Representative of the North Carolina Department of Public Instruction, "Interview with Author."

Representative of Rutherford County Schools, "Interview with Author."

¹³⁴ Public Schools of North Carolina, "READY Anywhere!," October 31, 2013, <http://www.ncpublicschools.org/docs/connectivity/ready-intro.pdf>.

¹³⁵ Representatives of MCNC and Representative of Golden LEAF, "Interview with Author."

Representative of Rutherford County Schools, "Interview with Author."

¹³⁶ AT&T Press Release, "AT&T Invests More Than \$250 Million in North Carolina Wireless and Wireline Networks in First Half of 2013."

¹³⁷ The Recovery Accountability and Transparency Board, "Recovery API."

¹³⁸ Representative of ERC Broadband, “Interview with Author.”

Representative of Rutherford County Schools, “Interview with Author.”

Representatives of the University of North Carolina at Pembroke, “Interview with Author.”

¹³⁹ Representative of CommScope, “Interview with Author,” September 10, 2013.

Glossary

Acronym	Definition
AMI	Automated Metering Infrastructure
APR	Annual Performance Progress Report
ASR	ASR Analytics, LLC
ASU	Appalachian State University
BRCC	Blue Ridge Community College
BTOP	Broadband Technology Opportunities Program
BYOD	Bring Your Own Device
CAI	Community Anchor Institution
CCI	Comprehensive Community Infrastructure
CLEC	Competitive Local Exchange Carrier
DPI	North Carolina Department of Public Instruction
DWDM	Dense Wave Division Multiplexing
ECC	ECC Technologies, Inc.
ECPS	Edgecombe County Public Schools
ECU	East Carolina University
EHR	Electronic Health Records
EMS	Emergency Medical Services
ERC	ERC Broadband
EVAAS	Education Value-Added Assessment System
FCC	Federal Communications Commission
GED	General Equivalency Degree
GIS	Geographic Information Systems
GLRBI	Golden LEAF Rural Broadband Initiative
HIPAA	Health Insurance Privacy and Accountability Act
IRU	Indefeasible Right Of Use
ISP	Internet Service Provider
IT	Information Technology
ITS	North Carolina Office of Information Technology Services
LAN	Local Area Network
LCS	Lee County Schools
LMS	Learning Management System

Acronym	Definition
MGSD	Mooresville Graded School District
NBM	National Broadband Map
NCC	Nash Community College
NCREN	North Carolina Research and Education Network
NCSHP	North Carolina State Highway Patrol
NCSU	North Carolina State University
NCTN	North Carolina Telehealth Network
NPRES	National Plan and Provider Enumeration System
NTIA	National Telecommunications and Information Administration
PA	Physician Assistant
PCC	Public Computer Centers
PI	Principal Investigator
POP	Points of Presence
PPR	Quarterly Performance Progress Report
RCC	Richmond Community College
RCS	Rutherford County Schools
SBA	Sustainable Broadband Adoption
STEM	Science, Technology, Engineering, and Mathematics
UNC	University of North Carolina
UNCP	University of North Carolina at Pembroke
VPN	Virtual Private Network
WAN	Wide Area Network
WFBMC	Wake Forest Baptist Medical Center
WFU	Wake Forest University
YCS	Yadkin County Schools

Bibliography

- Andes, Scott M., and Daniel D. Castro. *Opportunities and Innovations in the Mobile Broadband Economy*. The Information Technology and Innovation Foundation, 2010. <http://www.itif.org/files/2010-mobile-innovations.pdf>.
- ASR Analytics. *Progress towards BTOP Goals: Interim Report on PCC and SBA Case Studies. Broadband Technology Opportunities Program Evaluation Study (Order Number D10PD18645)*. Potomac, MD, 2012. <http://www.ntia.doc.gov/report/2012/progress-towards-btop-goals-interim-report-pcc-and-sba-case-studies>.
- AT&T Press Release. "AT&T Invests More Than \$250 Million in North Carolina Wireless and Wireline Networks in First Half of 2013," July 14, 2013. <http://www.att.com/gen/press-room?pid=24695&cdvn=news&newsarticleid=36895&mapcode=consumer|mk-att-wireless-networks>.
- Atkinson, Robert D., and Daniel D. Castro. *Digital Quality of Life: Understanding the Personal and Social Benefits of the Information Technology Revolution*. Washington, DC: Information Technology and Information Foundation, October 01, 2008. <http://www.itif.org/files/DQOL.pdf>.
- Beamon, Cindy. "Internet Provider Competition Heats up." *The Daily Advance*. January 13, 2013.
- Becker, Samantha, Michael D. Crandall, Karen E. Fisher, Bo Kinney, Carol Landry, and Anita Rocha. *Opportunity for All: How the American Public Benefits from Internet Access at U.S. Libraries*. Washington, DC: Institute of Museum and Library Services, March 2010. <http://www.gatesfoundation.org/learning/Pages/us-libraries-report-opportunity-for-all.aspx>.
- Blue Ridge Community College. "About BRCC," November 01, 2013. http://www.blueridge.edu/about_brcc/index.php.
- Briskin, Jessica, Michael Montalto-Rook, Tataleni I. Asino, and Yaozu Dong. "26B-K: Smart Apps: An Analysis of Educational Applications Available on Smartphones and the Implications for Mobile Learning (D&D)." In *Annual Meeting of the AECT Convention*. Hyatt Regency Orange County, Anaheim, CA: Association for Educational Communications and Technology, 2010. http://convention2.allacademic.com/one/aect/aect10/index.php?click_key=1&cmd=Multi+Search+Search+Load+Publication&publication_id=430393&PHPSESSID=jgkifdqag6qgtckajo0k657jc7.
- British Educational Communications and Technology Agency. *Extending Opportunity: Final Report of the Minister's Taskforce on Home Access to Technology*. Coventry, UK, July 2008. <http://dera.ioe.ac.uk/8285/>.
- Business Link. "Advantages and Disadvantages of Using Social Media." *Online Business Networking and Social Networking*, August 28, 2012. <http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1081912566&type=RESOURCES>.
- Centers for Medicare & Medicaid Studies. "National Plan and Provider Enumeration System (NPPES)." Washington, DC, July 2013. http://nppes.viva-it.com/NPI_Files.html.
- CommScope. "Who We Are," November 01, 2013. <http://www.commscope.com/About-Us/Who-We-Are/>.

- Communications Workers of America. *Speed Matters: Benefits of Broadband*. Washington, DC, 2009. http://files.cwa-union.org/speedmatters/CWA_Benefits_of_Broadbandr_2010.pdf.
- Crandall, Robert W., William H. Lehr, and Robert E. Litan. *The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data. Issues in Economic Policy*. Washington, DC: The Brookings Institution, July 2007. <http://www.brookings.edu/research/papers/2007/06/labor-crandall>.
- Dean, Michael Ann. "Using the Internet in the Job Search." In *Employment Options for Foreign Service Family Members*, 31–48. Washington, DC: Family Liaison Office, United States Department of State, 2001. <http://www.state.gov/m/dghr/flo/c21652.htm>.
- . "Using the Internet in the Job Search." In *Employment Options for Foreign Service Family Members*, 31–48. Washington, DC: Family Liaison Office, United States Department of State, 2001. <http://www.state.gov/m/dghr/flo/c21652.htm>.
- Digital Impact Group. "The Economic Impact of Digital Exclusion" 19104, no. 215 (2010).
- East Carolina University. "Fact Book 2011-2012," 2012. <http://www.ecu.edu/cs-acad/ipar/customcf/DL/FB/FactBook11-12.pdf>.
- Fairlie, Robert W. "The Effects of Home Computers on School Enrollment." *Working Paper*, September 2003. http://cjtc.ucsc.edu/docs/r_schoolcomp6.pdf.
- Fairlie, Robert W., Rebecca A. London, Rachel Rosner, and Manuel Pastor. *Crossing the Divide: Immigrant Youth and Digital Disparity in California*. Santa Cruz, 2006. <http://cjtc.ucsc.edu/docs/digital.pdf>.
- Federal Communications Commission. *Connecting America: The National Broadband Plan*, 2010. <http://www.broadband.gov/plan/>.
- . "Local Telephone Competition and Broadband Deployment Form 477," June 2012. <http://transition.fcc.gov/wcb/iatd/comp.html>.
- Freddoso, Joe, and MCNC. "NC in Prime Position for New Broadband Economy," April 08, 2013. <https://www.mcnc.org/btop/progress/reports>.
- Genachowski, Julius. *Broadband: Our Enduring Engine for Prosperity and Opportunity*. Washington, D.C., 2010.
- . "Remarks on Broadband Adoption," 2011. <http://www.fcc.gov/document/chairman-genachowski-broadband-adoption>.
- General Assembly of North Carolina. "Session Law 2013-185 House Bill 664," June 26, 2013. <http://ncleg.net/Sessions/2013/Bills/House/PDF/H664v6.pdf>.
- Golden LEAF Foundation. "About Us," October 31, 2013. <http://www.goldenleaf.org/about.html>.
- . "The Golden LEAF North Carolina Rural Broadband Initiative (NCRBI)," November 01, 2013. <http://www.goldenleaf.org/grantdetail.php?id=FY2010-368>.

- Hulbert, Linda Ann, and Regina C. McBride. "Utilizing Videoconferencing in Library Education: A Team Teaching Approach." *Journal of Education for Library and Information Science* 45, no. 1 (2004): 25–35. <http://www.jstor.org/stable/40323919>.
- Institute of Museum and Library Services. "Public Libraries in the United States Survey (FY2011)." Washington, DC, June 2013. http://www.ims.gov/research/public_libraries_in_the_united_states_survey.aspx.
- Ito, Mizuko, Heather Horst, Matteo Brittanit, Danah Boyd, Becky Herr-Stephenson, Patricia G. Lange, C.J. Pascoe, and Laura Robinson. *Living and Learning with New Media Summary of Findings from the Digital Youth Project. The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning*, November 2008. <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>.
- LaRose, Robert, Jennifer L. Gregg, Sharon Stover, Joseph Straubhaar, and Nobuya Inagaki. *Closing the Rural Broadband Gap, Final Technical Report*, November 30, 2008. <https://www.msu.edu/~larose/ruralbb/>.
- Lee County Schools. "Fast Facts," October 31, 2013. <http://www.lee.k12.nc.us/Page/86>.
- Lehr, William H., Marvin Sirbu, and Sharon Gillett. "Broadband Open Access : Lessons from Municipal Network Case Studies," 2008.
- MCNC. "About MCNC," November 13, 2013. <https://www.mcnc.org/about.html>.
- . "Access Service," October 16, 2013. <https://www.mcnc.org/services/access-service.html>.
- . *Building a Sustainable Middle Mile Network for Underserved Rural North Carolina Third Quarter Performance Progress Report, 2013*, 2013. http://www2.ntia.doc.gov/files/grantees/nt10bix5570011_mcnc_ppr2013_q3.pdf.
- . "Internet Service," October 16, 2013. <https://www.mcnc.org/services/internet-service.html>.
- . "Layer-1 Network Transport Service," October 16, 2013. <https://www.mcnc.org/services/layer-1-network-transport-service.html>.
- . "Network Assessment," October 16, 2013. <https://www.mcnc.org/services/network-assessment.html>.
- . "North Carolina Rural Broadband Initiative Application Part 1," September 10, 2009. http://www2.ntia.doc.gov/files/grantees/mcnc_round1_infrastructure_application_part1.pdf.
- . *North Carolina Rural Broadband Initiative Third Quarter Performance Progress Report, 2013*, 2013. http://www2.ntia.doc.gov/files/grantees/nt10bix5570120_mcnc_ppr2013_q3.pdf.
- . "Our Health Care Community - NCTN," November 15, 2013. <https://www.mcnc.org/our-community/healthcare>.
- Means, Barbara, Yukie Toyama, Robert Murphy, Marianne Bakia, and Karla Jones. *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Washington, DC: United States Department of Education, September 2010. <http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf>.

- Moody, Ruth H., and Michael P. Bobic. "Teaching the Net Generation without Leaving the Rest of Us Behind: How Technology in the Classroom Influences Student Composition." *Politics & Policy* 39, no. 2 (April 29, 2011): 169–194. doi:10.1111/j.1747-1346.2011.00287.x.
- Mooresville Graded School District. "About Our District," November 01, 2013. http://www.mgsd.k12.nc.us/MGSD/Our_District.html.
- Moran, Juan, Richard Ferdig, P. David Pearson, James Wardrop, and Robert Blomeyer. "Technology and Reading Performance in the Middle-School Grades: A Meta-Analysis with Recommendations for Policy and Practice." *Journal of Literacy Research* 40, no. 1 (January 2008): 6–58. doi:10.1080/10862960802070483.
- Nash Community College. "Nash Community College," November 01, 2013. http://www.nashcc.edu/index.php?option=com_content&task=view&id=53&Itemid=43.
- National Center for Education Statistics. "Elementary/Secondary Information System (ELSi)." Washington, DC, August 15, 2013. <https://nces.ed.gov/ccd/elsi/>.
- . "Integrated Postsecondary Education Data System (IPEDS)." Washington, DC, August 15, 2013. <https://nces.ed.gov/ipeds/>.
- National Telecommunications and Information Administration. "About." *BroadbandUSA: Connecting America's Communities*. Washington, DC, June 11, 2012. <http://www2.ntia.doc.gov/about>.
- . "Broadband Initiatives Program; Broadband Technology Opportunities Program Notice." Washington, D.C., 2009. http://www.ntia.doc.gov/files/ntia/publications/fr_bbnofa_090709.pdf.
- . *Broadband Technology Opportunities Program (BTOP) 16th Quarterly Program Status Report*, 2013. http://www.ntia.doc.gov/files/ntia/publications/ntia_btop_16th_quarterly_report.pdf.
- . "Broadband Technology Opportunities Program Notices." Washington, DC, January 22, 2010. http://www.ntia.doc.gov/files/ntia/publications/fr_btopnofa_100115_0.pdf.
- . "Building a Sustainable Middle Mile Network for Underserved Rural North Carolina Project Fact Sheet," 2010. http://www2.ntia.doc.gov/files/grantees/MCNC_BTOP_fact_sheet_LES_011910.pdf.
- . "North Carolina Rural Broadband Initiative Project Fact Sheet," October 31, 2013. http://www2.ntia.doc.gov/files/grantees/fact_sheet_-_mcnc.pdf.
- . "Post-Award Monitoring (PAM) Database 2013-09-12." Washington, DC: Distributed by National Telecommunications and Information Administration, 2013.
- . "State Broadband Initiative June 30, 2011." Washington, D.C.: United States Department of Commerce, 2011. <http://www2.ntia.doc.gov/Jun-2011-datasets>.
- . "Statement of Work for Broadband Technology Opportunities Program (BTOP) Evaluation Study," July 26, 2010.
- North Carolina Department of Public Safety. "North Carolina State Highway Patrol," November 01, 2013. <https://www.ncdps.gov/index2.cfm?a=000003,000014>.

- North Carolina State University. "Discovery Begins at NC State," October 31, 2013.
<http://www.ncsu.edu/about-nc-state/>.
- Nuechterlein, Jonathan E., and Philip J. Weiser. *Digital Crossroads: American Telecommunications Policy in the Internet Age*. Cambridge, MA: The MIT Press, 2005.
- OECD. "Broadband Networks and Open Access." *OECD Digital Economy Papers* no. 218 (March 04, 2013).
- Osimo, David. *Web 2.0 in Government: Why and How?* Seville, Spain: Institute for Prospective Technological Studies, 2008. <http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=1565>.
- Passey, Don, Colin Rogers, Joan Machell, and Gilly McHugh. *The Motivational Effect of ICT on Pupils. RR523*. Lancaster, UK: University of Lancaster, April 2004.
<https://www.education.gov.uk/publications/RSG/ICTSCH/Page1/RR523>.
- PriceWaterhouseCoopers. *Champion for Digital Inclusion: The Economic Case for Digital Inclusion*, October 2009. http://www.parliamentandinternet.org.uk/uploads/Final_report.pdf.
- Protheroe, Nancy. "Technology and Student Achievement." *Principal*, November 2005.
<http://www.naesp.org/resources/2/Principal/2005/N-Dp46.pdf>.
- Public Schools of North Carolina. "READY Anywhere!," October 31, 2013.
<http://www.ncpublicschools.org/docs/connectivity/ready-intro.pdf>.
- Representative of Blue Ridge Community College. "Interview with Author," September 10, 2013.
- Representative of Blue Ridge Electric Membership Corporation/RidgeLink LLC. "Interview with Author," September 10, 2013.
- Representative of Broadplex. "Interview with Author," September 10, 2013.
- Representative of CommScope. "Interview with Author," September 10, 2013.
- Representative of East Carolina University. "Interview with Author," September 12, 2013.
- Representative of ECC Technologies. "Interview with Author," September 09, 2013.
- Representative of Edgecombe County Public Schools. "Interview with Author," September 12, 2013.
- Representative of ERC Broadband. "Interview with Author," September 10, 2013.
- Representative of Lee County Schools. "Interview with Author," September 11, 2013.
- Representative of Mooresville Graded School District. "Interview with Author," September 09, 2013.
- Representative of Nash Community College. "Interview with Author," September 12, 2013.
- Representative of NC Broadband. "Interview with Author," September 11, 2013.
- Representative of North Carolina State Highway Patrol. "Interview with Author," September 2013.

Representative of North Carolina State University. "Interview with Author," September 09, 2013.

Representative of North Carolina Telehealth Network. "Interview with Author," September 13, 2013.

Representative of Richmond Community College. "Interview with Author," September 11, 2013.

Representative of Rutherford County Schools. "Interview with Author," September 10, 2013.

Representative of the North Carolina Department of Public Instruction. "Interview with Author," September 13, 2013.

Representative of Wake Forest University/Wake Forest Baptist Medical Center. "Interview with Author," September 10, 2013.

Representative of Yadtel Telecom. "Interview with Author," September 13, 2013.

Representatives of MCNC, and Representative of Golden LEAF. "Interview with Author," September 13, 2013.

Representatives of the University of North Carolina at Pembroke. "Interview with Author," September 11, 2013.

Richmond Community College. "About RCC," November 01, 2013.
<http://www.richmondcc.edu/about-rcc/>.

Rural Utilities Service, and National Telecommunications and Information Administration. "Broadband Initiatives Program & Broadband Technology Opportunities Program." *Federal Register* 74, no. 130 (July 09, 2009): 33104–34. <http://www.gpo.gov/fdsys/pkg/FR-2009-07-09/pdf/FR-2009-07-09.pdf>.

Rutherford County Schools. "Introduction to RCS," 2013.
[http://rcsnc.org/district_information/Introduction to RCS/](http://rcsnc.org/district_information/Introduction%20to%20RCS/).

Scarvell, Andrew. "Digital Literacy and Awareness in Australia' S New Global Frontier." In *First Media and Information Literacy Forum*. Fez, Morocco: UNESCO, 2011.
http://scarvell.net/andrew/blog/?page_id=15.

Schwarz, Alan. "Mooresville's Shining Example (It's Not Just About the Laptops)." *The New York Times*, February 12, 2012. http://www.nytimes.com/2012/02/13/education/mooresville-school-district-a-laptop-success-story.html?_r=0.

Shapley Research Associates, and Texas Center for Educational Research. *Final Outcomes for a Four-Year Study (2004–05 to 2007–08). Evaluation of the Texas Technology Immersion Pilot (eTxTIP)*, January 2009. <http://www.tcer.org/research/etxtip/>.

Shuler, Carly. *Pockets of Potential: Using Mobile Technologies to Promote Children's Learning*. New York, NY: The Joan Gans Cooney Center, January 2009.
<http://joanganzcooneycenter.org/Reports-23.html>.

The Recovery Accountability and Transparency Board. "Recovery API." *Recovery.gov*. Washington, DC, March 20, 2013.
<http://www.recovery.gov/FAQ/Developer/Pages/RecoveryAPI.aspx>.

- The South Dakota Bureau of Information and Telecommunications. "Broadband Benefits for Rural Areas," February 01, 2011. <http://broadband.sd.gov/Benefits-Rural.aspx>.
- . "Broadband Benefits for Rural Areas," February 01, 2011. <http://broadband.sd.gov/Benefits-Rural.aspx>.
- The State of Michigan. "The Benefits of Broadband," August 27, 2012. http://michigan.gov/broadband/0,1607,7-250-48184_48185---,00.html.
- Tufts, Shannon. "Interview with Author," September 09, 2013.
- United States Census Bureau. "2007-2011 ACS 5-Year Summary File." *American Community Survey*. Washington, DC, December 06, 2012. http://www.census.gov/acs/www/data_documentation/2011_release/.
- United States Department of Justice. Office of Justice Programs. Bureau of Justice Statistics. "Census of State and Local Law Enforcement Agencies (CSLLEA), 2008." *Directory of Law Enforcement Agencies Series*. Ann Arbor, MI: Inter-university Consortium for Political and Social Research, August 03, 2011. doi:10.3886/ICPSR27681.v1.
- United States Fire Administration. "National Fire Department Census Database," August 08, 2013. <http://apps.usfa.fema.gov/census/>.
- USDA Economic Research Service. "Rural Digital Economy: Online Activities." *Briefing Rooms*, August 13, 2009. <http://ers.usda.gov/Briefing/Telecom/demandservice.htm>.
- Valentine, Gil, Jackie Marsh, Charles Pattie, and BMRB. *Children and Young People's Home Use of ICT for Educational Purposes: The Impact on Attainment at Key Stages 1-4. RB672*, August 2005. <https://www.education.gov.uk/publications/RSG/Parentscarersandfamilies/Page12/RB672>.
- Van Deursen, A.J.A.M. "Internet Skills: Vital Assets in an Information Society." Enschede, The Netherlands: University of Twente, November 01, 2010. doi:10.3990/1.9789036530866.
- Wagner, Lindsay. "NC Schools and Districts Honored for High Graduation Rates." *The Progressive Pulse*, September 23, 2013. <http://pulse.ncpolicywatch.org/2013/09/23/nc-schools-and-districts-honored-for-high-graduation-rates/>.
- Wake Forest University. "Academics," November 01, 2013. <http://www.wfu.edu/academics/>.
- . "Common Data Set 2012-2013," November 01, 2013. <http://www.wfu.edu/ir/docs/cds2012wfu.pdf>.
- Wittwer, Jörg, and Martin Senkbeil. "Is Students' Computer Use at Home Related to Their Mathematical Performance at School?" *Computers & Education* 50, no. 4 (May 2008): 1558–1571. doi:10.1016/j.compedu.2007.03.001.
- Wynne, Maria E., and Lane F. Cooper. *Power Up: The Campaign for Digital Inclusion*. Office of Economic Development and Innovation, Microsoft Corporation, June 2007. http://www.digitalaccess.org/pdf/White_Paper.pdf.
- Yadtel Telecom. "About Us," October 31, 2013. http://www.yadtel.com/yadtel_telecom/about_us.php.