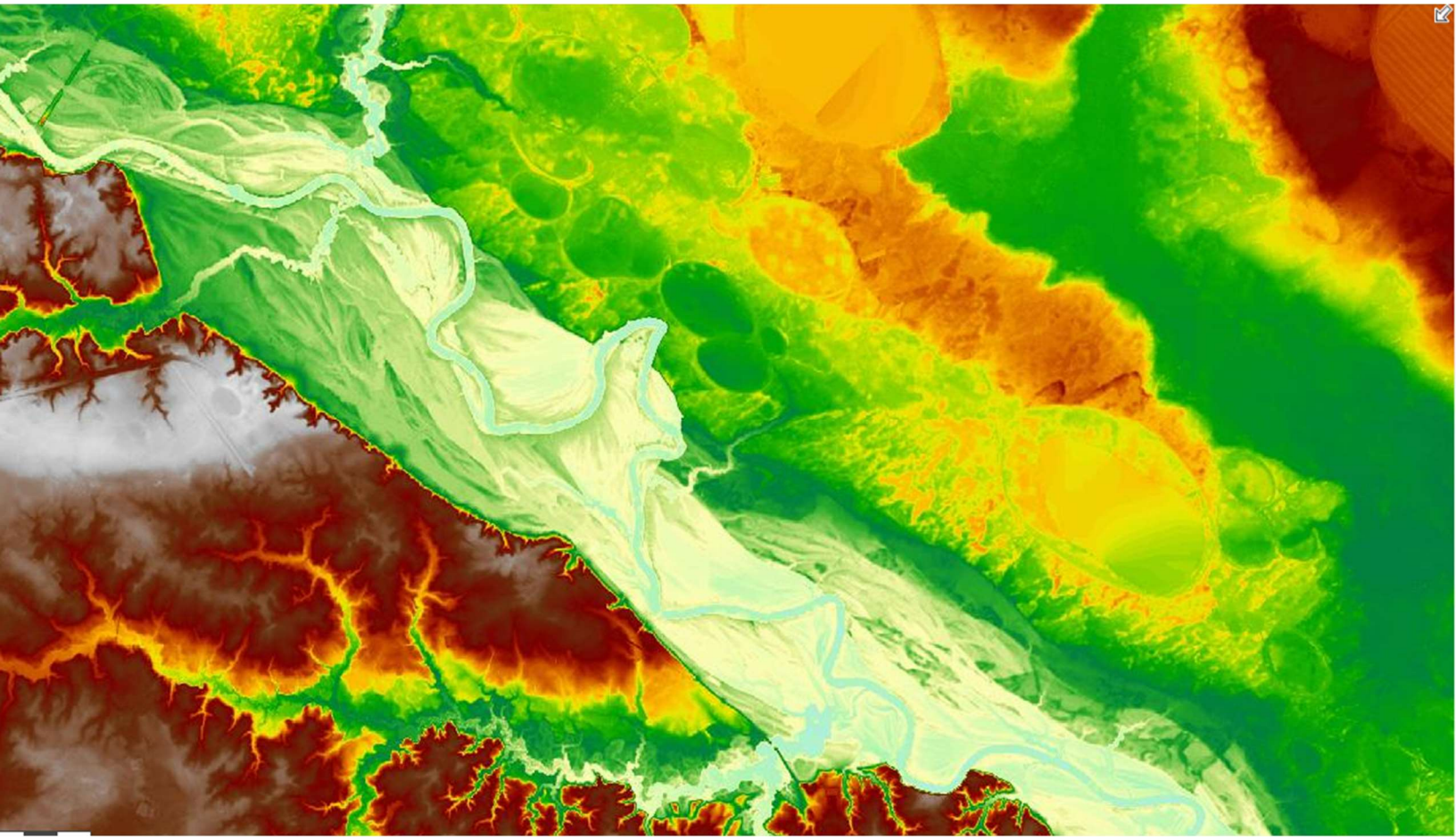
North Carolina Lidar Working Group

Business Plan



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Executive Summary

Light Detection and Ranging (lidar) derived elevation data is a fundamental dataset used by local, state, and federal agencies, public sector companies and non-profit organizations. Elevation data obtained with airborne lidar technology benefits a wide range of users of geospatial data in both the public and private sectors. The Statewide Mapping Advisory Committee (SMAC) of the North Carolina Geographic Information Coordinating Council (GICC) developed this North Carolina Lidar Business Plan to support the coordinated acquisition of seamless, statewide lidar-derived elevation data that meets or exceeds the United States Geological Survey (USGS) Three-Dimensional Elevation Program (3DEP) guidelines and standards.

Elevation data obtained with airborne lidar technology benefits a wide range of users of geospatial data, including private industry, agriculture, public agencies, non-governmental organizations, citizens, and educational institutions. Lidar data is routinely used in North Carolina to provide information about the elevation, contour, and characteristics of the Earth's surface in numerous applications throughout the state. Lidar data is used to identify features such as vegetation, road lines, structures, buildings, bridges and other features and infrastructure that may be hidden by tree cover and is often an alternative to costly field survey data when it is available. Some examples of the use of elevation data in North Carolina are:

1. **Floodplain mapping and flood warning**
2. **Engineering hydrologic and hydraulic analysis**, including stream mapping
3. **Land surveying applications**
4. **Identification and analysis of hazards**, such as landslides and flood, and determining structures and assets that may be at risk
5. **Change detection** to identify land surface changes, areas of development or coastal erosion, among many others
6. **Delineating watersheds and drainage areas**
7. **Engineering studies and engineering design services** and topographic surveys mandated by local zoning and permitting
8. **Mission critical activities** within Federal, state, and local agencies and local governments.

Estimating the Value of Lidar Benefits to North Carolina

To estimate the value of the benefit of lidar data at a national and state level, the National Oceanic and Atmospheric Administration (NOAA) and the USGS sponsored the 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022). The study included 45 federal agencies, 56 states and territories, and 58 non-governmental organizations to document national requirements for improved topographic and bathymetric elevation data and to estimate the benefits and costs of meeting these requirements. The study concluded that an improved national elevation program has the potential to generate over $13.5 billion in new benefits each year once a national elevation program is fully operational.

In North Carolina, state, territorial and regional governments, and academic and other non-governmental organizations participating in 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022), estimate gains of over $60.6 million in annual benefits from improved topographic and bathymetric elevation data in North Carolina. More detailed information about the study related to North Carolina can be found in the business plan.

Program Funding and Cost Considerations

For the two previous statewide lidar projects (2001-2005 and 2014-2017), data requirements differed. When North Carolina began the first statewide lidar project, no national guidelines/specifications were available. The North Carolina Floodplain Mapping Program worked with the Federal Emergency Management Agency (FEMA) and the USGS to develop guidelines and specifications for lidar data acquisition for the 2001-2005 statewide lidar project. The Coordinate Reference System used for the first two phases of statewide lidar acquisition was the North Carolina State Plane Coordinate System, North American Datum (NAD) 1983 (National Spatial Reference System (NSRS) 2001) datum for the 2001-2005 project and NAD 1983(2011) for the 2014-2017 project, with units of United States (US) Survey feet. Tiles have unique names and use a new naming convention (32 characters). The primary purpose of the statewide lidar projects was to support the floodplain mapping program and numerous other applications and uses and be readily available, free of charge, to the public and private sectors.

A statewide project necessarily has costs related to consistency, quality, completeness, maintenance of infrastructure for positional reference, data management, and public access to information. Based on costs for the two previous statewide lidar projects and the current statewide project (2020-2025), a total cost on the order of $465 per square mile or less (or about $25 million) would appear to be achievable for all cost components including geodetic services, program management and data access.

The dominant risk to the lidar program is the lack of dedicated yearly funding. There have been as many as 14 years between previous lidar updates with the common recommendation being 8 years or fewer. The orthoimagery program, with a history of dedicated yearly funding, has demonstrated the success and cost savings that can be achieved when data is regularly maintained. Regular updates are critical to meeting the needs of important data users including floodplain mapping, transportation, and economic development.

Program Management

To achieve the goals of the GICC regarding lidar elevation data for the state, the SMAC recommends a collaborative approach to future projects to take advantage of the experience and expertise of the agencies that managed and performed two statewide lidar projects and currently managing a third statewide project.

As a prime example, the following approach was used in the two previous (2001-2005 and 2014-2017) and the third statewide lidar elevation project that started in 2020.

- Overall program management was the responsibility of North Carolina Emergency Management (NCEM) in partnership with North Carolina Department of Transportation (NCDOT) taking advantage of agency lidar project management experience and capabilities. This expertise includes program management, lidar data acquisition, quality assurance and control, and data distribution.

- Management of geodetic control and horizontal quality control and related equipment was the responsibility of the NC Geodetic Survey (NCGS) to utilize experience managing and performing quality control in the field, maintaining datasets for control, and managing a statewide network of reference stations. The NCGS collaborated with NCEM for efficient workflow.

- Public access to lidar and elevation data (data download) and distribution of lidar data products is being managed through NCEM's Spatial Data Download (https://sdd.nc.gov/) and NC

OneMap (https://www.nconemap.gov/pages/elevation). In addition, NCEM and NCDOT have provided outreach in the form of presentations at conferences, workshops, and other public events and website updates.

As a framework, the recommended funding approach is to continue statewide lidar data collection (including lidar data acquisition, data access, data distribution, program management and investment in geodetic control) and work with the following groups to obtain funding that will support the recommendations contained in this plan:

- USGS 3DEP program (https://www.usgs.gov/3d-elevation-program)
- Other Federal agencies (NOAA, FEMA, and USDOT).
- State Agencies
- Local Governments
- Public-Private partnerships (utilities companies and nonprofits)
- Funding from federal and state agencies, local governments, private companies, and non-profits will depend on project locations, requirements, and availability of funds.

The SMAC recommends changing the data collection plan from five (5) phases to four (4) phases. A four-phase plan as shown in the figure below would be designed to match the NC 911 Board Statewide Orthoimagery Program areas and each phase would be collected one year in advance of the aerial imagery data collection.

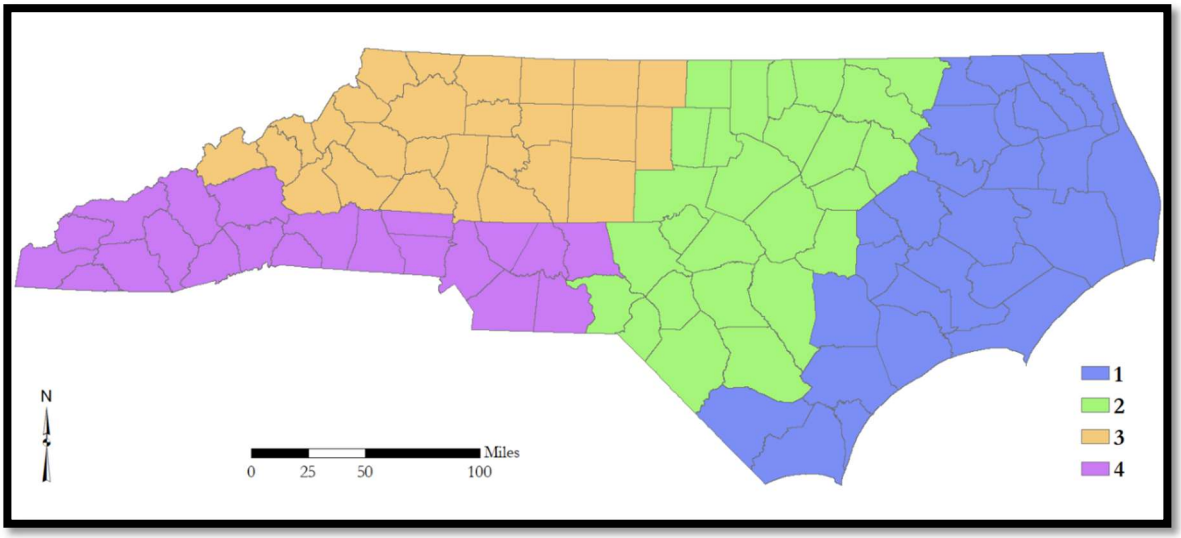

Figure 1 Proposed lidar phases will support frequent updates and provide valuable elevation data for the orthoimagery program quality control process.

The SMAC recommends completing the current (2020-2025) statewide lidar data collection project using the existing five-phase plan and the North America Datum of 1983, National Geodetic Vertical Datum of 1988, and Geoid18. For future lidar data collection projects the SMAC recommends utilizing the four-phase plan that matches the NC 911 Board Statewide Orthoimagery Program areas and recommends using the North American Terrestrial Reference Frame (NATRF2022), North American-Pacific Geopotential Datum of 2022 (NAPGD2022), Geoid2022, 2022 North State Plane Coordinate System, and the International Foot.

Recommendations Summary

Lidar Working Group Business Plan Recommendations
1. Recognize lidar as a critical framework dataset that brings millions of dollars in benefits to the citizens of North Carolina
2. Identify a regular funding mechanism to update lidar data on a four-year cycle
3. Lidar data should be QL1 or better meeting USGS and ASPRS standards
4. Take advantage of federal partnerships for program continuity and cost savings
5. Take advantage of state agency lidar and project management expertise for program oversight
6. After the current cycle is completed, begin collection using the NATRF2022, the NAPGD2022, GEOID2022, and the 2022 North Carolina State Plane Coordinate System

Introduction

Lidar technology has an impressive history in North Carolina. As an early adopter of lidar technology, North Carolina began its first statewide collection in the year 2001. This first generation lidar was completed in 2005. At the time, it was cutting edge technology at one point every three meters with 25-centimeter accuracy. A second lidar collection (second generation) occurred between 2014 and 2017, and advances in lidar technology produced a product with 30 points per square meter and 10 cm accuracy. The most recent update began in 2020 and is ongoing.

Lidar data is critical to floodplain mapping, transportation planning, economic development, energy corridor protection, hydrographic analysis, and risk analysis for erosion, wildfire, and coastal hazards. Due to the importance of lidar to these programs, the North Carolina Floodplain Mapping Program (NCFMP), NCGS, and NCDOT have collectively funded and managed lidar acquisition. Important partnerships have been fostered with the USGS 3DEP.

Program History

Lidar is described by its Quality Level (QL), and over the past 18 years, North Carolina's lidar quality level has increased. Quality Levels are determined by the nominal pulse spacing (density of collected points per square meter) and vertical accuracy as a Root Mean Square Error (RMSE) among other specifications. The first generation lidar was QL3, while subsequent collections have improved to QL2 and finally QL1. Technology and specifications for lidar have been substantially improved since the first statewide collection in 2001-2005. Technology advances include improvements to the sensors and processes for managing this level of data, as well as software advancements which allow for ease of data use.

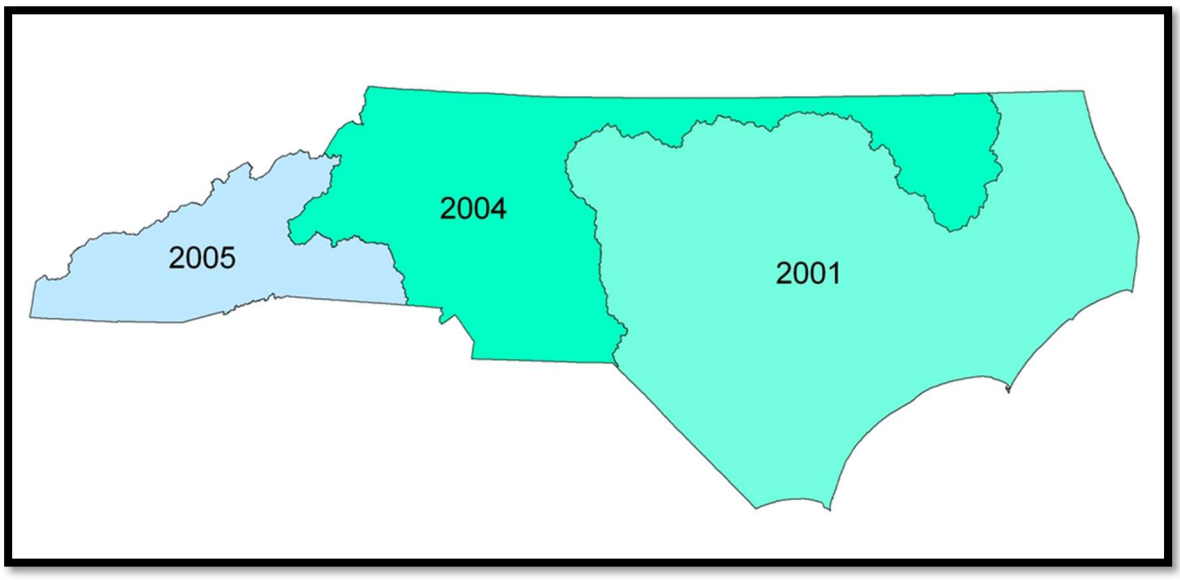

Figure 2: First lidar collection areas in North Carolina. (First Generation 2001-2005)

Quality Level	$RMSE_z$ (non-vegetated area) (m)	NVA at the 95-percent confidence level (m)	VVA at the 95th percentile (m)
QL0	≤ 0.050	≤ 0.098	≤ 0.15
QL1	≤ 0.100	≤ 0.196	≤ 0.30
QL2	≤ 0.100	≤ 0.196	≤ 0.30
QL3	≤ 0.200	≤ 0.392	≤ 0.60

Table 1. Absolute vertical accuracy in meters(m) for lidar data and digital elevation models.
RMSEz: Root mean square error in z
NVA: Non-vegetated vertical accuracy
VVA: Vegetated vertical accuracy

In 2014, after a fourteen-year gap since the first lidar collection, the NCFMP, NCGS, and NCDOT initiated a 2nd Generation Statewide Lidar acquisition. The data was initially acquired at two (2) points per square meter or Quality Level 2 (QL2) as defined by USGS. Since 2014, approximately sixty (60) counties have been acquired at this standard. Lidar collection occurred in phases covering approximately twenty counties in each phase. North Carolina acquired Phases 1-3 (coastal and eastern piedmont) at the accuracy standard of Quality Level 2 (2 points per square meter). The second generation lidar points were classified to identify ground, three vegetation heights, bridges, buildings, and water. This improved classification facilitates vegetation calculations, potential for wetland determination, automated building detection with details of lowest and highest adjacent grade and elevation of structure, and classification of the road networks and bridges for planning road construction.

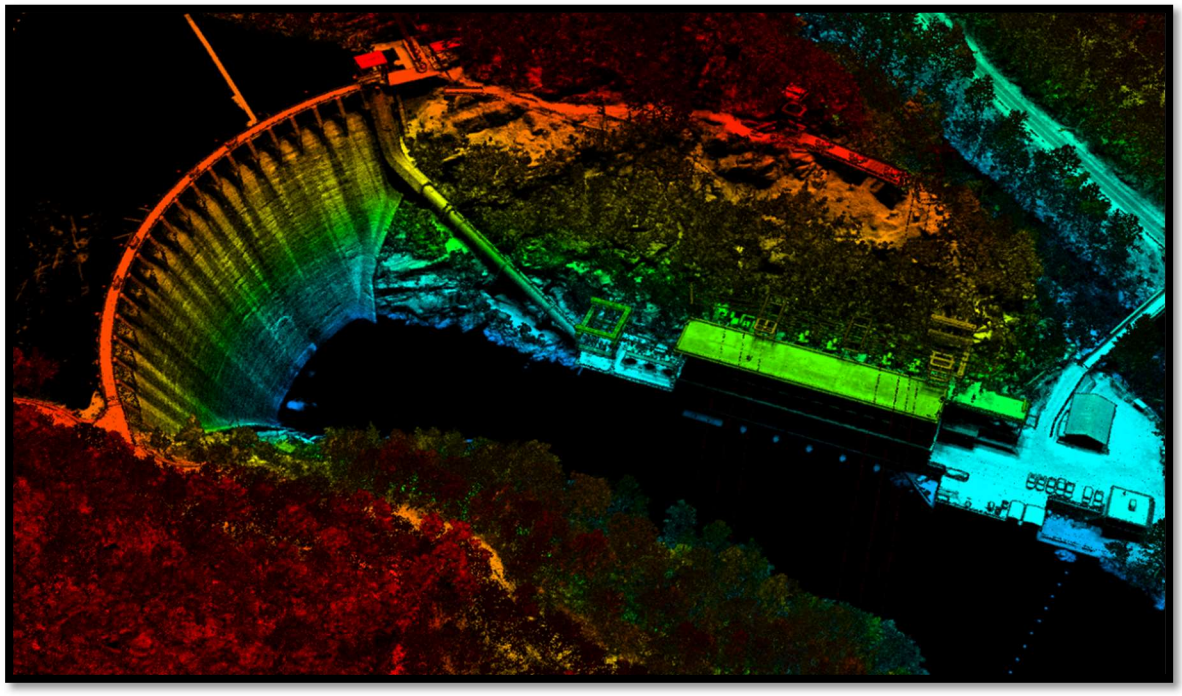

Figure 3: Geiger-mode lidar data for Fontana Dam

In 2015, a new technology became commercially available. Geiger-mode lidar, which had been extensively used by the United States military, was tested in North Carolina. The NCFMP and NCGS tested two different Photon Counting sensors alongside a traditional sensor at a high-density acquisition. The NCFMP performed a quality control review of the vertical and horizontal accuracies. Geiger was determined to be a highly beneficial set of data which would allow for highly accurate stream determination, automated extraction of building footprints, as well as potential for a high level of utility determination. Phases four and five acquisition utilizes the new Geiger technology. This technology allows for the collection of lidar at a much greater density, potentially one hundred (100) points per meter, as well as much faster collection with the potential of being able to collect lidar for the state in one year. The phases four and five (mountains and western piedmont) deliverables were collected at thirty (30) points per square meter which would allow for utility collection such as power lines and transmission towers. An eight (8) point per square meter deliverable (QL1 data) was provided to the state along with the 30 points per square meter dataset. This technology also allows for greater coverage in urban areas between buildings and extreme detail on road networks. Quality Level 1. Lidar was acquired and incorporated into the production of special flood hazard areas (SFHAs), with North Carolina updating over 30,000 miles of studies and generating new base flood elevations.

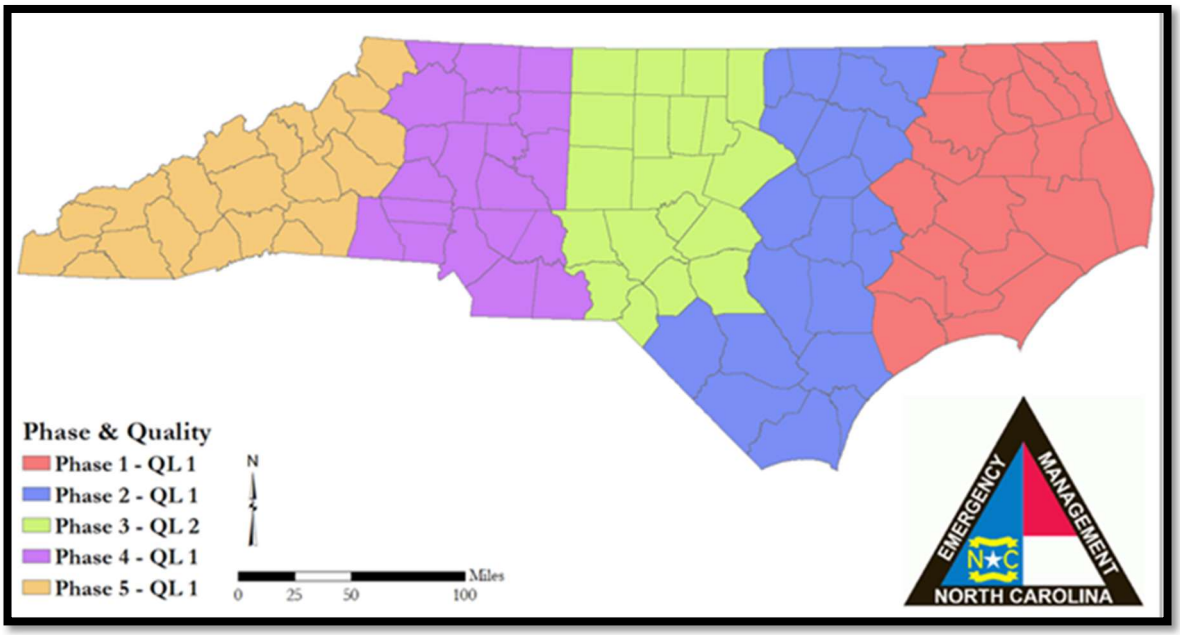

Figure 4: Status of lidar data collection in North Carolina as of 12/31/2023.

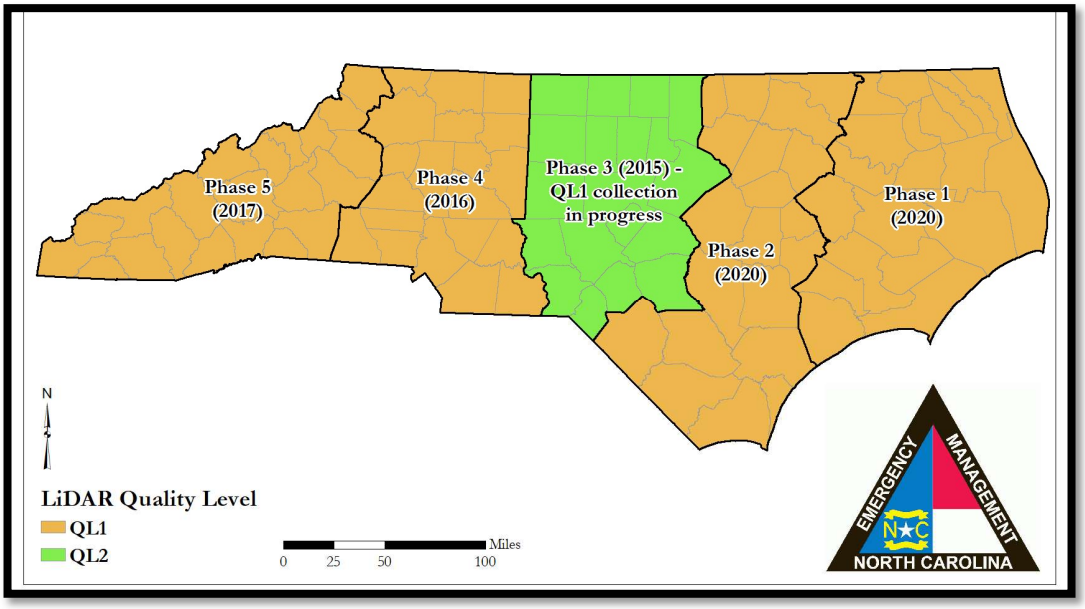

Figure 5: 2024 lidar project area

The NCFMP, NCGS, and NCDOT (additional funding partners are Chatham County and the United States Forest Service) are now on the 3rd statewide data collection. In 2020, the USGS and National Oceanic and Atmospheric Administration (NOAA) collected new Quality Level 1 (QL1) LIDAR elevation data in eastern North Carolina for Phases one and two. This data was fully delivered to North Carolina in 2022. The USGS and NOAA 2020 lidar project included inland topographic and coastal bathymetric lidar data collection. The QL1 2020 data collected in eastern NC has been converted to NCSPC, US Survey Feet, and tiled to the NC lidar tiling system. Using the 2020 lidar data NCEM has developed Digitial Elevation Models (DEM) Mosaics by county in 3.125, 5, 10, 20, and 50 foot cell size.

For more information about the history of lidar projects in North Carolina, go to [this storymap link.]

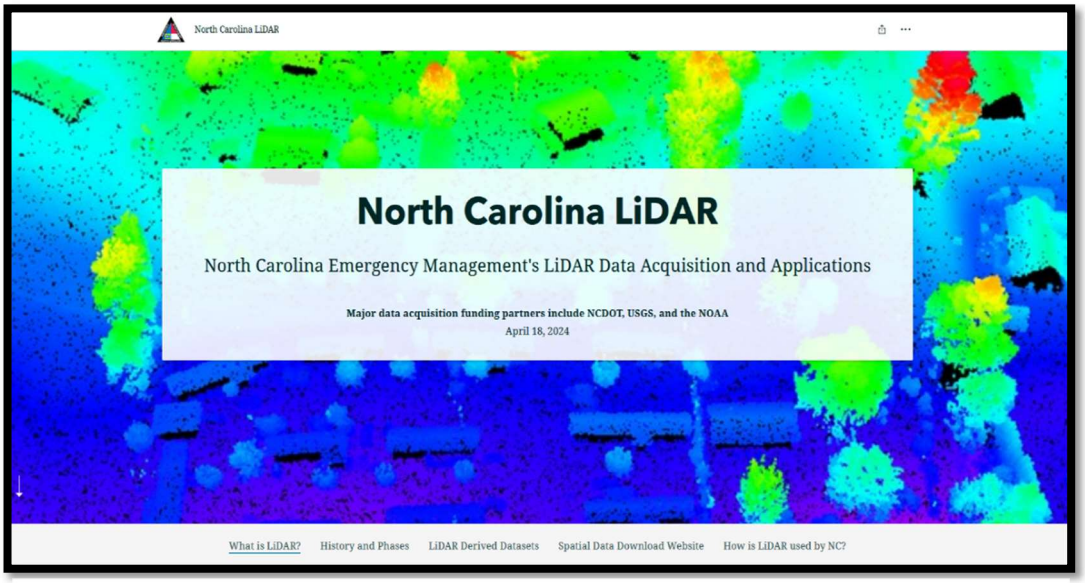

Figure 6: Lidar story map created by NC Emergency Management.

Lidar Overview

Aerial lidar is a unique and beneficial technology supporting multiple initiatives for engineering, planning, government, and environmental use cases. Lidar systems consist of a laser scanning sensor that emits millions of pulses of light per second, coupled with Global Navigation Satellite System (GNSS) technology and an inertial measurement unit (IMU) to position data accurately. Each pulse of light reflects off a feature's surface, such as a building, vegetation, or the ground, and is returned to the lidar sensor, accurately measuring that feature's elevation and horizontal location. These laser pulses are processed and finally generated into a “point cloud (points of all X, Y, and Z values of returns)," representing the project area's features and elevations, and can be used to create powerful and valuable mapping products, such as surface models and hydrography networks.

NOAA provides more information on lidar, lidar collection, and its uses on their Digital Coast website and at the National Geodetic Survey’s lidar web page (What is LIDAR? | NGS Facts | NGS INFO - About Us | National Geodetic Survey (noaa.gov)

Aerial Lidar

Aerial lidar has brought digital mapping to a new age, where highly accurate lidar point clouds have produced advanced topographic mapping products across the entire United States. Both raster and vector datasets can be created using lidar point cloud data, such as digital elevation models and building outlines. Accurate lidar data and derivative products, such as lidar point clouds and surface models, are now readily available for public use across most of the United States with regard to the USGS' 3DEP (https://www.usgs.gov/3d-elevation-program). Furthermore, lidar can be incorporated into aerial photogrammetric mapping and conventional land surveying practices, which can enhance the productivity of collecting mapping data and, in many instances, can significantly increase the vertical accuracy of aerial mapping products.

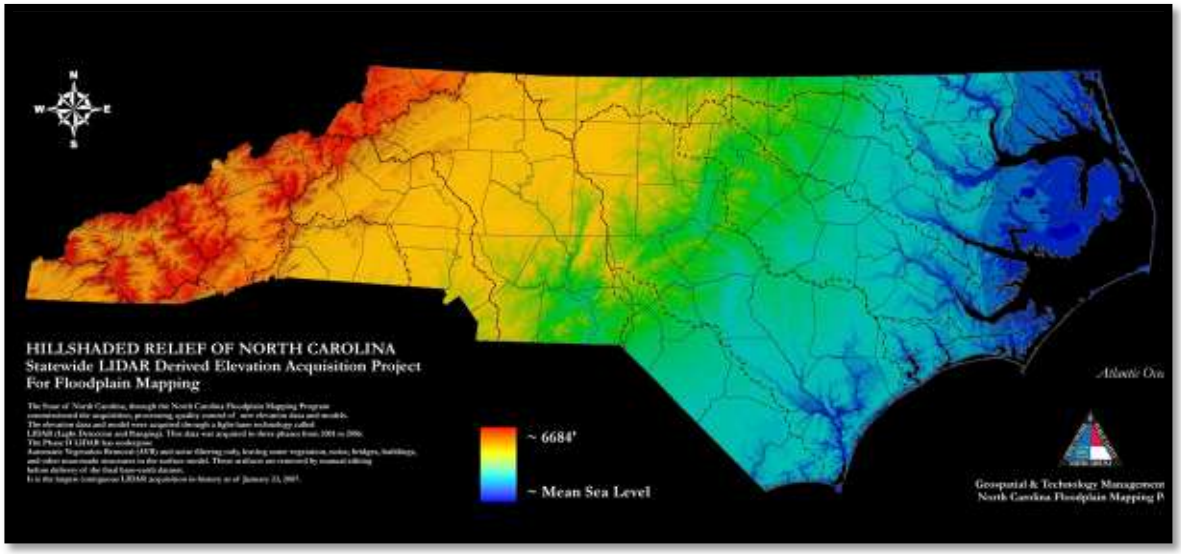

Figure 7: Lidar derived Digital Elevation Model (DEM) Circa 2000-2005.

Airborne Topobathymetric Lidar

Nearshore airborne topobathymetric (topobathy) lidar uses a green laser or near infrared lidar to collect topographic data for dry land and submerged areas. Collection depths maximums are dependent on water clarity and collection instrumentation. Topobathy lidar is more expensive and difficult to obtain than lidar collection on dry land. However, this technology fills a gap in collection of bathymetric data in areas too shallow for traditional survey ships.

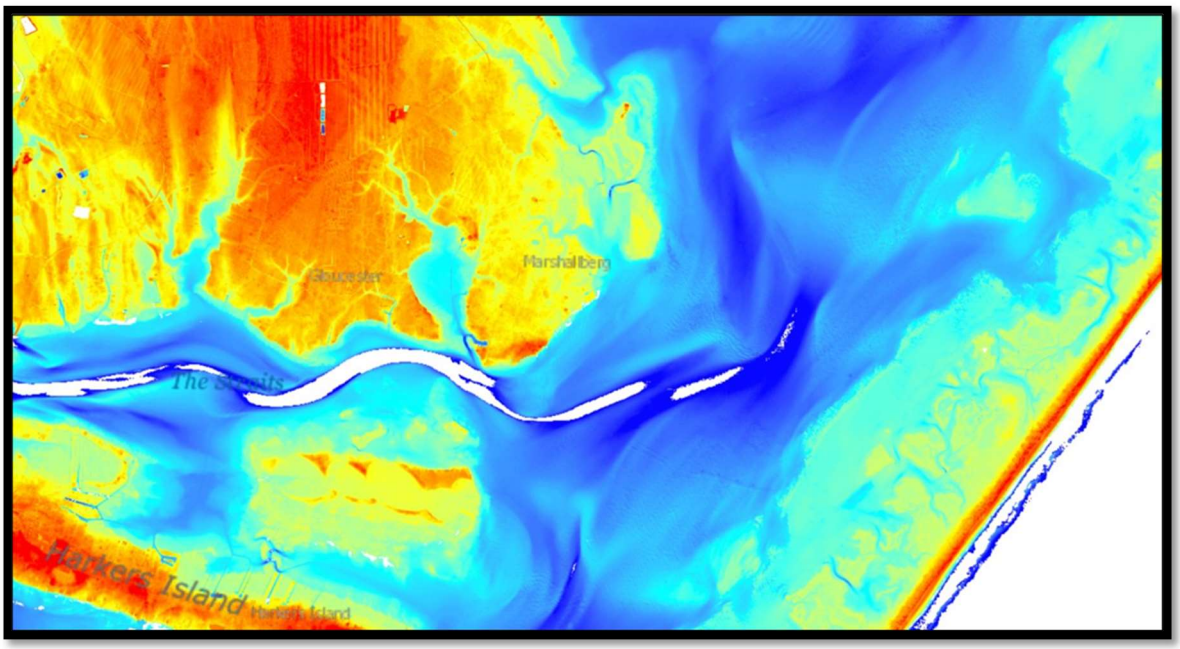

Figure 8: Example of bathymetric lidar data collected along the NC coast as part of the 2020 USGS lidar project. (Source: National Geodetic Survey)

Topobathy lidar data provides valuable information for navigation, coastal zone management, flood modeling, and sediment transport. The data collected by topobathy lidar can support engineering projects such as coastal infrastructure development, dredging operations, and beach nourishment efforts by providing detailed topographic and bathymetric information. For more information on topobathy lidar, please visit:

Coastal Topobathy Lidar (noaa.gov)

Business Plan Purpose

The purpose of the business plan for lidar is to highlight the importance of lidar data, to develop a plan for yearly collection in a phase of North Carolina, and provide options for funding lidar data collection.

The Floodplain Mapping Program, NCEM and the NCDOT have been working with federal, state, and local partners since 2000 to obtain funding to collect statewide lidar data. This has limited the consistent collection of statewide lidar data. Lidar data in phases 1-3 have been collected when funding has been obtained.

The Statewide Mapping Advisory Committee (through the GICC) has played a key role in advising NCEM and NCDOT in each phase in planning the three statewide data collection projects. NCEM and NCDOT are

fully engaged in the past and current statewide lidar data collection process and should be considered as the data stewards and authoritative source for this critical framework data.

Lidar Program Goals

Obtain sustainable yearly funding for keeping high resolution statewide lidar data current and accessible. “Sustainable” means a consistent, yearly source of funding. “Current” means that lidar data was captured within one of the last five years on a county basis. “Accessible” means that lidar data users have online access to map services and downloadable files, and that online map services meet user requirements to support all geospatial client applications.

Lidar Benefits to North Carolina

Lidar data is routinely used in North Carolina to provide information about the elevation, shape, and characteristics of the Earth’s surface in a number of applications throughout the state. Lidar data is used to identify features, such as vegetation, road lines, houses, buildings, and other features and infrastructure that may be hidden by tree cover and is often an alternative to costly field survey data when it is available. Lidar is vital in engineering hydrologic and hydraulic analysis and plays a crucial role in the identification and analysis of hazards, such as landslides and flood, and determining structures and assets that may be at risk. Routine collection of lidar allows change detection to identify, for example, land surface changes, areas of development, or coastal erosion, among many others. The private sector routinely uses lidar for engineering studies and engineering design services and topographic surveys mandated by local zoning and permitting regulations. Furthermore, many state agencies and local governments utilize lidar to perform mission critical activities.

The NCDOT uses lidar for many applications where elevation or grade information is needed over a larger area or high traffic area as an alternative to field survey data. This includes using lidar to efficiently and reliably estimate structure/asset elevations that include roadway and bridge surfaces. The elevations derived from lidar are used as the ‘Bridge Overtopping’ threshold in the NCDOT’s BridgeWatch application and roadway elevations in the Flood Inundation Mapping and Alert Network for Transportation (FIMAN-T) to identify roadway inundation. Both applications monitor, in real-time, valuable transportation infrastructure subject to potentially hazardous conditions and provide NCDOT officials and Emergency Managers real-time alerts to respond to dangerous or critical conditions. North Carolina is the only state in the nation at this time that has implemented this amount of structure-based freeboard and overtopping thresholds statewide. As the lidar program is maintained and updated statewide, the continued classification of “roadway” and “bridge” will provide an efficient means for updating these critical values as the BridgeWatch and FIMAN-T systems expand.

Mapping using lidar supports the Earth Mapping Resource Initiatives (MRI) Program, the U.S. GeoFramework Initiative, and the North Carolina landslide inventory and modeling and supports a comprehensive landscape analysis to identify potential critical mineral deposits, geologic hazards, surface water flowpaths, and possibly, groundwater vulnerability when combined with additional analyses. The NC Dept. of Environmental Division of Coastal Management has utilized lidar to interpret Mean High Water (MHW) shorelines and look at beach foreshore and dune changes. And the N.C. Department of Agriculture and Consumer Services utilize lidar data as an engineering survey supplement to prepare engineering designs and reports for a variety of agricultural, forestry, and stormwater best management practices.

The NC Geological Survey regularly uses lidar data products for detection, identification, analysis and mapping of landslides, surficial deposits, and other landslide-related landforms. The resulting maps are delivered to the public via ArcGIS Online where concerned citizens can view and interact with feature data layers that describe locations of past landslides and areas susceptible to future landslides. Additionally, the NCGS uses lidar for channelized debris flow modeling, to perform landform analysis and identify bedrock structure, for coastal plain mapping to identify potential geologic hazards, surface water flow paths, and areas for critical mineral exploration, among others. Continued lidar collection is critical to the NC Geological Survey for the detection and measurement of land surface changes to identify, for example, (1) newly developed landforms caused by the occurrence of new landslides, (2) removal of landslide-related landforms due to changes in land use, such as, construction and timber harvest, (3) lidar differencing to detect changes in elevation caused by erosion, deposition, and sedimentation related to landslides and debris flows, and (4) periodic monitoring of slow-moving landslides to understand average rates of movement and total displacement.

Uses of Lidar Data
Floodplain mapping
Flood Warning
Transportation network
Hydrographic purposes
Erosion delineation
Economic development
Energy corridor planning and management
Wildfire management, planning, and response
Aviation navigation and safety
Natural resources conservation
Mitigation and resilience projects
Precision agriculture
Geologic Mapping

Table 2: Important uses of Lidar Data in North Carolina

Private developers routinely use lidar for development projects. Lidar can be used to identify and note areas where a potential project may be suitable, borderline, or unsuitable for development. Private practice uses of lidar data in land surveying include calculating steepness of slopes, preliminary subdivision design, storm pipe design, drainage area calculations, sub meter location of features such as creeks, streams, and watercourses, roads and roadbeds, ridgelines and identifying areas with dense vegetation that may require additional field time for survey crews. The topographic data is used during feasibility portion of the project to plan for civil design including sanitary sewer, storm sewer, roadway plans, and others. Lidar data allows better cost analysis to be performed before projects reach preliminary design allowing project decision makers to have a clearer picture of costs, timeline, environmental impact, and scope.

Local governments also use lidar to manage their jurisdictions. For example, the Town of Apex uses lidar data for digital elevation models, hillshades, and surface morphology for visualization and determination of features hidden by tree cover. The Town of Apex has further used lidar to identify draws for water flow and to locate abandoned roads no longer in use. Lidar was used to determine the height of existing buildings along the main street of Apex to develop new building codes for downtown building heights. Furthermore, the use of lidar has been incorporated into the town's Unified Development Ordinance (UDO) for Single-Family Residential Grading and Resource Conservation Areas as an alternative to field verified topography. The Town of Apex has a continued need to use lidar data to generate specific feature classes, such as roadway curb and building footprints, as the town continues its rapid development.

Elevation models derived from lidar also play a major role in the NC 911 Board's Statewide Orthoimagery Program. These elevation models are used by the program to create an orthophoto

through a process called differential rectification which eliminates image displacements due to photographic tilt and terrain relief. This process also rectifies the imagery to a uniform scale so measurements such as distance, angle, position, and area can be made directly from the orthophoto. If the elevation data is not current or if the region has experienced substantive growth since the last elevation data was produced, the imagery produced will have errors and distortions that will need to be corrected by manually editing the elevation model. This increases the costs associated with the imagery project. Therefore, having elevation data with a consistent maintenance plan and high-level of accuracy will reduce the costs to the NC 911 Board.

These are only a few of the use cases of lidar to the State of North Carolina. Lidar is used in many more applications throughout the state and supports cost-efficient and accurate information in applications that would otherwise be impractical or too costly if lidar data were not available. Because lidar is a relatively new technology, the use cases of lidar are expected to grow in the future. The next section looks at the value of lidar benefits to North Carolina.

Estimating the Value of Lidar Benefits to North Carolina

To document national requirements for improved topographic and bathymetric elevation data and to estimate the benefits and costs of meeting these requirements, the NOAA and the USGS sponsored the 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022).[1] The study included 45 federal agencies, 56 states and territories, and 58 non-governmental organizations.

Respondents were asked to provide both a qualitative and quantitative estimate of the future benefits their program would gain from meeting their 3D elevation data requirements. Future annual benefits were estimated for the following categories:

Operational Benefits, which include time savings, cost savings or cost reductions (e.g., savings on purchases), increased revenues to the organization, and mission-driven performance improvements. Respondents were asked to estimate both qualitative and quantitative (dollar) future annual benefits in either hours (annual or monthly) or as dollars.

Customer Service Benefits, which include value added to products or services, improved response or timeliness, and improved customer experience. Respondents were asked to estimate both qualitative and quantitative (dollar) future annual benefits in either hours (annual or monthly) or as dollars.

Societal Benefits, which include education or outreach; environmental benefits; and public safety, including life and property. Respondents were asked to provide a qualitative estimate of future annual benefits their program as “Major,” “Moderate,” “Minor,” “None,” or “Don’t know.”

Nationwide, the results of the study report that an improved national elevation program has the potential to generate over $13.5 billion in new benefits each year once fully operational, of which $7.6 billion of annual benefits were reported for state, regional, county, local, and tribal governments. It is important to note that the reported benefits were those that could be estimated only by federal agencies, states and territories, and NGOs willing to participate in the study. These benefits are likely undercounted for several reasons, including difficulties in estimating dollar benefits generally, but

[1]Dewberry (2022) 3D Nation Elevation Requirements and Benefits Study. Available at https://www.dewberry.com/services/geospatial-mapping-and-survey/3d-nation-elevation-requirements-and-benefits-study

especially for societal and intangible benefits, the lack of participation of private industry due to competition and privacy concerns, and the underreporting of benefits to secondary and tertiary business uses, among others.[2]

In North Carolina, state, territorial, and regional governments, and academic and other non-governmental organizations, participating in 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022), estimate to gain over **$60.6 million in annual benefits** from improved topographic and bathymetric elevation data. Figure 9 below reports the estimated annual benefits to North Carolina from lidar by business use. The business uses of Geologic Assessment and Hazard Mitigation, Flood Risk Management, and Infrastructure and Construction Management account for nearly 50% of the estimated total benefits of lidar to North Carolina. However, lidar benefits were reported for 22 unique business uses.

Figure 9: Estimated Annual Benefits to North Carolina from Lidar Data by Business Use (Source: Data from 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022))

In addition to the business uses that lidar supports, Figure 9 presents the annual benefits of lidar by the mission critical activity that would not be possible without lidar data. Lidar is critical to geologic mapping and analysis, transportation infrastructure, coastal zone management, and hazard identification and mitigation. These four mission critical activities account for over half of the estimated benefits of lidar with $32.8 million of annual benefits to these mission critical activities performed by state agencies and organizations reported in the USGS's 3D Nation Elevation Requirements and Benefits Study (Dewberry 2022). Lidar is also critical to and provides benefits to a number of additional important mission critical activities performed by agencies and organizations throughout the state, as presented in Figure 10 below.

[2] Please see Section 8.4 of the 3D Nation Elevation Requirements and Benefits Study (2022) for a broader discussion of undercounted benefits.

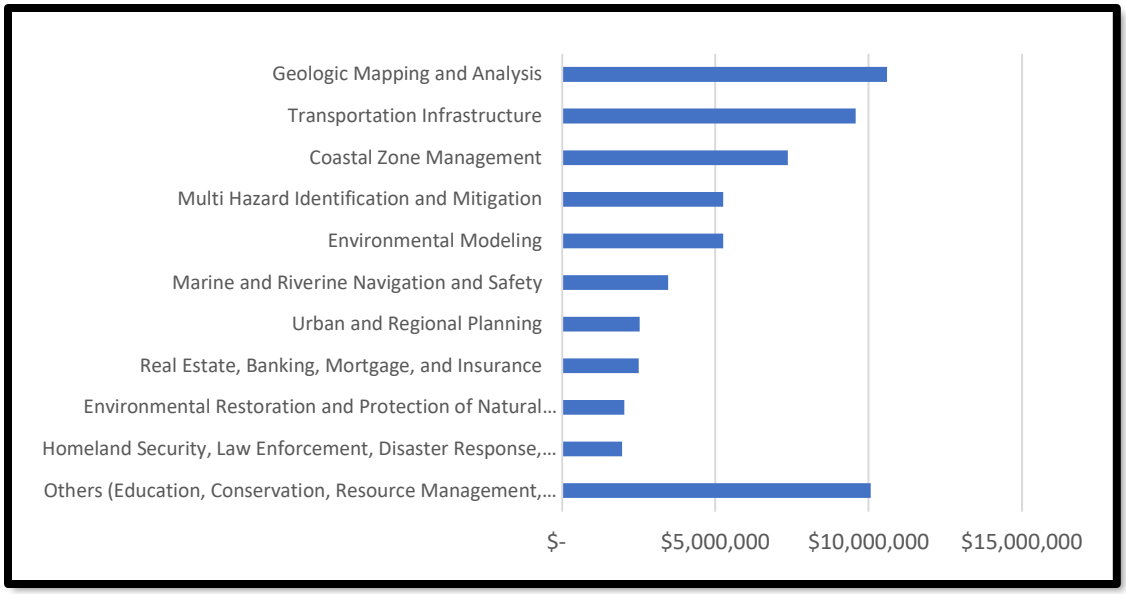

Figure 10: Estimated annual benefits to North Carolina from Lidar data by mission critical activity.

It is estimated that approximately 75% of the total of $60.6 million annual benefits to North Carolina from lidar data, i.e., $45 million in annual benefits, are from inland topography. Inland and nearshore bathymetry each account for approximately 12% of the total annual benefits, e.g., over $7 million each. Reported benefits from offshore bathymetry were nearly $100,000 a year. Monetary estimates were not provided for all benefits, and it is expected that the total benefits of lidar to North Carolina are higher.

What is the Cost of Lidar Acquisition in North Carolina?

This section offers cost estimates based on past projects in North Carolina and information from the USGS 3DEP.

Using data from past lidar projects, it is estimated that a statewide project would cost on the order of $25 million, or about $645 per square mile based on the recommended specifications (Quality Level 1). Therefore, an ongoing lidar program that captures data for one-fourth of the state annually is estimated to cost $6 million to $7 million per year on average with acquisition in the western regions to be more expensive per square mile due to increased flight requirements. The original statewide (2001-2005) lidar cost was $25 million for the project.

The cost for both statewide projects did not account for significant costs incurred as in-kind services by state agencies (NCFMP, NCGS, and NCDOT) that collaborated on the project, including project planning, contractor management, quality control, data distribution, and technical services.

For any county or statewide project, most tasks are assigned to private contractors that have invested in equipment, expertise, and methods and are licensed in North Carolina to provide professional land surveying services and provide lidar specific deliverables that adhere to USGS 3DEP and State specifications.

As explained in the funding section, contractors are acquired by the NC Qualifications-Based Selection (Mini Brooks) process which is a qualifications-based selection process that includes negotiation of price after selection of a qualified contractor. Project components include:

- Flight planning,
- Establishing ground control points,
- Lidar data acquisition (flights) and,
- Creating or updating a digital elevation model.

The cost for components of a lidar project are variable from year to year and county to county, influenced in part by contractor investment in equipment, availability of appropriate aircraft, fuel prices, labor costs, flight plan variations to accommodate differences in terrain, and other factors.

Cost components also include management of contractors, which includes evaluating proposals, contracting, product review and acceptance, and management of a statewide program. In addition, data distribution and public access are cost components for a statewide program to assure data sharing to realize benefits to lidar data users.

National Lidar Cost Considerations

The USGS provides cost estimates for the collection of topographic lidar for inland topography at various quality levels within the continental United States (CONUS), ranging from QL0HD to QL2. Acquisition costs are based on average estimated government contractor costs and include contractor Quality Assurance/Quality Control (QA/QC), ensuring seamless data in the area of interest, and lidar product generation. These costs do not include government validation of the contractor's work, derivative product generation, government IT costs for data sharing, or government contract management costs.

Acquisition costs vary by an estimation of the difficulty to collect and process lidar data in different areas. Difficulty factors that affect costs include considerations such as slope, canopy cover, other land cover, and urban density. Examples of difficulty factors include the following:

- **Easy:** Little slope or canopy cover, no large urban or suburban areas;
- **Medium:** Low and medium density urban environments; medium slopes, 25-50% canopy cover; dense grasses; and
- **Hard:** Hard to process due to large urban environments; high slopes; evergreen forest, 50- 100% canopy cover, wetlands.

Table 3 below presents the national average estimated costs to collect topographic lidar per square mile by the level of difficulty of collecting lidar in the area.

Quality Level	Lidar Cost/sq. mi. CONUS Easy	Lidar Cost/sq. mi. CONUS Medium	Lidar Cost/sq. mi. CONUS Hard
QL0HD	$663	$813	$1,068
QL0	$530	$650	$854
QL1HD	$441	$541	$711
QL1	$353	$433	$569
QL2	$190	$220	$325

Table 3. Average estimated costs to collect topographic lidar per square mile (2022). (Source: Dewberry (2022) 3D Nation Elevation Requirements and Benefits Study.)

Based on the estimates in Table 3, the cost of collecting QL1 statewide topographic lidar in North Carolina with 53,819 square miles of land and assuming one-third of the state as easy, one-third as medium, and one-third as hard, statewide topographic lidar costs are estimated at just under $25 million. This results in an annual cost of topographic lidar acquisition of around $6 million to $7 million, assuming topographic lidar needs to be updated every 5 years, i.e., one-fifth of the state is updated annually. This estimate is in line with lidar program costs based on past North Carolina Floodplain Mapping Program and North Carolina Geodetic Survey projects.

Similar estimates are provided by the USGS to estimate the acquisition of inland, nearshore, and offshore bathymetry should these be included as part of the statewide elevation data acquisition program.

The DEQ Flood Resiliency Blueprint includes information on the benefits of lidar data and the need for a scheduled statewide data collection cycle of lidar data. The cost associated with developing various datasets are shown in Table 4.

Statewide Dataset	Estimated Costs
Statewide High Resolution Topographic Data	$3.55M - 4.8M (Annually)
Bathymetry	Variable based on collection method $2,500-$7,500 / square mile
Building Data	$2.0M

Table 4. Cost to develop or update recommended datasets. (Source: Draft DEQ Flood Resiliency Blueprint)

Using past statewide lidar data collection cost information, the cost estimates for the current (2020-2025) statewide data collection project, USGS 3DEP program for a project phase in North Carolina, and the cost estimates from the DEQ Flood Resiliency Blueprint, $25 million is the estimated cost of collection, processing, management and distribution of a statewide lidar project on either on a five (5) year or four (4) year cycle.

Lidar Standards

Since the development of the USGS 3DEP Program, NCEM and NCDOT have used the 3DEP base specifications for the 2014-2017 statewide lidar project and the current 2020-2025 lidar project. It is recommended that all future North Carolina statewide lidar projects and any county level projects

utilize the 3DEP program standards for the projects and collect lidar data at USGS 3DEP Quality level 1 or better.

Technical Specifications

The project deliverables would conform to the USGS product specification for LiDAR and derived products in effect at the time of project data acquisition. As of this writing, the current version of the USGS Lidar Base Specification as posted on the USGS "Lidar Base Specification Online" website (https://www.usgs.gov/core-science-systems/ngp/ss/lidar-base-specification-online) is **2024 rev. A.**

Data Collection

In brief, the collection would entail the following:

- Aggregate nominal pulse density ≥8 points/m^2
- Aggregate nominal post spacing of ≤0.35 m
- Table 5: The North Carolina Lidar classification scheme of 15 categories, 2 of which are optional.
- Vertical accuracy of 10 cm (3.36 inch) RMSEz

Deliverables

Deliverables will include metadata, intensity images, and a 500-meter buffer zone that would extend into the bordering North Carolina counties as well as the bordering South Carolina and Virginia counties. LAS files would be delivered in the ASPRS version in effect at the time of the GPSC task order and will include return. The current version is 1.4-R15 format (https://www.asprs.org/divisions-committees/lidar-division/laser-las-file-format-exchange-activities). The LAS files would have 10 levels of Classification and an optional 2 levels of additional Classification (Table 5).

Code	Description
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building (automated)
7	Low Point (Noise)
9	Water
10	Rail
11	Road Surface
13	Wire – Guard (Shield)
14	Wire – Conductor (Phase)
15	Transmission Tower
16	Wire-structure Connector (e.g., Insulator)
17	Bridge Deck
18	High Noise
20	Ignored Ground (breakline proximity)
64-255	User Definable

Table 5: Lidar Classification

Raw point cloud data

- Compliant LAS v1.4-R15
- Delivered in statewide 2,500 ft x 2,500 ft tiling scheme (approximately 14,400 tiles)
- Metadata to FGDC standards
- Georeferenced information included in all LAS file headers
- GPS times would be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each return
- Intensity values
- Full swaths, all collected points to be delivered
- 1 file per swath, 1 swath per file, file size not to exceed 2GB

Classified point cloud data

- Compliant LAS v1.4-R15
- Georeferenced information would be included in the LAS header
- GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each return
- Intensity values
- Tiled delivery, without overlap

Bare earth surface (raster DEM)

- DEMs at three cell sizes: 3.125-foot (ft), 10-ft, and 20-ft in GeoTiff formats
- Georeferenced information would be included in raster file
- Tiled delivery, without overlap
- DEM tiles would show no edge artifacts or mismatch
- Void areas (i.e., areas outside the project boundary, but within the tiling scheme) would be coded using a unique "NODATA" value. This value would be identified in the appropriate location within the file header.
- Depressions (natural or man-made sinks) would not be filled (as in hydro-enforcement)
- Water bodies (ponds and lakes), wide streams and rivers ("double-line"), and other non-tidal water bodies would be hydro-flattened (hydro-corrected) in GeoTIFF format in 3.125-ft, 10-ft, and 20-ft raster sizes
- Tree/Veg Canopy (optional item)
- Impervious surfaces (optional item)
- Digital Surface Model (optional item)

Countywide Bare earth surface (raster DEM) (optional)

- Countywide DEMs at five cell sizes: 1-ft, 3.125-ft, 10-ft, 20-ft, and 50-ft in Environmental Systems Research Institute (ESRI) Grid Format.
- Delivered as a single ESRI file geodatabase containing the corresponding hydro model and tile layout feature classes as well.
- Shall include a 5000-foot buffer around the county boundary (or the equivalent of two 2500-ft2 Lidar tiles) when possible.

Intensity images

- Gray scale, 8-bit, GeoTIFF format, 10 ft raster cell size (Figure 11)

Figure 11: Example of an intensity image derived from lidar.

Breaklines

- Hydro breaklines files to USGS specs- Esri geodatabase format
- Hydro-Flattening (Optional)
- Waterbodies with a surface area greater than 0.25 acres
- Riverways wider than 40'

Road Edge of Pavement (optional)

- High detail road edge of pavement polygon in Esri shapefile format
- Collect road edge polygons delineating the edge of pavement along all road surfaces contained within the State's "RomeLrs" seed file.
- High detail bridge deck collection classified as found during the road collection.

Buildings (optional)

- Building change detection analysis and provide an updated S_BUILDING feature class file for each of the 19 Phase 3 counties.
- Utilize the latest S_BUILDING dataset in order to make updates based on the newly collected and classified LiDAR data.

Terrain datasets

- Countywide terrains stored as individual file geodatabase format.
- Lidar LAS file bare earth points, as multipoint features, will be embedded into the terrain and hard clipped to the current State County boundaries.

Tiling scheme

Data tiled to the North Carolina statewide seamless tiling scheme created from the 10,000 ft x 10,000 ft grid specified in the "https://it.nc.gov/documents/files/north-carolina-technical-specification-lidar-base-mapping". The new tiling scheme is 2,500 ft x 2,500 ft, which would allow for easier use based on the size of the data.

Terrain datasets by county

Terrain datasets are generated by county from the lidar masspoints. These countywide terrains are stored as individual file geodatabase with the bare earth masspoints embedded as multipoint features and hard clipped to the current State County boundaries.

Bare earth surface DEMs are produced as hydro-flattened GeoTIFF rasters at three cell sizes: 3.125-ft, 10-ft, and 20-ft. These are delivered in both NC grid tiles and as county wide mosaics with a 5000-ft overlap along the county boundary. Water bodies (ponds and lakes), wide streams and rivers ("double

line"), and other non-tidal water bodies are collected at USGS specifications. The polyline z hydro features are available upon request. Void areas are coded as "NO DATA" and depressions are not filled.

Independent Quality Assurance (QA)/Quality Control (QC) report

Validation of the data includes vertical quality control with independent surveyed control points collected within each county; automated checks of density; road comparisons against existing road lines; point density comparisons within class, such as noise points misclassified; and road classification validation. Quality control would be completed referencing the USGS product specification for Lidar and derived products in effect at the time of the GPSC task order. As of this writing, the current version of the USGS Lidar Base Specification as posted on the USGS "Lidar Base Specification Online" website (https://www.usgs.gov/core-science-systems/ngp/ss/lidar-base-specification-online) is **2024 rev. A** and the current vertical accuracy table is posted on "Lidar Base Specification: Tables" webpage (https://www.usgs.gov/core-science-systems/ngp/ss/lidar-base-specification-tables) (Table 1).

Project Timeline:

Lidar data collection will be performed during leaf-off conditions (January – March). The estimated delivery dates for the processing and classification and all products would proceed as follows (Table 6):

Delivery dates*		
When the Acquisition phase is conducted:	**Processing calibration and classification would be delivered on an incremental schedule until the beginning of:**	**All products and deliverables should be available by beginning of:**
January-March	November -December of the same year as data acquisition	February of the following year of acquisition

Table 6: The estimated delivery dates for the processing and classification of all products and deliverables.

***Note:** Quality control would be performed with all deliverables.

Lidar Program Organization

The SMAC recommends an approach to future projects to take advantage of past lidar project experience and subject matter lidar expertise at NCEM and NCDOT. As a prime example, the following approach has been used for the two previous (2001-2005 and 2014-2017) statewide lidar data collection projects and the current third statewide data collection project (2020-2025):

- For the two previous and current statewide lidar projects, program management was the responsibility of North Carolina Emergency Management (Floodplain Mapping Program and North Carolina Geodetic Survey) and North Carolina Department of Transportation (Photogrammetry, Hydraulics and Location and Surveys units)

- Management of imagery acquisition, processing, and visual quality control was the responsibility of the NCEM and NCDOT to take advantage of large project management, quality control, and data management experience and lidar expertise.

- Management of geodetic control and horizontal/vertical quality control and related equipment was the responsibility of the NC Geodetic Survey to utilize experience managing and performing quality control in the field, maintaining datasets for control, and managing a statewide network of reference stations.

- Public access to lidar data (map services, data download, and related methods) and distribution of products (masspoints, DEMs, and breaklines) is being managed through NCEM's Spatial Data Download (https://sdd.nc.gov/). In addition, NCEM provides outreach in the form of presentations at conferences, working groups, and other public events.

- Technical support and advice is provided by the Working Group for Orthoimagery and Elevation (http://www.ncgicc.com/Default.aspx?tabid=143) in the GICC's SMAC.

This organizational structure supports efficiency and effectiveness in meeting a rigorous set of lidar standards relating to collection, processing, quality control, outreach to users, and public access to information. North Carolina is fortunate that essential elements are in place, including:

- Agency subject matter experts with multiple years of experience in all phases of a lidar project.

- Agencies with NC licensed Professional Land Surveyors to meet the requirements of NC General Statute 89C-19

- Agencies that have established working relationships, agreements, and understandings for an effective team approach, and personnel who have expertise in professional services and technology, are licensed Professional Land Surveyors in North Carolina, and have experience in Qualifications-Based Selection (QBS) contracting.

Organizational Structure Detail

The organizational structure should be composed of

- Qualifications-based selection of contractors,
- Project tasks
- Technical support

QBS contracting

In the North Carolina "Engineering and Land Surveying" General Statute (§ 89C), "elevation data" is included in the "practice of land surveying" definition. The collection of lidar elevation data is regulated by the North Carolina Board of Examiners for Engineers and Surveyors (NCBEES) https://www.ncbels.org/), which requires that the acquisition and production of lidar elevation data in North Carolina be provided by an NCBEES licensed Professional Land Surveyor.

North Carolina state and local agencies wanting to contract engineering or surveying services must adhere to the "Procurement of Architectural, Engineering, and Surveying Services" General Statute (§ 143-64.31. - .33, see Appendix A), which is commonly known as the Mini Brooks Act http://www.ncbels.org/forms/minibrooksact.pdf) that outlines the QBS contracting procedure:

Additional information about the QBS (Mini-Brooks) process can be found at this link.

https://www.sog.unc.edu/blogs/coates-canons/mini-brooks-act-faqs

In addition to contracting NC licensed professional land surveying firms to acquire and deliver the lidar data and other deliverables, other licensed professional land surveying firms can be contract through a QBS process to perform the independent Quality Control/Quality Assurance (QA/QC) work in order to insure that:

- Each project delineated procedure has been followed
- Each project delineated standard has been met
- The final product meets each project delineated requirement

The QA/QC firms provide the State and subsequent data users with assurances on the

Lidar data's accuracy and precision and that it meets or exceeds. As with the legislated requirement to acquire the aerial imagery firms through a QBS process, the acquisition of the independent QA/QC firms must likewise be done by a QBS process.

Project Tasks

Project tasks are:

- Planning
- Validation range verification
- Data acquisition
- Internal and independent quality control
- Production of deliverables
- Posting of quality control reports
- Distribution of lidar project deliverables

Technical Support

Technical will be provided by the program management team that has experience and expertise in all phases of a lidar project. The program management team can request advice from the Working Group for Orthophotography and Elevation Planning (http://www.ncgicc.com/Default.aspx?tabid=143)) in the GICC's SMAC.

Implementation Plan and Recommendations

Lidar Data Collection

The 2001-2005 and 2014-2017 statewide lidar projects and the current statewide project used five phases of data collection as shown in the image below in Figure 12.

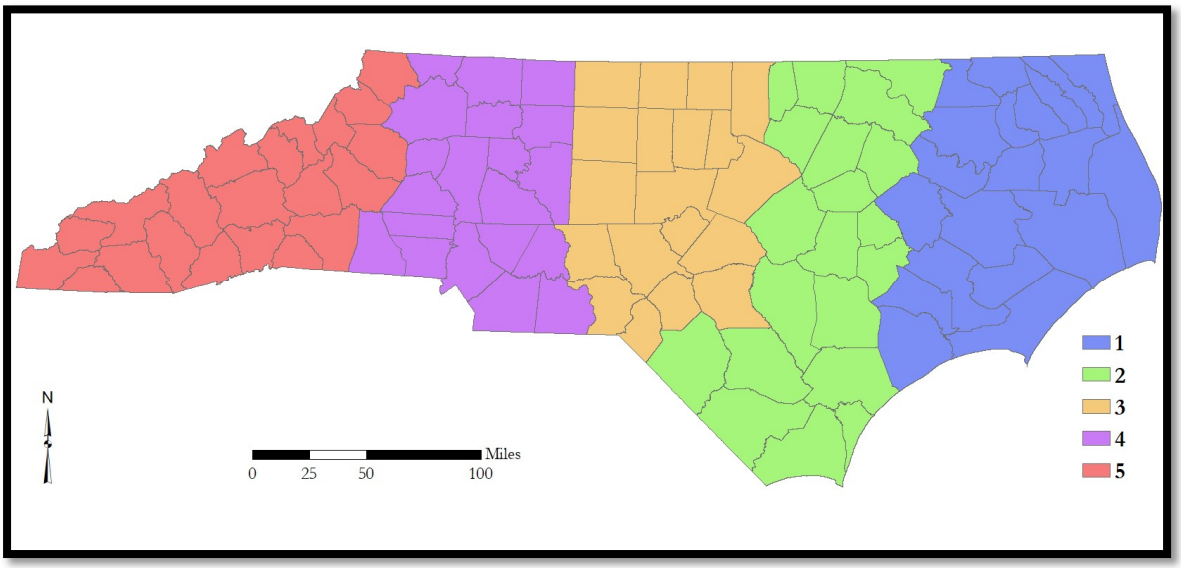

Figure 12: Option A for lidar project areas and collection cycle. (Current collection phases)

The advantages of using the five (5) phase plan are:

- Has been used successfully since 2001 for lidar data collection in North Carolina.
- Data collection areas are compact, and the project areas are manageable.

The disadvantage of using the five (5) plan are:

- Does not match the NC 911 Board Statewide Orthoimagery Program areas

An alternate data collection plan would be to change from five (5) phases to four (4) phases. A four-phase plan as shown in Figure 13 above would be designed to match the NC 911 Board Statewide Orthoimagery Program areas and each phase would be collected one year in advance of the aerial imagery data collection.

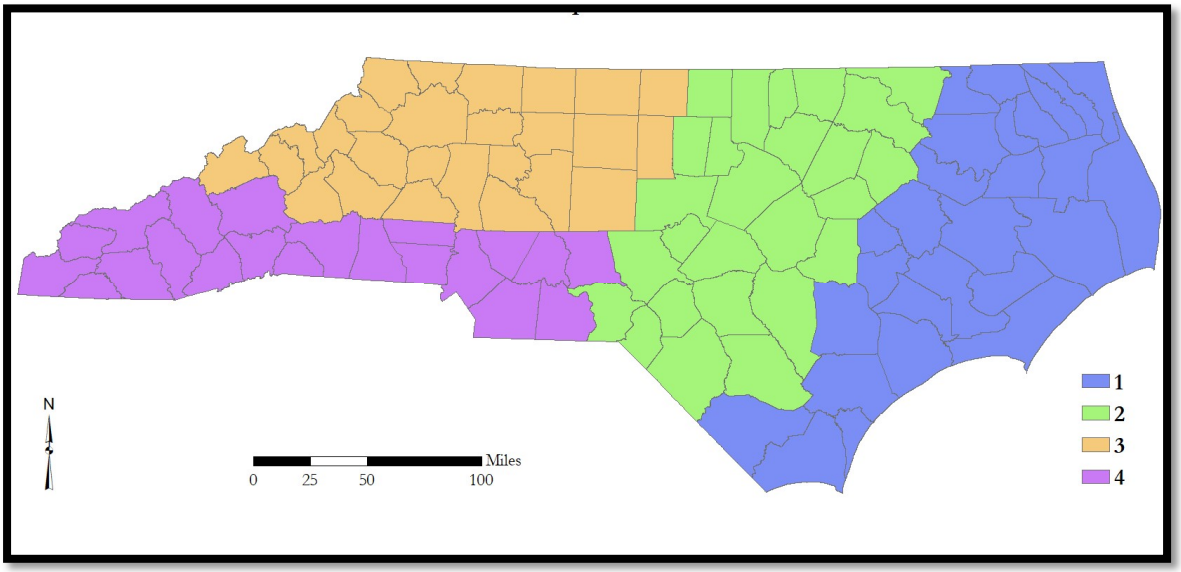

Figure 13: Option B for lidar project areas and collection cycle. (Proposed 4 phase plan)

The advantages of using the four (4) phase plan are that they would provide the NC 911 Board Statewide Orthoimagery Program projects digital elevation models that are not more than one year old.

The disadvantages of using the four (4) phase plan are that the phase areas are larger and would require more contracting resources

Lidar data collection recommendations

1. Complete the current (2020-2025) statewide lidar data collection project using the four-phase plan.
    - Use the North America Datum of 1983, National Geodetic Vertical Datum of 1988, and Geoid18.

2. For the fourth statewide lidar data collection project utilize the five-phase plan that matches the NC 911 Board Statewide Orthoimagery Program project areas.
    - Use the NATRF2022, NAPGD2022, Geoid2022, 2022 North State Plane Coordinate System, and International Foot.

Lidar LAS Specifications recommendation

Change from the current North Carolina LAS specifications (pages 13-14) and classification to the American Society for Photogrammetry and Remote Sensing (ASPRS) LAS Specifications for state managed lidar projects.

Collaboration

The USGS' 3DEP program was developed to collaborate and reduce duplication in the collection of lidar data. The USGS recognizes the value of lidar data and has partnered with North Carolina in lidar collection. Continued partnership will be important to the program. The USGS has published a 3DEP summary for North Carolina outlining use cases, benefits, and program status. USGS utilizes SeaSketch (Figure 14) to identify lidar project needs.

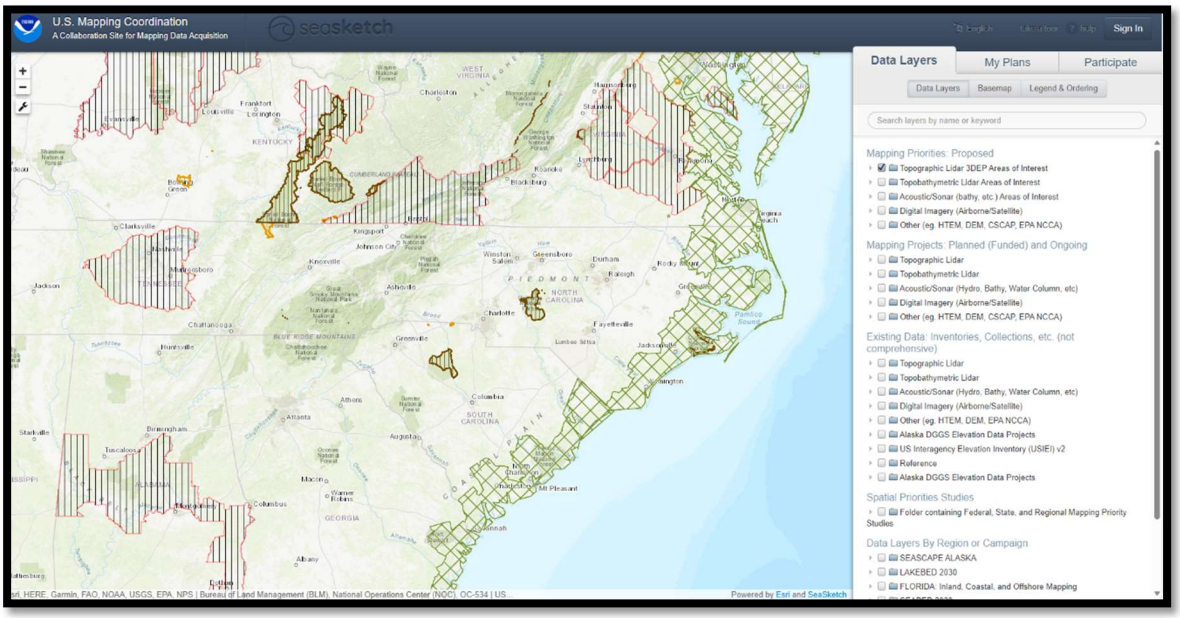

Figure 14: USGS SeaSketch application showing lidar project needs. This application allows partners to share project needs in a single place.

Advantages for using SeaSketch to identify lidar projects:

- Assists North Carolina when applying for federal grants to support a lidar data project
- Can be used by the public (local, state, and federal agencies) and private (companies and non-profits) sectors to identify the lidar project areas of interest.

Funding Sources

Funding to continue North Carolina's efforts to collect lidar data depends on a funding source, project budgeting, and planning. NCEM and NCDOT have used a variety of funding sources to support the two statewide lidar projects and the current third statewide lidar projects. These funding sources include nonrecurring funds from the General Assembly, NCEM, NCDOT, USGS 3DEP grant funds, federal agencies, and local governments. Currently no dedicated yearly funds for lidar projects are available.

As a framework, the recommended funding approach is to continue statewide lidar data collection (including lidar data acquisition, data access, data distribution, program management and investment in geodetic control) and work with the following groups to obtain funding that will support the recommendations contained in this plan:

1. Federal agencies (USGS 3DEP program, NOAA, FEMA, and USDOT).
2. State Agencies

3. Local governments
4. Public-Private partnerships (utilities companies and nonprofits)

Funding from federal and state agencies, local governments, private companies, and non-profits will depend on project locations, requirements, and availability of funds.

Geodetic Control

The North Carolina (NC) Continuously Operating Reference Stations (CORS) that provides data for the North Carolina Real Time Network (RTN) is a cost-effective and time-conserving component of past and future lidar projects. The NC CORS/RTN supports lidar data collection, processing, and quality assurance/quality control. North Carolina Geodetic Survey operates and maintains the Official Survey Base (General Statute 102) which includes passive monuments geodetic monuments and CORS/RTN.

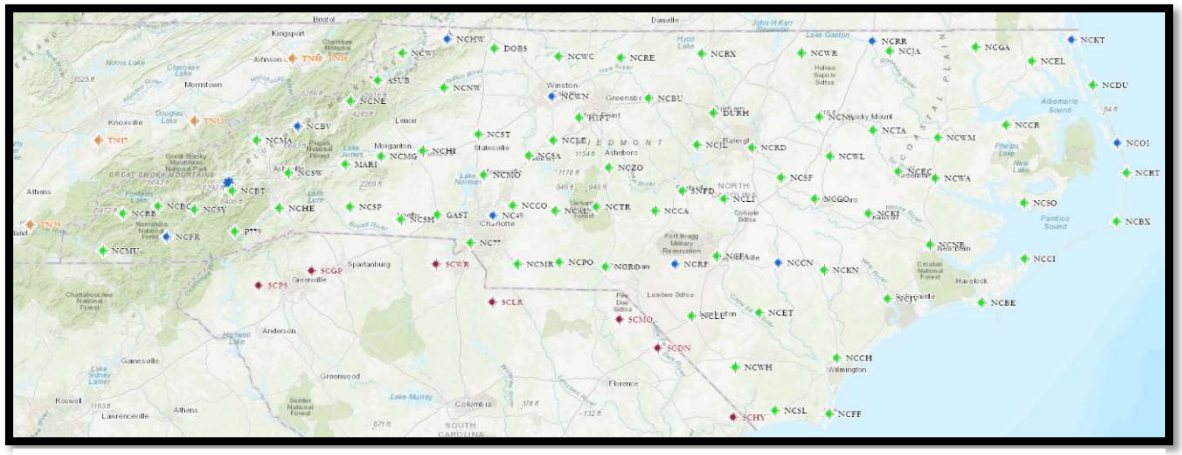

Figure 15: Map of NC Continuously Operating Reference Stations

Data Distribution and Storage

Geospatial users of lidar data use a variety of software applications (e.g. ESRI, QGIS, AutoCAD, etc.) to produce derivative products from the lidar data. NCEM developed Spatial Data Download (SDD) as shown in Figure 16 to assist users in obtaining lidar data that was collected as part of the statewide lidar project in a format that can be consumed by a variety of software applications. SDD provides geospatial users a tool that allows the selection of custom areas that fit the users project area. SDD provides access to the latest generation of statewide lidar data.

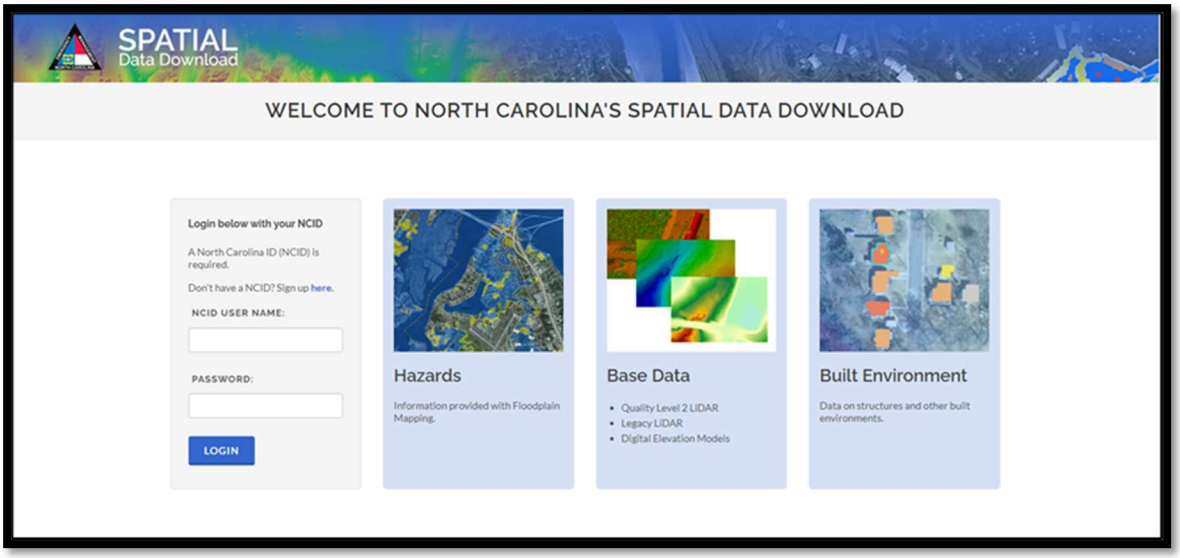

Figure 16: NC Emergency Management's Spatial Data Download site.

Historical and archival lidar data is stored by NCEM off the primary physical servers sourcing SDD application but remains available for distribution via the Large Data Request form found on the SDD web site. In addition to hosting the data on SDD, NCEM also provides NCDOT Photogrammetry, CGIA, and other state agencies with a complete set of all data for each phase of the statewide lidar project. NC OneMap is a source of many lidar-derived data products, such as contours, digital elevation models, and streaming map services for hillshade, elevation, and others. The size of lidar data poses a special challenge to data storage and distribution. Regular lidar maintenance includes not only regular acquisition updates but also regular maintenance of IT resources that support the storage and distribution of the data.

Implementation of Future Projects

For the purpose of generating the most benefits for users of aerial lidar data in North Carolina, the SMAC recommends the following approach to lidar data acquisition, funding, and program management.

For statewide lidar acquisition, the SMAC recommends Option B which divides the state into four phases, with flights beginning in 2026, and additional flights in 2027, 2028 and 2028 (See figure 13.) The SMAC also recommends that NCEM and NCDOT complete the current statewide lidar project using the existing five phases (Option A) and reference the lidar data to NAD83(2011) and NAVD88 utilizing Geoid18.

The SMAC further recommends that the NATRF2022, NAPGD2022, GEOID2022, and the 2022 North Carolina State Plane Coordinate System be utilized for all lidar projects after the current statewide lidar project is completed in 2025.

The following advantages to this approach are:

1. A four-year cycle would provide the NC 911 Board Statewide Orthoimagery Program projects with digital elevation models that are not more than one year old.
2. This approach would create consistent annual demand for contractor services.
3. Smaller regional and local firms would be more likely to have the capacity to compete for selection.
4. The division of the western region into north and south project areas reduces the risk of not acquiring images over the mountains before leaves emerge in the spring.

Risks and Dependencies

The dominant risk to the lidar program is the lack of dedicated yearly funding. There have been as many as 14 years between previous lidar updates with the common recommendation being 8 years or fewer. The orthoimagery program, with a history of dedicated yearly funding, has demonstrated the success and cost savings that can be achieved when data is regularly maintained. Regular updates are critical to meeting the needs of important data users including floodplain mapping, transportation, and economic development. The following are risks and dependencies for a statewide lidar project.

- Weather conditions limit the number of days and hours suitable for capturing lidar data.
- Forest fires which limit the number of days for data collection.
- Natural disasters, particularly flooding, may obscure ground features and delay data collection. Lidar data that meets specifications for, cloud-free skies, and leaf-off conditions.
- Data storage and sharing requires regular investment in IT infrastructure and technical staff
- Program management requires staff with expertise in contract management and lidar technology.

Recommendations Summary

Lidar Working Group Business Plan Recommendations
1. Recognize lidar as a critical framework dataset that brings millions of dollars in benefits to the citizens of North Carolina
2. Identify a regular funding mechanism to update lidar data on a four-year cycle
3. Lidar data should be QL1 or better meeting USGS and ASPRS standards
4. Take advantage of federal partnerships for program continuity and cost savings
5. Take advantage of state agency lidar and project management expertise for program oversight
6. After the current cycle is completed, begin collection using the NATRF2022, the NAPGD2022, GEOID2022, and the 2022 North Carolina State Plane Coordinate System

Appendix A: Procurement Statutes

Article 3D.
Procurement of Architectural, Engineering, and Surveying Services.
§ 143-64.31. Declaration of public policy.

(a) It is the public policy of this State and all public subdivisions and Local Governmental Units thereof, except in cases of special emergency involving the health and safety of the people or their property, to announce all requirements for architectural, engineering, surveying, construction management at risk services, design-build services, and public-private partnership construction services to select firms qualified to provide such services on the basis of demonstrated competence and qualification for the type of professional services required without regard to fee other than unit price information at this stage, and thereafter to negotiate a contract for those services at a fair and reasonable fee with the best qualified firm. If a contract cannot be negotiated with the best qualified firm, negotiations with that firm shall be terminated and initiated with the next best qualified firm. Selection of a firm under this Article shall include the use of good faith efforts by the public entity to notify minority firms of the opportunity to submit qualifications for consideration by the public entity.

(a1) A resident firm providing architectural, engineering, surveying, construction management at risk services, design-build services, or public-private partnership construction services shall be granted a preference over a nonresident firm, in the same manner, on the same basis, and to the extent that a preference is granted in awarding contracts for these services by the other state to its resident firms over firms resident in the State of North Carolina. For purposes of this section, a resident firm is a firm that has paid unemployment taxes or income taxes in North Carolina and whose principal place of business is located in this State.

(b) Recodified as G.S. 143-133.1(a) by Session Laws 2014-42, s. 3, effective October 1, 2014, and applicable to contracts awarded on or after that date.

(c) Recodified as G.S. 143-133.1(b) by Session Laws 2014-42, s. 3, effective October 1, 2014, and applicable to contracts awarded on or after that date.

(d) Recodified as G.S. 143-133.1(c) by Session Laws 2014-42, s. 3, effective October 1, 2014, and applicable to contracts awarded on or after that date.

(e) For purposes of this Article, the definition in G.S. 143-128.1B and G.S. 143-128.1C shall apply.

(f) Except as provided in this subsection, no work product or design may be solicited, submitted, or considered as part of the selection process under this Article; and no costs or fees, other than unit price information, may be solicited, submitted, or considered as part of the selection process under this Article. Examples of prior completed work may be solicited, submitted, and considered when determining demonstrated competence and qualification of professional services; and discussion of concepts or approaches to the project, including impact on project schedules, is encouraged. (1987, c. 102, s. 1; 1989, c. 230, s. 2; 2001-496, s. 1; 2006-210, s. 1; 2013-401, s. 1; 2014-42, ss. 3, 4.)

Appendix B: Use Cases

Forestry

The United States Forest Service (USFS) leverages LiDAR derived products and is actively engaged in new acquisitions of airborne LiDAR either through sole solicitations, 3DEP, and/or Federal, Tribal, and State partners. Use of LiDAR varies across the regions and forest, but for the National Forests in North Carolina (NFsNC), USFS works with the State's LiDAR data acquired through NCEM. The USFS has established a new Partner Agreement with NCEM, working with NCEM to cost share on the current LiDAR Phase III, and intend on continuing our partnership with the state in future acquisitions that cover USFS System Lands.

LiDAR products made from the NC LiDAR acquisitions:

- High Resolution Digital Elevation Models
- High Resolution Digital Surface Models
- High Resolution Multi-Directional Hillshaded Relief Models
- Canopy Height Models
- Canopy Density Models
- Canopy Height Standard Deviation Models
- Percent Slope Models
- Aspect Models

These are some of the applications we use LiDAR derived products for:

- Updated USFS Road and Trail Centerlines on all 4 National Forest in North Carolina.
- Generated hydro flowlines for new project areas the forest is working on
- Modeling potential stream flow diversion sites at road drainage crossing
- 1' and 2' Contour CAD files for engineering and landscape planning & design
- Change Detection vegetation canopy density
- Change detection vegetation loss/gain
- Viewshed Analysis – Scenery
- Archeology
- Area Capacity Tables for volume estimate of open pit mines
- Wildland-Urban interface fuels reduction planning

Agriculture

Engineering staff with the Department of Agriculture and Consumer Services utilize LiDAR data as an engineering survey supplement to prepare engineering designs and reports for a variety of agricultural and stormwater best management practices. LiDAR is vital in engineering hydrologic and hydraulic analysis associated with these best management practices due to the required analysis scale, which would otherwise be much more impractical, costly, and less accurate if the data was not available.

The Division of Coastal Management utilizes lidar to interpret MHW shorelines and look at beach foreshore and dune changes in the past. If we see that regular updates might be occurring and depending on data resolution, I can see us doing this on a routine basis.

NCDOT Bridgewatch Thresholds

NCDOT professionals are charged with the formidable task of protecting, maintaining, and replacing over 15,000 bridges along over 80,000 miles of roadway statewide. To help meet this challenge, NCDOT has implemented a 5-year program using the BridgeWatch application by US Engineering Solutions. Bridgewatch is an online asset management service that enables transportation professionals to proactively monitor, in real-time, valuable transportation infrastructure which is potentially subject to hazardous conditions. BridgeWatch collects and processes real-time and forecast data from meteorologic, hydrologic, and oceanographic sources, gauges, and other sensing devices. Data is compared against user input bridge parameters, such as flood impact (floodwaters reaching structure levels) or roadway overtopping. NCDOT officials and Emergency managers receive alerts via SMS text, email, and application dashboard when bridges are experiencing a dangerous or critical condition.

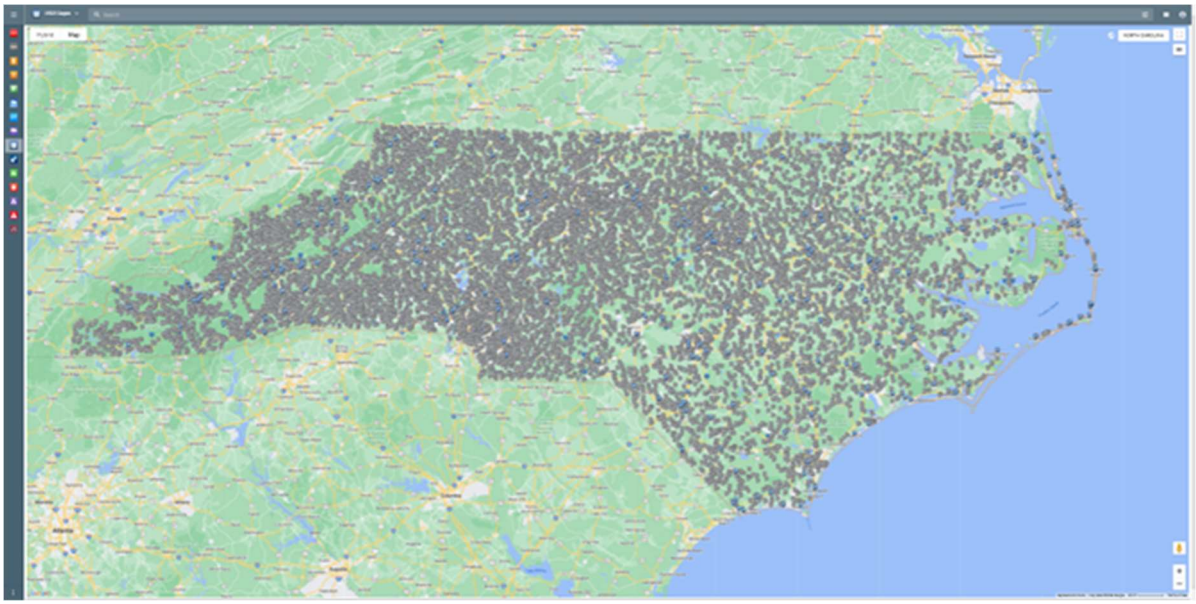

Figure 177: Before and during natural hazards such as riverine flooding and Hurricane storm surge, NCDOT uses the BridgeWatch application to monitor and provide alerts and work order management for over 15,000 at risk bridges and assets statewide.

Data Need

The BridgeWatch software can provide real-time alerts (email and text) to NCDOT staff, emergency managers and stakeholders for all monitored bridges and assets statewide. These alerts are based on thresholds defined at each asset and compared for forecasted or measured conditions at each site. One key data requirement for the NCDOT was the incorporation of accurate and reliable structure/asset elevations. These elevations include deck / roadway elevations, low chord elevations, roadway over topping elevations and other key asset levels such as ferry ramps, levees, flap gates and other key facilities. These thresholds allow for critical alerts to be provided for bridge monitoring, closure, and post event inspection. The NCDOT did not have a comprehensive database of structure elevations for the derivation of these values in a timely and cost-effective manner.

Solution

The current NC lidar datasets contain LAS point cloud classification for both “roadway” and “bridge”. These classified points in the current lidar datasets allow for the generation of a digital

Figure 188: Example of QL-1 lidar data classification of "Road" and "Bridge" used to develop roadway elevation model statewide.

elevation model of the roadway and bridge surface. The addition of the “bridge” classified lidar point affords the efficient generation of this roadway survey elevation model at a fine resolution.

The BridgeWatch team (or data Sentinels) created polygons spanning the bridge structure using available imagery. From these polygons, the team was able to relate elevation values (in NAVD 88) for the structure deck by using a statewide road raster elevation ribbon.

Zonal Statistics geoprocessing tools were used to determine the bridge deck elevations within these structure polygons. For most bridges, the mean elevation was used from the structure polygons as the

"Bridge Overtopping" threshold elevation in BridgeWatch. Exceptions were made for causeway structures where the minimum values indicated when the approach roadway would be overtopped. For bridges, the low chord elevations were determined as an offset from these lidar derived bridge deck (or

Figure 199: Example of low chord alert and field verification. BridgeWatch links structure elevation thresholds and stream gauge readings statewide monitoring bridge performance and roadway overtopping in real time.

roadway elevations). These offsets values were based on NCDOT bridge databases, existing survey or hydraulic models. The BridgeWatch Software alerts were then configured for each applicable bridge for freeboard, low chord and roadway over topping conditions.

Statewide Value

The leveraging of the North Carolina lidar classifications of "roadway" and "bridge" in the existing QL-1 datasets available allowed for efficient and accurate attribution of elevation data for high-risk transportation assets statewide in the implementation of the BridgeWatch software. North Carolina is the only state in the nation at this time that has implemented this amount of structure-based freeboard and overtopping thresholds statewide.

As the lidar program is maintained and updated statewide, the continued classification of "roadway" and "bridge" will provide an efficient means for updating these critical bridge values as the BridgeWatch system expands.

NCDOT FIMAN-T Road Elevations

Expanding upon the successful FIMAN system, in 2020 NCDOT and NCEM partnered to develop FIMAN-T, a web-based tool used to provide NCDOT officials and emergency management stakeholders with real-time and forecasted flood inundation depths along roads, bridges, and other NCDOT assets in support of risk-based decision-making during flooding events. The goal of FIMAN-T is to provide visualization and metrics for roadway inundation, bridge hydraulic performance and identify potentially impacted NCDOT assets. This will enhance NCDOT's responsiveness during flooding events by generating data and reports for use in disaster response and planning.

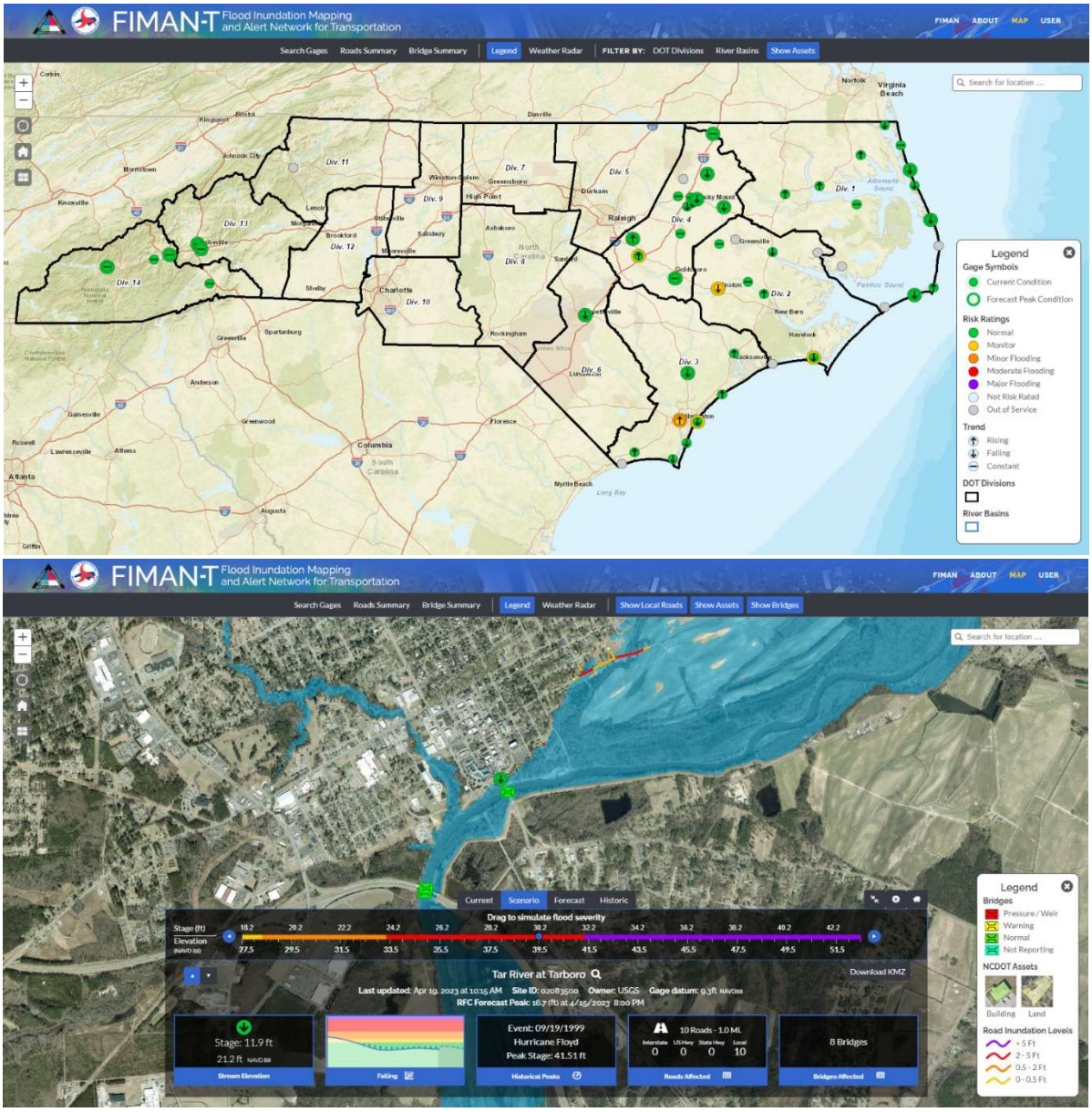

Figure 20: Before and during natural hazards such as riverine flooding and Hurricane storm surge, NCDOT uses the FIMAN-T application to monitor at-risk roadways and DOT assets. .

Data Need

To identify and classify roadways that are at risk of flooding, FIMAN-T needs accurate and complete roadway and bridge elevation data. These elevations include roadway elevations, bridge deck and low chord elevations, and other key asset levels such as ferry ramps, levees, flap gates and other key facilities. These elevations in a roadway elevation raster allow for analysis against modeled flood scenarios in order to predict when and where a roadway will experience flooding, as well as classifying the expecting flood depths. While the current NC lidar datasets contains these elevations, on-going maintenance is required to capture new development and roadway projects.

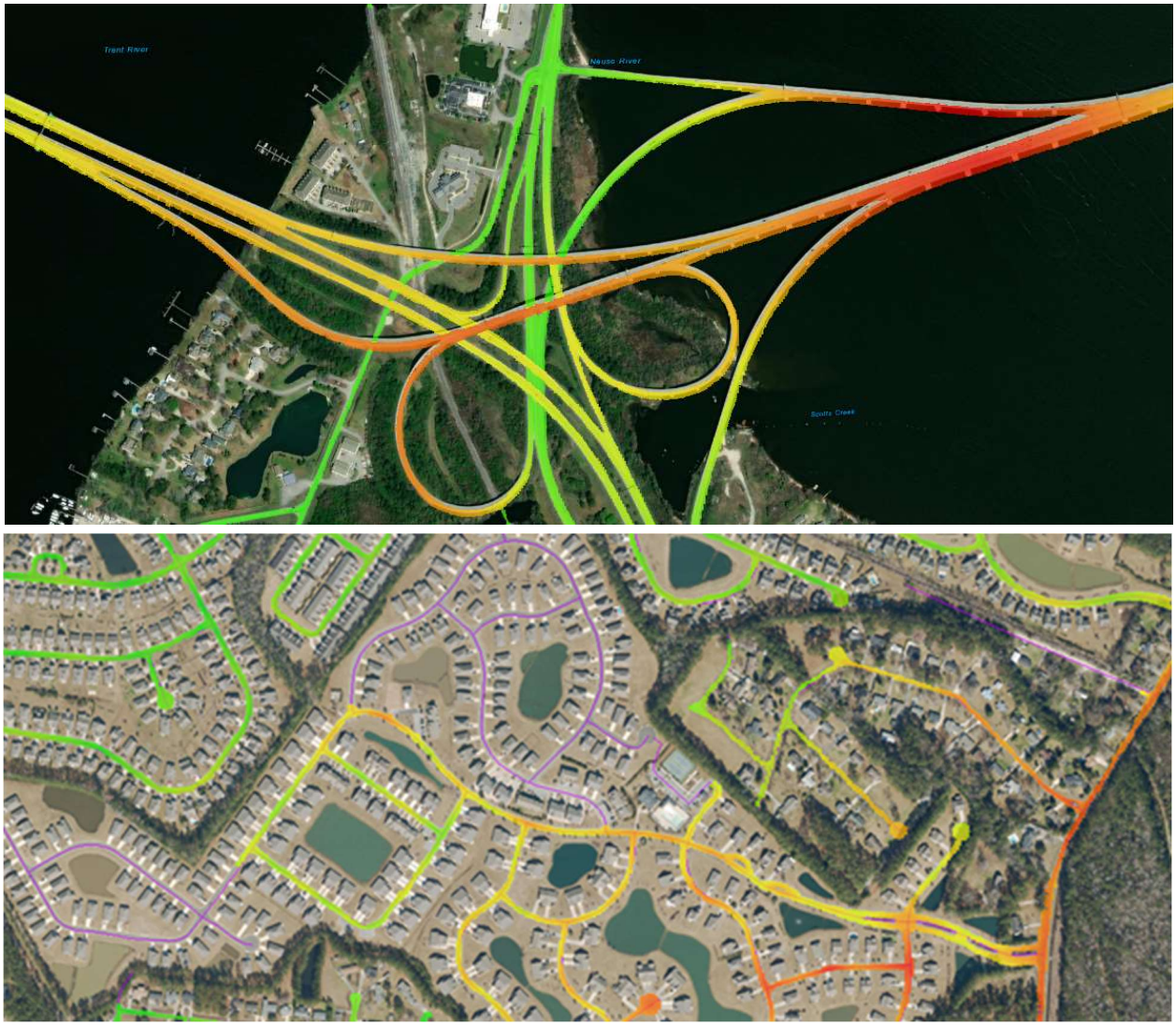

Figure 21: Examples of roadway elevation raster developed from QL-1 lidar data, and gaps in coverage.

Utilization

The current NC lidar datasets contain LAS point cloud classification for both "roadway" and "bridge". These classified points in the current lidar datasets allow for the generation of a digital elevation model of the roadway and bridge surface. Once a hydraulic model of the flooding is complete, the roadway elevation raster can then be utilized to identify depth of flooding along roadways and bridges. This analysis leads to the data creation in FIMAN-T, which displays flooded roads and bridge impacts.

Statewide Value

The leveraging of the North Carolina lidar classifications of "roadway" and "bridge" in the existing QL-1 datasets available allowed for efficient and accurate analysis of elevation data for high-risk transportation assets statewide. As the lidar program is maintained and updated statewide, the continued updated roadway elevation rasters will provide an efficient means for updating and expanding coverage as the FIMAN-T system expands.

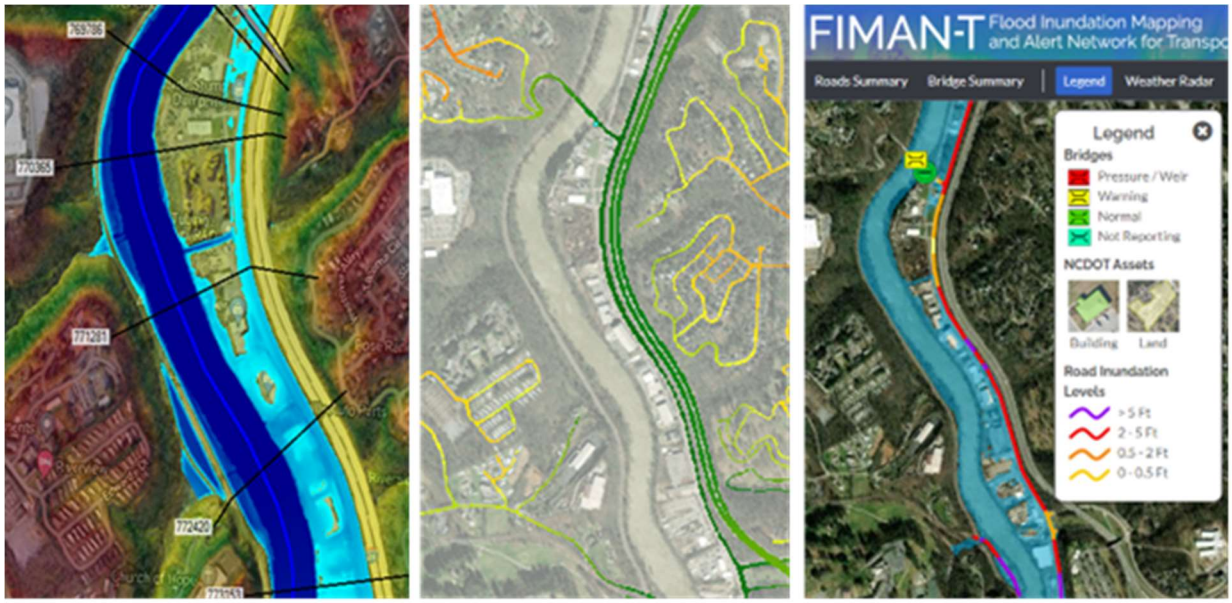

Figure 22: Example of French Broad River at Asheville. Hydraulic model (left), roadway elevation raster (middle), and FIMAN-T product (right).

Landslide Mapping

The mission of the NCGS is to provide unbiased and technically accurate applied earth science information to address societal needs. This includes geologic maps, mineral resource and geochemical information, geohazard maps and modeling, and earth science education initiatives. The agency examines, surveys and maps the geology, mineral resources and geohazards of the state, while encouraging the wise conservation and use of geologic resources by industry, commerce, agriculture and government for the general welfare of the citizens of North Carolina.

The NCGS is responsible for producing maps and geodatabases of landforms, features, and their attributes that related to landslide hazards with a focus on western North Carolina counties. NCGS regularly uses the 2017 QL1 lidar data products for detection, identification, analysis and mapping of landslides, surficial deposits, and other landslide-related landforms. The resulting maps are delivered to the public via ArcGIS Online where concerned citizens can view and interact with feature data layers that describe locations of past landslides and areas susceptible to future landslides.

Detailed characterization of landslide and debris flow processes, interpreted from lidar products and validated with field work. Map shows multi-phase, landslide failure and runout including slackening of rock masses resulting in incipient and primary wedge failure followed by channelized debris flow, and secondary wedge failure and channelized debris flow.

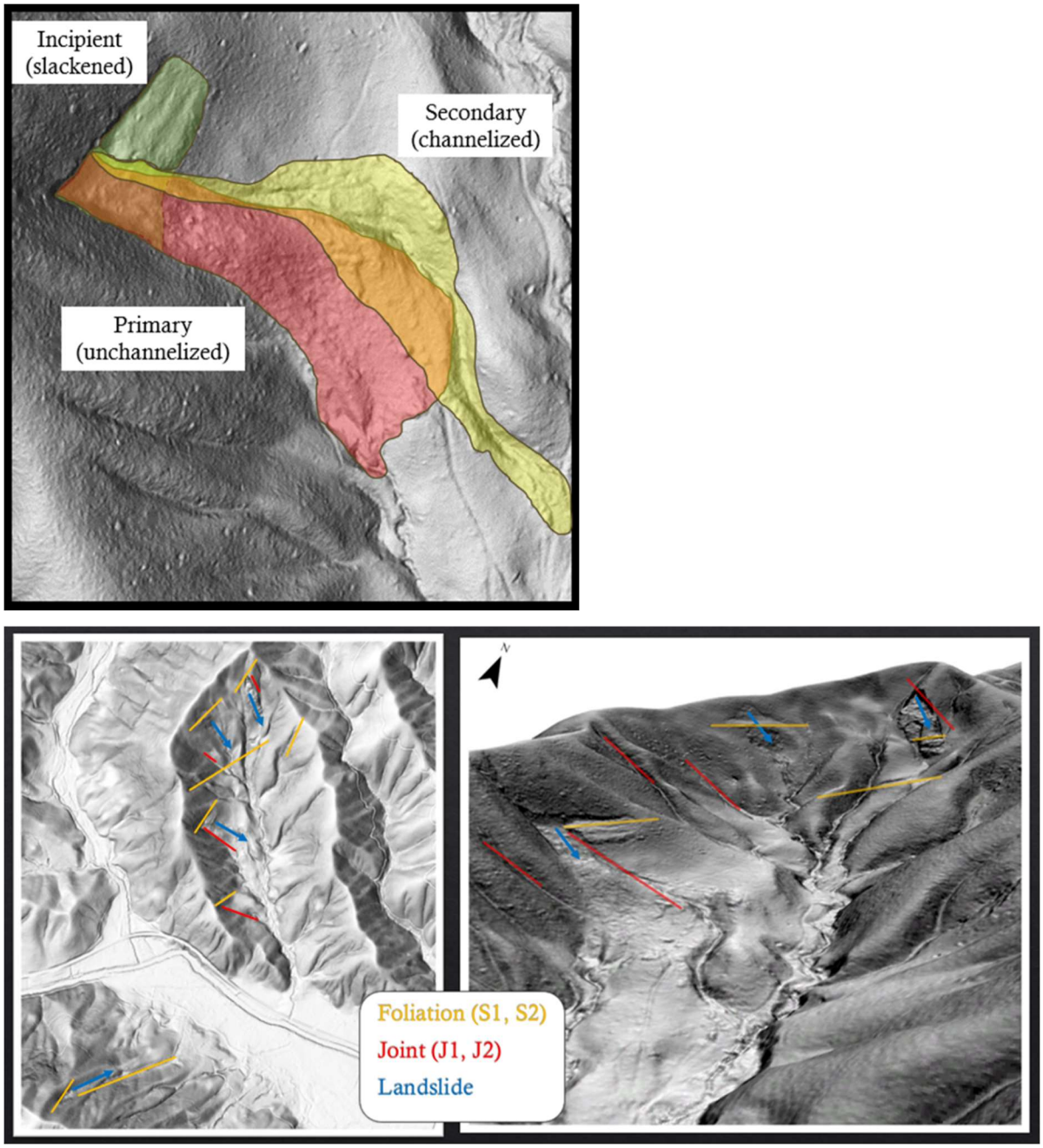

Figure 23: Example of geological lineament mapping from lidar derived hill shade and slope shade (3D view).

Analytical use of lidar DEM as the only input for modeling of terrain units. This approach allows for efficient and precise semi-automated mapping and classification of landform assemblages called terrain units with varying levels of landslide susceptibility.

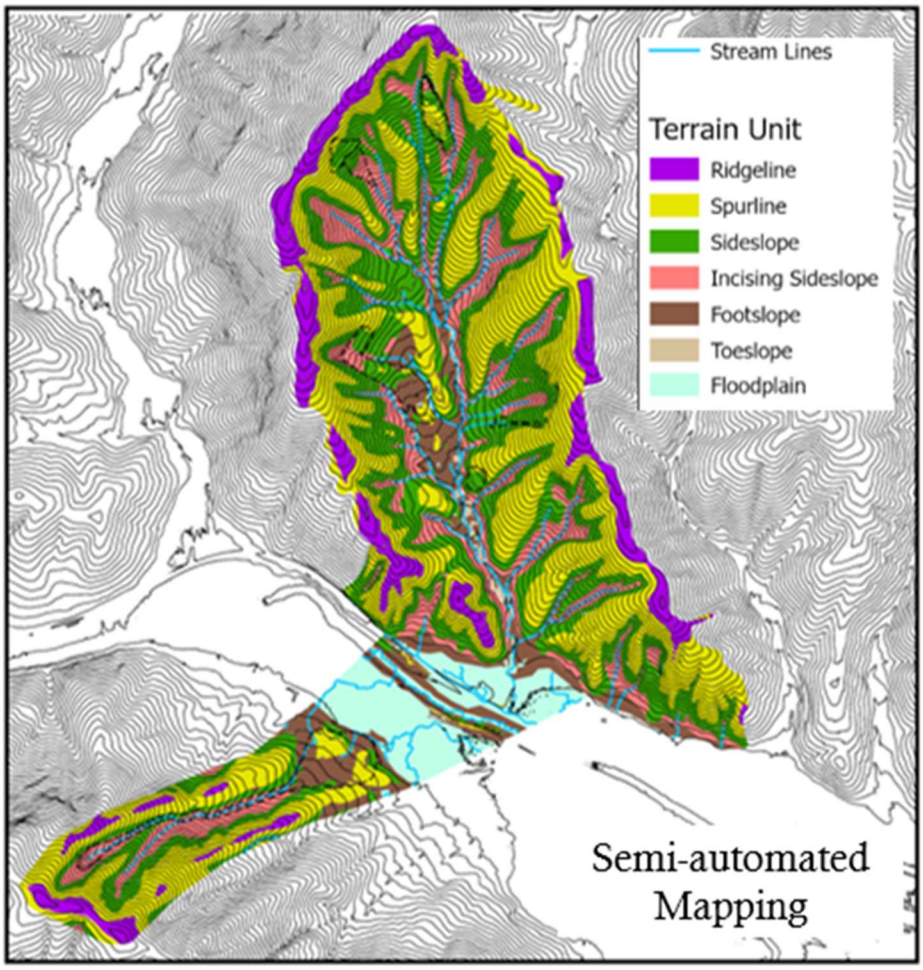

Figure 24: Semi Automated Mapping

Debris Flow Modeling

The NCGS uses LiDAR in its potential channelized debris flow pathway modeling. A geoprocessing tool called CDF Pathways was developed and requires a DEM and a Hydro-conditioned DEM as input. The tool creates slope and planform curvature derivatives from the DEM. Debris flow initiation is determined by the intersect of the slope and curvature values entered by the user. Flow Direction is determined from the Hydro-Conditioned DEM. Using the multitude of LiDAR derivatives as inputs, the CDF Pathways tool can create polygon representation of potential channelized debris flow pathways.

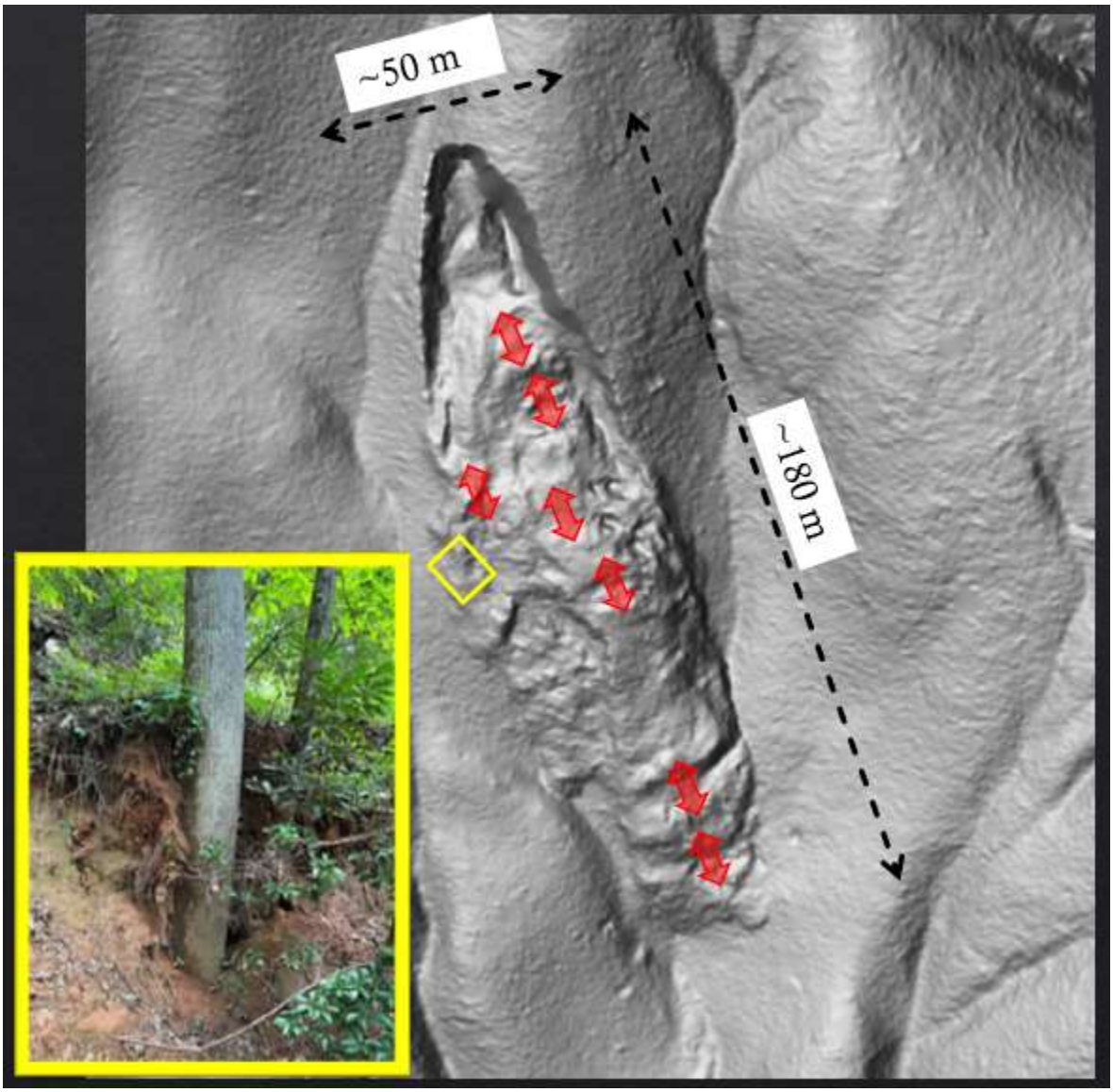

Figure 25: Actively "creeping" (slow-moving) landslide in Pisgah National Forest that was identified in 2020 in the QL1 lidar hill shade and was verified in the field to be actively moving. Time-series lidar would allow for volumetric and displacement analysis and estimation of a rate of movement.

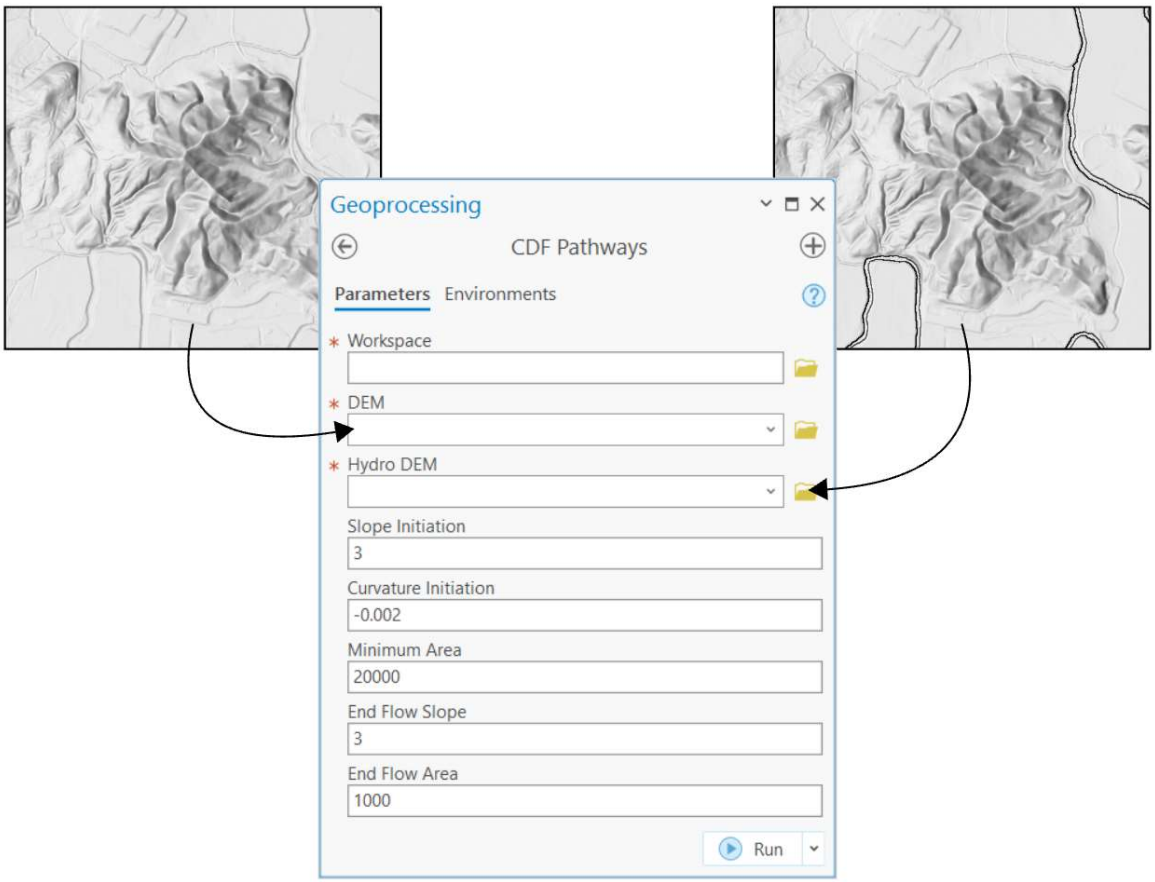

Figure 26: CDF Pathways geoprocessing tool showing DEM (depicted as a hill shade) and example text inputs.

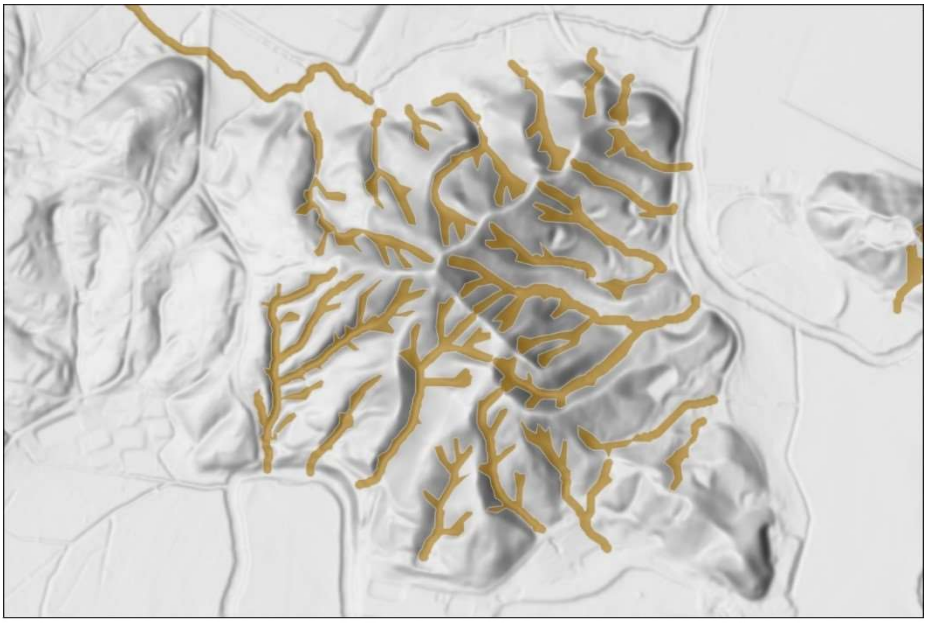

Figure 27: Geoprocessing tool polygon output showing potential channelized debris flow pathway.

Identifying Bedrock Structure

We utilized lidar-derived hill shade and topographic metric raster images combined with focused ground surveys to identify and compare multiple map-scale folds in the eastern Blue Ridge province of western North Carolina. Utilizing a combination of Topographic Position Index (TPI) metric raster and standard hill shade imagery derived from a 0.5-meter vertical resolution LiDAR DEM, we are able to perform a landform analysis. Amphibolite outcrop and topographic calculations used to highlight outcrop (below).

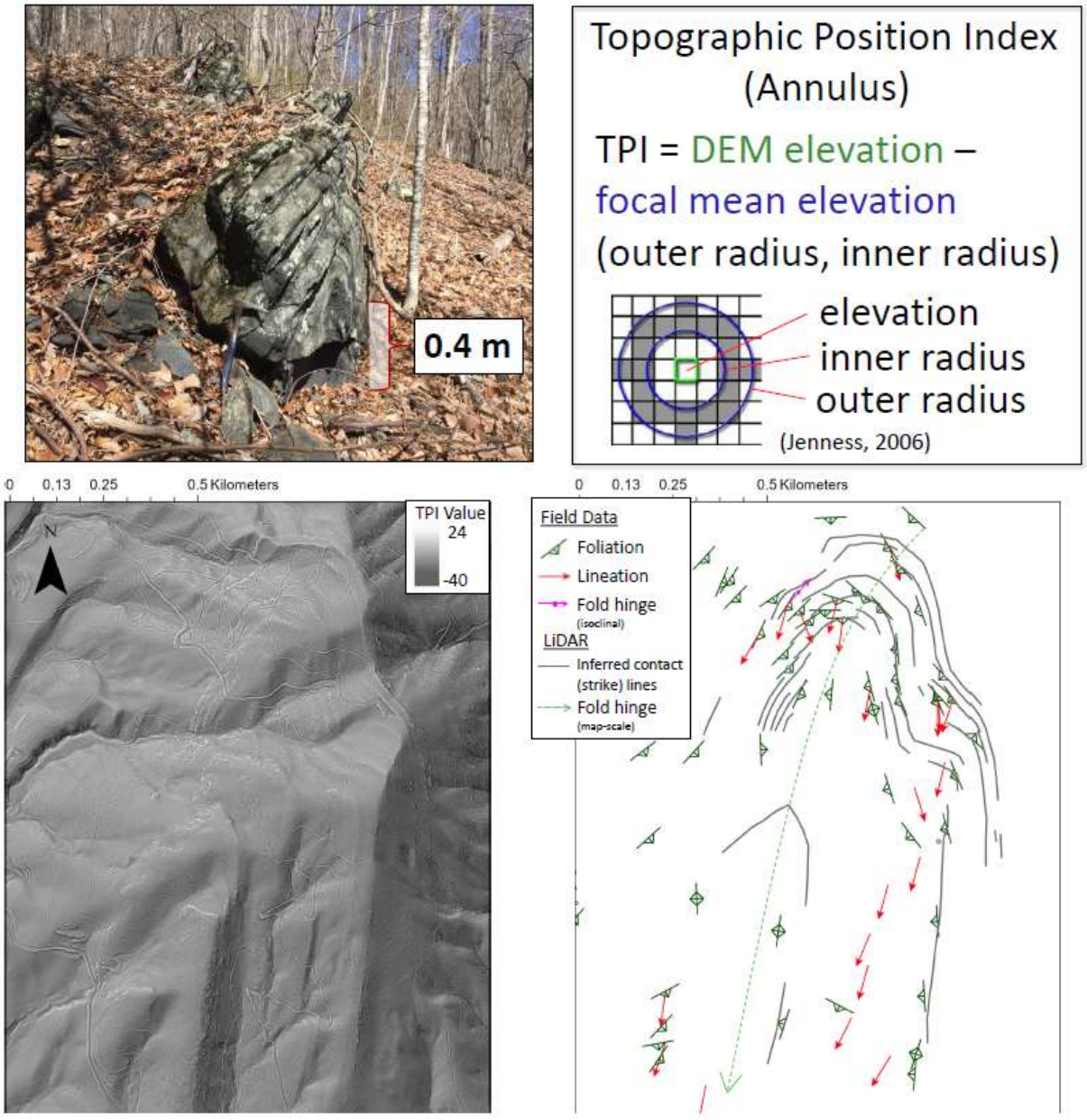

Figure 28: Amphibolite outcrop and topographic calculations used to highlight outcrop.

Lidar derived hill shade and TPI highlighting amphibolite fins (high TPI values) and bedrock structure defining synform plunging to the southwest.
Bedrock structure field data and inferred contact (strike) lines from LiDAR (left) analysis.

Coastal Plain Mapping

NCGS Coastal Plain Program geologists use LiDAR to create morpho-stratigraphic maps of the Coastal Plain province (44% of the State). When combined with subsurface investigations (drilling) to define stratigraphy, these detailed landform maps help identify: 1) potential areas for critical mineral exploration, 2) potential geologic hazards, 3) surface water flowpaths, and 4) the geologic framework of the shallow aquifer system and its associated groundwater vulnerability.
Hillshade, slope, and contour lines (1 m, 0.5 m and 0.25 m) were created from LiDAR. These derivatives were used in conjunction with orthoimages to interpret the landform elements that form the relict Quaternary landscape (Figures 29 and 30). This data set is also currently used for the Earth MRI projects in the Fall Zone placer zone.

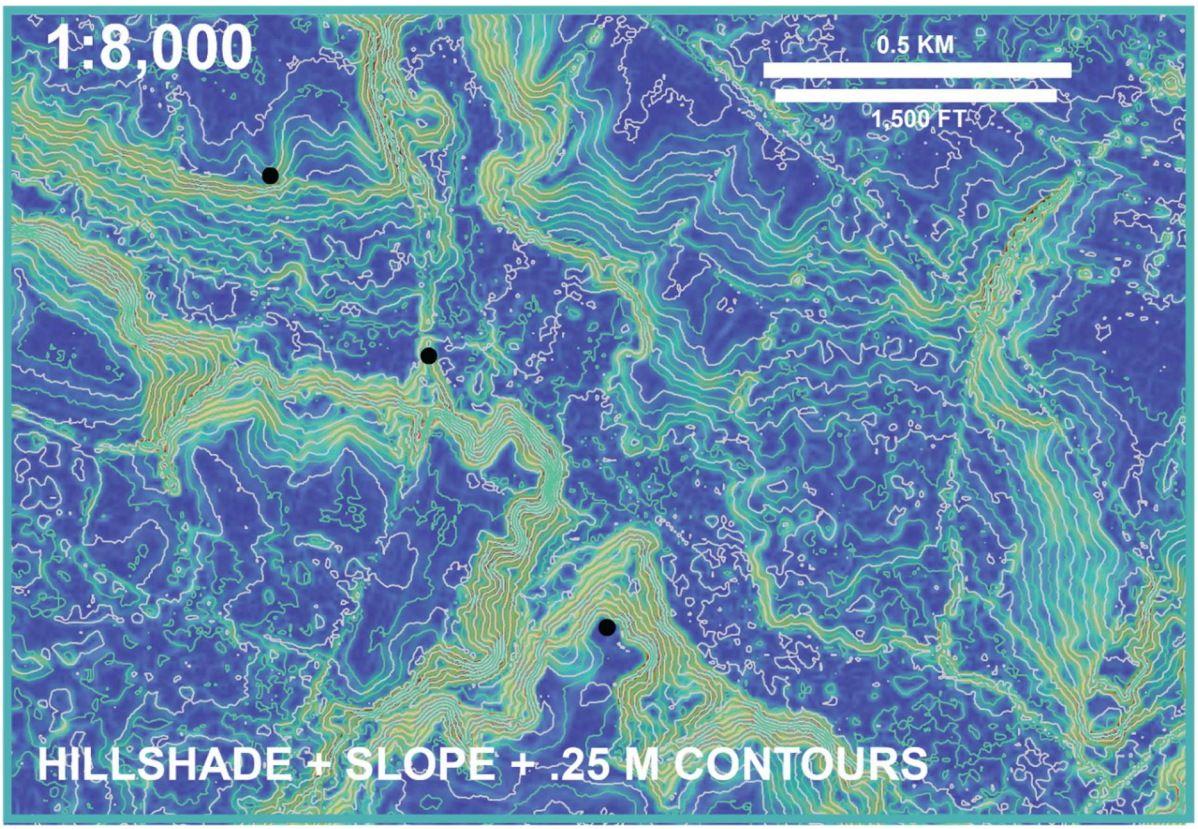

Figure 29: Example use of hillshade, slope and 0.25-meter contour lines to interpret landform elements on the Coastal Plain. Black circles are points of reference between figure 29 and figure 30.

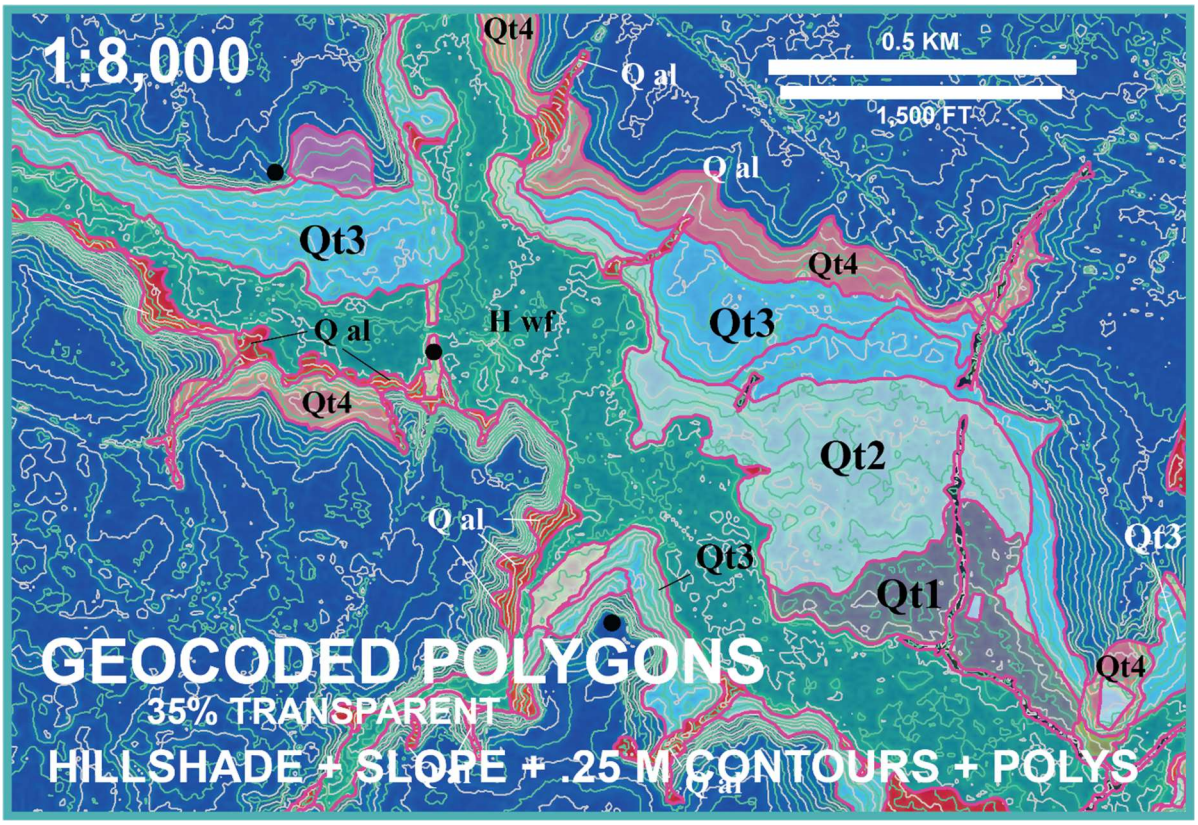

Figure 30: Landform elements depicted as geocoded polygons overlayed on hillshade, slope, and 0.25-meter contour lines; same area as shown in Figure 29. Black circles are points of reference between figure 29 and figure 30.

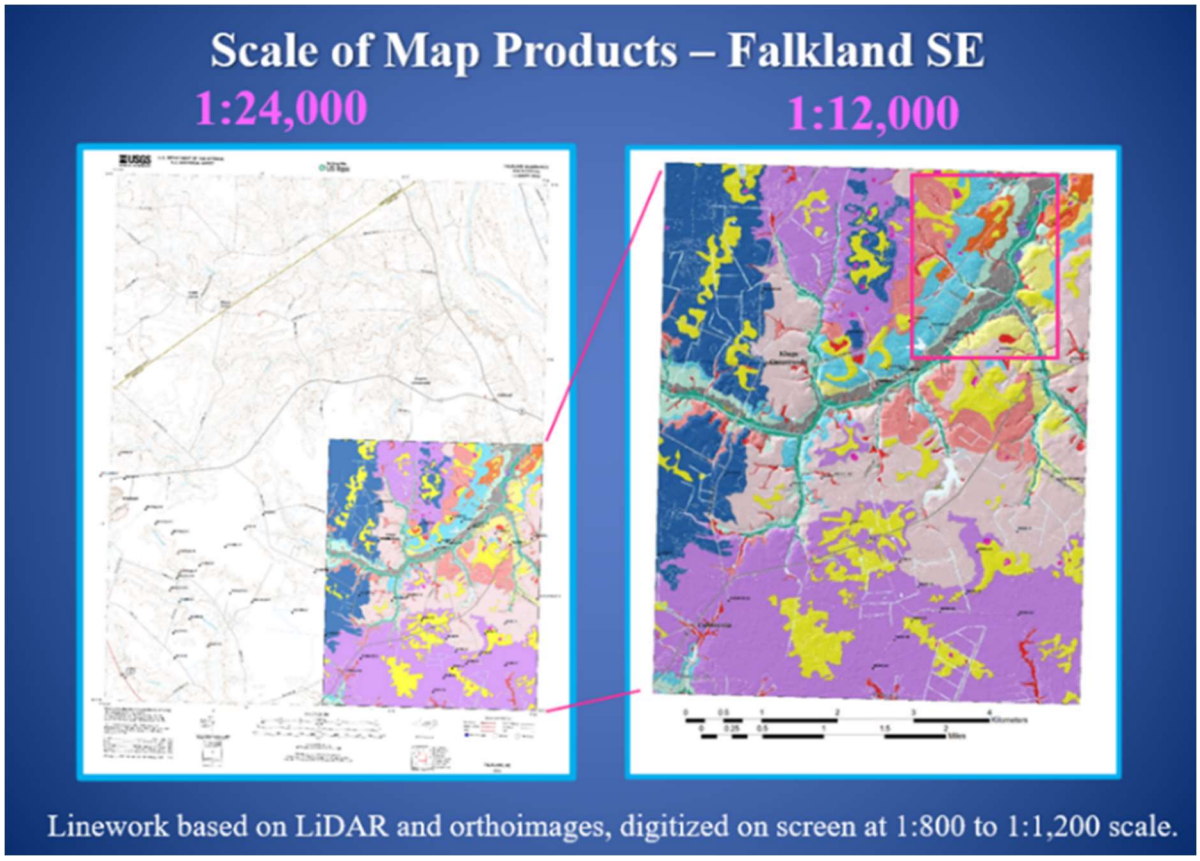

Figure 31: Geocoded polygons derived from LiDAR and orthoimages, digitized on the screen at a scale of 1:800 to 1:1200. An example of a morpho-stratigraphic map of Falkland 7.5-minute quadrangle, Southeast quadrant is provided for Falkland, Southeast Quadrant, of the 7.5-minute quadrangle. For 7.5-minute quadrangle mapping, heads-up digitizing on screen is conducted at a scale of between 1:1200 and 1:800, depending on complexity of the landscape. A quality assurance review is conducted at a scale of 1:625 to 1:400. Map products are shown at a scale of 1:24,000 and 1:12,000.

A single QL1 lidar data capture does not allow for the detection and measurement of land surface changes related to landslides, such as,

1. newly developed landforms caused by the occurrence of new landslides,
2. removal of landslide-related landforms due to changes in land use, such as, construction and timber harvest,
3. lidar differencing to detect changes in elevation caused by erosion, deposition, and sedimentation related to landslides and debris flows,
4. periodic monitoring of slow-moving landslides to understand average rates of movement and total displacement.

Ongoing capture of QL1 lidar data will allow NCGS to provide timely and accurate mapping of landslides and analysis of landslide hazards by providing a time-series dataset that currently does not exist.

State and National Value

Mapping using LiDAR supports the Earth MRI Program, the U.S. GeoFramework Initiative, and N.C. landslide inventory and modeling. Once defined, the landform units which are part of a comprehensive

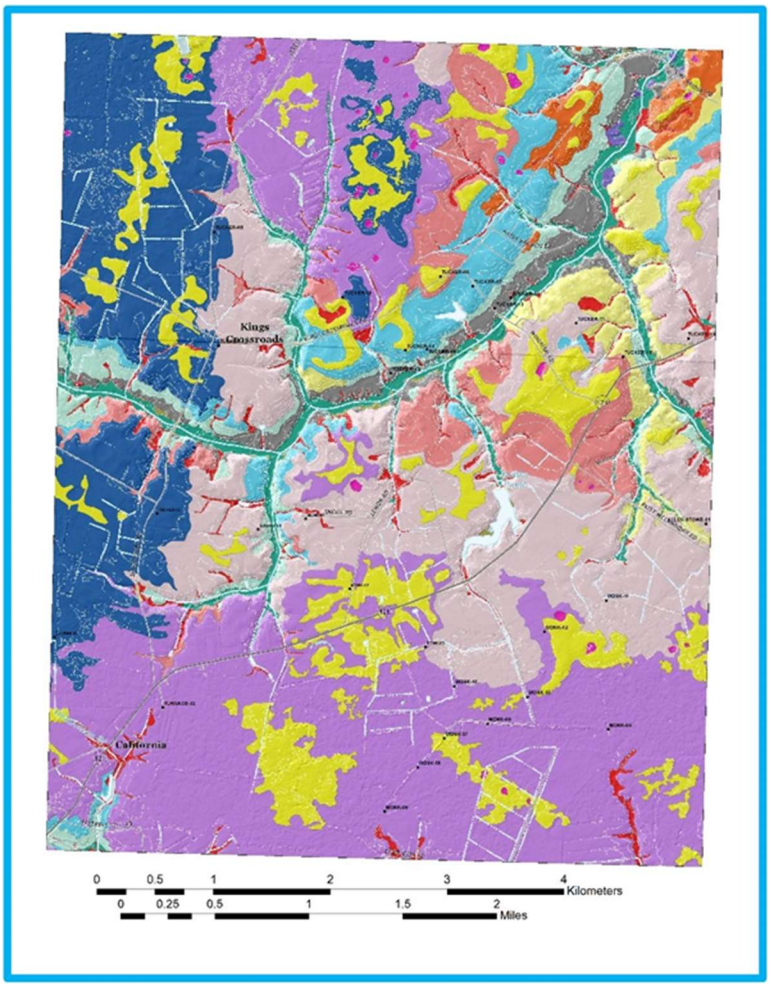

Figure 32: G Zoomed in view shows details of geocoded polygons based on orthoimages used with LiDAR (hillshade, slope, contours and elevation grids).

landscape analysis, can be coded for potential critical mineral deposit, geologic hazard, surface water flowpath, and possibly, groundwater vulnerability if combined with a detailed stratigraphic analysis.

Earth MRI

The U.S. is 100% dependent on imports for 21 critical mineral commodities and is at least 50% dependent on imports for another 28 critical mineral commodities. Defining the geologic framework for critical minerals exploration is now a top priority at the national level. The Bipartisan Infrastructure Law provided $320 million over five years to the Earth MRI program to advance scientific innovation and map critical minerals vital to the Nation's supply chains, economy and national defense. Studies sponsored by Earth MRI aim to identify areas with potential for undiscovered critical mineral deposits that could reduce U.S. mineral import dependence, thereby strengthening national security, creating jobs within the private sector, and generating ancillary economic and social benefits. The work will modernize our understanding of the Nation's fundamental geologic framework and improve knowledge of domestic critical mineral resources, a key step in securing a reliable and sustainable supply of the critical minerals that power everything from household appliances and electronics to clean energy technologies like batteries and wind turbines.

U.S. Geoframework Initiative (Statemap)

The US Congress recently tasked the U.S. Geological Survey with compiling a geologic map of the entire United States by 2030. The USGS provides funding to the NCGS to assist with this mapping effort at the 100K and in some cases, detailed 24K scale. LiDAR is crucial to complete these deliverables in the coastal plan area and helpful in the blue ridge. Once this preliminary Morpho-stratigraphic mapping is complete, it will be used to train Artificial Intelligence (AI) to increase efficiency.

Survey Carolina Pllc

Surveyors and Engineers were having trouble finding reliable topography data to base feasibility, preliminary design, and other survey data for future development, planning, and land surveying data. Existing surface model data sets, such as Legacy LiDAR from NCFRIS, are not as dense, up to date, or accurate as QL2 LiDAR provided by North Carolina Emergency Management.

Feasibility Studies

LiDAR can be used to identify and note areas of a potential project that may be suitable, borderline, or unsuitable for development. This topographic data is used during feasibility portion of the project to plan for civil design including sanitary sewer, storm sewer, roadway plans, and others. Using LiDAR data, better cost analysis can be performed before projects reach preliminary design allowing project decision makers a clearer picture of cost, timeline, environmental impact, and scope.

Preliminary Design

QL2 LiDAR provides a dataset called “Bare Earth” which can be used by designers for preliminary site design. This dataset proves to be a useful tool due to its accuracy. Compared with conventional field topography provided by surveyors, QL2 LiDAR has been found to be within +-5” of surveyed ground topography under canopy in various project survey areas in Piedmont Region of North Carolina. Consistencies to surveyed data improve when in low vegetation or no vegetation environments. Limitations to this dataset include precise horizontal location of watercourses including banks and centerlines, vertical positions of hardscapes such as asphalt or concrete under tree or vegetative canopy, and areas that have been disturbed since the dataset was acquired.

The age of the QL2 dataset is becoming an important issue, considering most of the Piedmont Region of North Carolina was acquired in 2014-2015. To keep consistent and quality use of QL2 LiDAR, datasets should be updated and provided on a regular and scheduled basis.

Quality Assurance/Quality Control (QA/QC)

The statewide LiDAR dataset can also be used as a QA/QC tool for survey data. Wide area survey projects such as stormwater and sewer inventories for cities and towns in particular can benefit. Using the LiDAR as an independent verification can build confidence and provide a way to detect possible blunders in these large survey efforts that contain thousands of individual structure locations. However, rapid development in some parts of the state can limit this application as data becomes outdated.

Benefits of Lidar to Surveyors

Private practice use of QL2 Bare Earth data in land surveying include calculating steepness of slopes, preliminary subdivision design, storm pipe design, drainage area calculations, sub meter location of features such as creeks, streams, and watercourses, roads and roadbeds, ridgelines and identifying areas with dense vegetation that may require additional field time for survey crews. Each of these features

that can be designed, located or planned utilizing QL2 LiDAR improves the overall accuracy, time efficiency, and customer cost in a private practice land surveying company.

Department of Environmental Quality, Division of Water Resources

Business Process, Process Justifications, and Data Required

Public Water Supply Lines

Occasionally water systems have issues with bacteria or other contaminates getting into the water supply or the lines. Knowing where the closest connection is to another working system during these emergency times would be helpful to get clean water to the public much faster when needed. Would also help to know who to contact for emergency connections. Along with knowing location of connections, knowing where the line valves are located would greatly help turn contaminated lines off faster. (Byron Burrell)

Could be used for permitting wells. See more below (from Ed Watson) about knowing the distance from where the applicant is hoping to install a well or if a variance can be issued for a well construction. (Ed Watson)
When spills occur or other environmental issues occur that contaminate drinking wells, it would greatly help to know where the public water supply lines are located. Staff would then be able to determine the distance of those private properties with contaminated well to the public supply lines. (Sean McGuire)

We'll need Distribution lines for identifying water systems interconnections and to help systems find emergency interconnection opportunities, PWS Service Area boundary polygons, PWS intake point data, wastewater returns (discharge) point data for Local Water Supply Plans and planning efforts in general. Withdrawal and return point data are also helpful for designing hydrological models and studying IBT requests. (Charley Theobald)

Wastewater Collection System Lines

When looking at permitting a new well, knowing where the wastewater collection system lines are located, would make this permitting process much faster. It also helps with variance approvals and speed at which that gets done. Having this information in a GIS format would also save resources and time in researching and waiting on communications about if lines are there and general locations of those lines. Significant amount of time is spent on this information searching by staff. (Ed Watson)

Stormwater Network

Having knowledge of where existing stormwater networks are located will help refine and clean up hydrography layers. (Andy Kiley)
The headwater stream modeling group (HSSD) had asked for stormwater infrastructure data from a few municipalities in certain pilot watersheds in order to help sketch out "urban" boundaries using outfall locations, etc. Our usual method of stream modeling (using LiDAR and elevation derivatives) doesn't work too well on flat paved over areas and gets confused with culverts, bridges, and underground pipes. In addition, the modeling effort might also use the location of culverts (perhaps including smaller driveway pipes) to improve our computer generated "streams". (Ernest Hahn)

Infrastructure Data Format, Scale, Accuracy, and Extent

For all data listed above, DWR would love to have the data in shapefiles, hosted feature services, or any other format that can be easily imported or used in an ESRI ArcGIS Online format. Scale and extent completely depend on the provider and what they are willing to share. The division would like to know what the accuracy level is but would not require a specific accuracy.

Data Security

DWR is willing to develop a data use agreement or review one provided by the data provider. Once confirmed by council that the division would be able to do so, the division would keep all data internal unless otherwise agreed upon by both parties.

Project Impact/Data Impact

Having access to this infrastructure data would save DWR staff significant amounts of time in a variety of ways across several sections of the division. Majority of the need for this data is for spatial awareness. Most of the time, our staff must reach out to various utilities to inquire about locations of lines, valves, etc., which can slow down turn-around times for permit processing and emergency responses. The extent of this slow down could be very impactful during emergency situation.

Person County NC Economic Development

Business Process

Inventory Survey – As a government economic development organization, we utilize the infrastructure data to analyze where and how many viable sites we may have for new industry.

Business Process Justification

This process is very important to our work because we always need to be prepared to develop new sites for when existing sites become developed. It takes time and money to expand infrastructure, so if we do not evaluate this routinely, we will find ourselves in a situation where we may not be able to develop new sites to attract new industry because we are years away from being able to build new infrastructure. If we do not have available sites, we will not attract new projects to bring jobs and investment for the community.

Infrastructure Data Required

For our inventory survey, we use all the data types in the above bulleted list as well as transportation corridors, such as roads and rail.

Infrastructure Data Obtained

We utilize our local public GIS web application, as well as an internally developed private web application. We also use the NCDOT interactive map. With the public application, roads and streams, ponds, and wetlands are available, as are traffic counts on the NCDOT tool. On the internal, private application, we can access publicly owned telecom data as well as water and sewer, which was recently added to the public application. With aerial imagery sometimes we can tell where electric transmission lines are, but not extensively and not at what capacity. None of the public utilities data provides capacity information except traffic counts on some roads. We also know that some of the data is missing with the systems that we do have and may be inaccurate. The data is available on interactive online maps and is printable to PDF. For the most part, what we have is county-wide. The most current water, sewer, telecom and all electric and gas is unavailable except what may be discerned from satellite images, i.e., visible transmission lines and natural gas equipment.

Note from the GIS Manager: We have some extremely basic privately owned telcom data. It is not spatially accurate or complete and has no indication of capacity.

Data Security

For some evaluations we were able to see snapshots of gas and electric after contacting the utility companies. The imaging was so narrow in scope that it was not a confidentiality issue. When we were able to see the water and sewer on our internal application only, it was password-protected and only used for internal use.

Note from the GIS Manager: We password protect web applications which feature sensitive utility information, however, the REST services themselves are open and could be exploited. The City of Roxboro just allowed us to publish their water and sewer data on a public facing application. The locations of system features are provided, but there is no attribution. We provide copies of water/sewer data by request only, and I typically ask the City/let them know when those requests come in and honor their wishes to share or not share or share only a portion. We have data for some privately owned telcom networks and data for networks built by the County or MCNC. None of that data is shared with the public and viewing that information in Desktop/Pro is limited by user.

Ideal Infrastructure Data

It would be helpful to know the location of all infrastructure and to know that it was updated when the system was expanded or reduced. It would be helpful to know the capacity of what is available. It would be helpful to have this information be available on an interactive map and to be available on one tool that is not county specific. It is difficult to know what our specific resources are and how we compare to other areas to best plan and develop as a region.

Project Impact

By understanding the constraints and being a public body, we know to reach out to our service providers to confirm what we see on a map that may or may not have the most accurate data. To have a comprehensive and reliable tool would be the most helpful when we are working with projects to provide site selection services. Some of this information is not readily available even through service providers, such as telecom, yet it is a critical part of site development. Having the data more readily accessible could help prevent time wasted when moving advancing a site in a selection process that may have inaccurate or incomplete information displayed.

Person County Geographic Information Systems Department

BUSINESS PROCESS

Citizens relocating to the area often want to know what utilities are available and where, especially telecommunications.

BUSINESS PROCESS JUSTIFICATION

I work in the same office with our building inspections department and issue addresses as people applying for permits. We often get asked which power company services a particular piece of property, and we cannot answer that question. The same goes for telecom/internet providers. We typically tell the citizens to ask a neighbor or look at the utility poles on their property for a metal placard with the name of the utility owner. There are telecom maps online, but we have found them to be unreliable as they tend to overstate coverage and speed. It just seems like this is not a

sufficient answer for people who are interested in investing in a home in Person County; we can't answer the most basic of questions for them.

INFRASTRUCTURE DATA REQUIRED

Service areas for power, water, sewer, telecom, and natural gas. In the case of telecom, speeds would be nice (dial-up, broadband, etc.).

INFRASTRUCTURE DATA OBTAINED

As a GIS Manager, I have access to water and sewer data provided from the City of Roxboro via shapefile. It's fairly spatially accurate, represents the majority of their systems, but has next to zero attribution. I am able to tell a citizen that they have water and sewer lines that either cross their property or are nearby (in the street for example). That information is also publicly available on our primary GIS application and we supply a disclaimer that presence of a water/sewer utility is not a guarantee of service.

For power and natural gas I have no reference material. Duke and Piedmont EMC both service this area and have websites where you can type in addresses to determine if an address is covered by the company. However, because we are the addressing authority and the citizen is in the early stages of building, quite often their addresses don't register in the respective systems.
For telcom, I have an extremely low quality dataset that was generated via windshield survey and hand drawn on a map. The data is of such poor spatial precision and accuracy that we can't rely on it at all. Communication tower information is available from the FCC. However, several companies may have equipment hung on the same tower. The FCC data lists each of those companies as a separate facility with different lat/long (even though it's the same tower). It's a manual process to get that information from the FCC into a format I can make sense of. Also, since the cell sectors are dynamic, I'm unable to capture that information in my static databases.

I have GIS data for the County-owned fiber network and the MCNC line running through the County. They are of higher spatial quality with very little attribution.

DATA SECURITY

I am allowed to share water and sewer data for emergency purposes (CAD, fire departments, etc.). I cannot share that data beyond those purposes and refer those requests to the data owners (City). We have data for some privately owned telcom networks and data for networks built by the County or MCNC. None of that data is shared with the public and viewing that information in Desktop/Pro is limited by user.

IDEAL INFRASTRUCTURE DATA

Ideally, we'd be able to model the real world in GIS. Utility networks and locations of sensitive structures would be an ideal outcome of this data as would service areas which we could make available to the public.

PROJECT IMPACT

When we cannot answer basic utility questions for the public we lose credibility, which is hard to come by in the first place. It causes a lot of frustration on the part of someone who is doing their due diligence on a piece of property before they seek to buy it.

Department of Insurance

BUSINESS PROCESS
Insurance companies need to know the distance to the closest fire hydrant for underwriting purposes.

BUSINESS PROCESS JUSTIFICATION
Insurance adjusters and underwriters need a way to determine distance to the closest fire hydrant. If fire hydrant locations are not made publicly available via web application, then they have to call GIS and/or City staff to get them to measure in ArcGIS while on the phone.

INFRASTRUCTURE DATA REQUIRED
Spatially accurate fire hydrant locations. Attribution not required.

INFRASTRUCTURE DATA OBTAINED
Partially due to the volume of calls from insurance companies, the City (water GIS data owners) allowed us to put this information on our primary GIS website which provides a measuring tool. They provided shapefiles which I put into a geodatabase and published as a REST service. No attribution is provided to the public via this method.

DATA SECURITY
There's a disclaimer on our website that presence of a water/sewer utility is not a guarantee of service.

IDEAL INFRASTRUCTURE DATA
In allowing the County to publish the fire hydrant locations publicly, our needs were met as well as those needs of the insurance companies.

PROJECT IMPACT
The primary impact of having the fire hydrant data on a public GIS portal is that we receive fewer phone calls asking us for distance to a fire hydrant. In the past, we could always tell when someone was shopping for insurance because we'd get the fire hydrant distance question for the same house from 3 insurance agents within an hour to two. Each call was maybe only a few minutes, but the reduction in interruptions has been a massive improvement. Now, if we do receive a call, it's usually stepping someone through how to use the measuring tool on the website instead of us doing the measuring for them.

Person County, Highway Project

BUSINESS PROCESS
NCDOT plans major road improvements and wishes to mitigate and/or understand the challenges with utility information.

BUSINESS PROCESS JUSTIFICATION

NCDOT contacted the Person County GIS department to obtain utility information surrounding a project on the main thoroughfare through Roxboro. Some utilities will need to be relocated permanently or on a temporary basis during the project. Others will likely need to be replaced due to condition or age and the age of a utility might factor into who is responsible for the funding. NCDOT also needed us to supply facilities that might require no interruptions of service such as water to dialysis centers or electricity to telecom facilities.

INFRASTRUCTURE DATA REQUIRED

Locations and decent attribution for water, sewer, stormwater, telecom, electricity, and natural gas lines, facilities, etc.

INFRASTRUCTURE DATA OBTAINED

Initially, NCDOT asked for the GIS data for the project area. I received approval from the City to distribute the water and sewer information to NCDOT as well as approval from our IT department to distribute the location of county-owned Fiber Optic network information. Along with that info comes the locations of poles for aboveground fiber lines; those poles are not owned by the County and tend to carry multiple utilities. We do not have electricity, natural gas, or stormwater information that can be shared. I gathered the GIS data and clipped it all to the study area provided on project drawings from NCDOT, zipped up the data, and e-mailed it out. A few days later, the person who had made the request couldn't understand why he couldn't open a .shp in Adobe; what they actually needed was maps, not data, so I turned around and made maps instead.

DATA SECURITY

We did disclose that the data should not be shared beyond the scope of the NCDOT project. However, there's no metadata stating that. Also, the data shared was for a small area and not the whole system which may provide a little security.

IDEAL INFRASTRUCTURE DATA

Ideally, we would have accurate water, sewer, and stormwater data from the city as well as from private companies (telecom, electric, and natural gas). Pipe materials, age/date installed, diameter/capacity, etc., information would be available on the wet utilities. For the dry utilities, it's a little different for this project area. The majority of those utilities are above ground and hung on poles. What we would need is the pole locations tagged with the utilities hung on the pole. We'd also need locations of dips into the ground or buildings as well as switches and transformers for electric along with number of phases and KVA. For natural gas, line locations and connections to service lines/meters would be ideal.

PROJECT IMPACT

Project planning is crucial for NCDOT – it helps them plan both physically and financially for a difficult project such as the one being proposed. For the City and County, it would be beneficial to have GIS data of high enough quality to model the utility networks such that when a facility is impacted, we could quickly identify the source of the problem. Also, there's a stormwater issue located near this project that would need to be monitored so good GIS data would help with that as well.

Department of Transportation, Asset Management and Maintenance

BUSINESS PROCESS

NCDOT Asset Management Program, Roadway Maintenance Program and Pavement Management Program.

BUSINESS PROCESS JUSTIFICATION

The 3 programs mentioned above support the daily maintenance activities that provide safe and operational roadway facilities to the citizens of North Carolina. Each Program requires detailed utility information about what is contained within the NCDOT ROW for the benefit of worker safety (all 5), knowledge of contributing systems (stormwater), and maintenance project planning (all 5).

INFRASTRUCTURE DATA REQUIRED

All available including but not limited to Water/sewer, Electrical, Natural gas, Telecommunications and Stormwater maintained by Federal, State, Local and Private entities.

INFRASTRUCTURE DATA OBTAINED

Generally good data is unavailable. To date the only data NCDOT has been able to obtain is through historical records created or maintained in-house as part of the project delivery process, freely available data via download or web service from federal state or local municipalities, and older paper or scanned digital plans acquired from other sources. The only major power provider to knowingly contribute some level of data to date is Duke Power which has provided its ROW polygons.

DATA SECURITY

Currently NCDOT has no agreements with any utility provider for routine delivery or secure data access to utility data as part of the support for the project delivery process.

IDEAL INFRASTRUCTURE DATA

Ideal infrastructure datasets would take the form of a secure or publicly available web service in the format of an ArcGIS Feature Service. These endpoints would represent utility locations within the 5 categories of data, at a mapping scale of 1”=40’ that would meet national map accuracy standards for that scale. Due to the spatial extent of NCDOT project locations, essentially our ideal datasets would amount to a service area wide coverage of all utility data for each utility provider. Ideal attribute data would include material types, ages, sizes, owners, and include Z value for depth where possible.

PROJECT IMPACT

More detail is better when it comes to the NCDOT Maintenance Programs. Ideal data as soon as possible allows for better worker safety, better project planning and an overall better product for the citizens of the state. Missing or inadequate data can lead to worker safety issues, and as with project delivery, budget, schedule, and planning errors that could be avoided.

Department of Transportation, Emergency Response

BUSINESS PROCESS

NCDOT Emergency Response Support.

BUSINESS PROCESS JUSTIFICATION

The various divisions within NCDOT are required to respond to varying emergency situations occurring within the NCDOT ROW. Better knowledge of what is contained within the NCDOT ROW will allow for better worker safety and more effective communication in emergency situations.

INFRASTRUCTURE DATA REQUIRED
All available including but not limited to Water/sewer, Electrical, Natural gas, Telecommunications and Stormwater maintained by Federal, State, Local and Private entities.

INFRASTRUCTURE DATA OBTAINED
Generally good data is unavailable. To date the only data NCDOT has been able to obtain is through historical records created or maintained in-house as part of the project delivery process, freely available data via download or web service from federal state or local municipalities, and older paper or scanned digital plans acquired from other sources. The only major power provider to knowingly contribute some level of data to date is Duke Power which has provided its ROW polygons.

DATA SECURITY
Currently NCDOT has no agreements with any utility provider for routine delivery or secure data access to utility data as part of the support for the project delivery process.

IDEAL INFRASTRUCTURE DATA
Ideal infrastructure datasets would take the form of a secure or publicly available web service in the format of an ArcGIS Feature Service. These endpoints would represent utility locations within the 5 categories of data, at a mapping scale of 1"=40' that would meet national map accuracy standards for that scale. Due to the spatial extent of NCDOT project locations, essentially our ideal datasets would amount to a service area wide coverage of all utility data for each utility provider. Ideal attribute data would include material types, ages, sizes, owners, and include Z value for depth where possible.

PROJECT IMPACT
Better data will allow better response times for emergency situations and a safer response for all involved. More detail will allow for better response planning and effective communication.

Use Case provided by Department of Transportation, Hydraulics Unit

BUSINESS PROCESS
NCDOT Hydraulics Program. This program is responsible for managing stormwater runoff from NCDOT maintained facilities.

BUSINESS PROCESS JUSTIFICATION
The Hydraulics program requires as much detail as possible in regard to stormwater facilities either in the NCDOT ROW, contributing drainage to the NCDOT ROW or taking drainage away from the NCDOT ROW. This knowledge allows for better planning for stormwater facilities that manage runoff from NCDOT facilities. Some of these activities involve rapid responses that fall outside the normal project delivery process.

INFRASTRUCTURE DATA REQUIRED
All available Stormwater data maintained by Federal, State, Local and Private entities.

INFRASTRUCTURE DATA OBTAINED
Some stormwater data is available from some municipal resources but in most cases, metadata is lacking and thus the data cannot be verified for quality. To date the only data NCDOT has been able to

obtain is through historical records created or maintained in-house as part of the project delivery process, freely available data via download or web service from federal state or local municipalities, and older paper or scanned digital plans acquired from other sources. The only major power provider to knowingly contribute some level of data to date is Duke Power which has provided its ROW polygons.

DATA SECURITY

Currently NCDOT has no agreements with any utility provider for routine delivery or secure data access to utility data as part of the support for the project delivery process.

IDEAL INFRASTRUCTURE DATA

Ideal infrastructure datasets would take the form of a secure or publicly available web service in the format of an ArcGIS Feature Service. These endpoints would represent utility locations within the stormwater category of data, at a mapping scale of 1”=40’ that would meet national map accuracy standards for that scale. Due to the spatial extent of NCDOT project locations, essentially our ideal datasets would amount to a service area wide coverage of all utility data for each utility provider. Ideal attribute data would include material types, ages, sizes, owners, and include Z value for depth where possible.

PROJECT IMPACT

More detail is better when it comes to the NCDOT Hydraulics Program. Ideal data as soon as possible allows for better Hydraulic design, better project planning and an overall better product for the citizens of the state. Missing or inadequate data can lead to poor design and as with project delivery, budget, schedule and planning errors that could be avoided.

Department of Transportation, Case Project Delivery

BUSINESS PROCESS

NCDOT Project Delivery (Roadway, Rail, Aviation). Each of the above 5 listed data categories are currently evaluated for their respective locations as part of the project delivery process for NCDOT Roadway, Rail, and Aviation projects. This process is a major effort involving multiple NCDOT divisions and spans the project timeline from initial project concept all the way to project letting, just prior to construction and includes encroachment permits. These activities generally span a time frame of multiple years as the facility is planned and designed. Any evaluation and negotiations related to utilities usually occurs late in the project delivery process due to stipulations from the utility owners that the project design must be in its final design stages before they will begin planning to adjust the location of their facilities. It is at this time the full scope of what is in the ground and what must be done is tackled.

BUSINESS PROCESS JUSTIFICATION

The Project Delivery process is an essential function of NCDOT which serves to bring new and upgraded facilities to the public at an appropriate cost. Delays in obtaining details about the existing or proposed Right of Way for Rail, Road or Aviation projects effects project budget and schedule.

INFRASTRUCTURE DATA REQUIRED

All available including but not limited to Water/sewer, Electrical, Natural gas, Telecommunications and Stormwater maintained by Federal, State, Local and Private entities.

INFRASTRUCTURE DATA OBTAINED

Generally good data is unavailable. To date the only data NCDOT has been able to obtain is through historical records created or maintained in-house as part of the project delivery process, freely available data via download or web service from federal state or local municipalities, and older paper or scanned digital plans acquired from other sources. The only major power provider to knowingly contribute some level of data to date is Duke Power which has provided its ROW polygons.

DATA SECURITY

Currently NCDOT has no agreements with any utility provider for routine delivery or secure data access to utility data as part of the support for the project delivery process.

IDEAL INFRASTRUCTURE DATA

Ideal infrastructure datasets would take the form of a secure or publicly available web service in the format of an ArcGIS Feature Service. These endpoints would represent utility locations within the 5 categories of data, at a mapping scale of 1"=40' that would meet national map accuracy standards for that scale. Due to the spatial extent of NCDOT project locations, essentially our ideal datasets would amount to a service area wide coverage of all utility data for each utility provider. Ideal attribute data would include material types, ages, sizes, owners, and include Z value for depth where possible.

PROJECT IMPACT

More detail earlier in the project delivery process is better when it comes to the NCDOT project delivery process. Ideal data as soon as possible allows for better project planning and more effective communication in regard to the challenges any project will face. More detail will allow for better project budgeting and scheduling due to the ability to ascertain the level of effort required to complete any relocation work. Missing or inadequate data leads to budget, schedule and planning errors that could be avoided

General Observation, Aging Workforce

BUSINESS PROCESS

Requests for local infrastructure data in N.C. are likely to be made to local governments. Cities and counties are providers of numerous utility services, primarily water and sewer but also including stormwater, electricity, and natural gas. Wide variation exists in the workforce experience and capacity of these local governments, and as experienced employees retire, institutional knowledge of how to best respond to infrastructure data requests is likely to decrease.

Local governments vary significantly across the 100 counties and 551 incorporated municipalities in N.C. For instance, of those 551 municipalities, three-quarters have a population less than 5,000. Nearly 40 percent of municipalities have a population of less than 1,000. (https://www.osbm.nc.gov/facts-figures/population-demographics/state-demographer/municipal-population-estimates). This impacts the services these governments are able to provide and the associated workforce to provide them. As an example, many smaller municipalities do not have dedicated GIS employees themselves, instead relying on partners at the county level to provide such services. Decentralization of this function presents an additional layer of challenges when infrastructure data is requested.

Similar differences are seen in these local governments that are providers of water and wastewater services. In the most recent water and wastewater rates survey conducted by the Environmental Finance Center at the University of North Carolina Chapel Hill (https://efc.sog.unc.edu/resource/tables-

water-and-wastewater-bills-and-rate-structures-north-carolina-january-2020), of the 472 utility providers with available data on service connections, 180 had 1,000 or fewer water customers. Compared to the largest utilities in the state that serve tens or hundreds of thousands of customers, resources available to respond to infrastructure requests among smaller utilities are much more limited.

These challenges could be exacerbated in the years to come due to the nature of the industry's workforce. The looming retirement of experienced employees is a challenge across all sectors of government and the broader workforce as well. This may be particularly true in the case of utility providers. The N.C. Chamber's recent Framework for North Carolina Water Policy report (https://ncchamber.com/wp-content/uploads/Framework-for-NC-Water-Policy-FINAL.pdf) stated, "North Carolina also faces challenges related to an aging workforce as well as data management." Statistics from the Bureau of Labor Statistics cited in this blog post (https://efcnetwork.org/operating-at-a-deficit-solutions-to-a-water-and-wastewater-operator-shortage/) from an author at the EFC indicate that, nationally, more than 50 percent of water and wastewater operators are age 45 or older, with nearly 30 percent of them over age 55. Less than 20 percent of operators are younger than 35, with 1 percent age 24 or younger.

PROJECT IMPACT

There are a number of smaller utilities in the state that serve a limited amount of customers and maintain a limited staff with which to do so (at least in comparison to the state's larger utilities). In many cases, these utilities are served by key experienced staff members who may be approaching retirement age. As these workers prepare to leave the workforce, institutional knowledge such as the existence of key data, how to access it, how to respond to requests for it, etc., could be departing these utilities as well. For utilities that serve areas that have experienced less economic development in recent years, it could be that procedures for providing data have been little utilized, if they have ever been utilized at all. Existing data may or may not be in readily accessible formats. These potential challenges are hurdles for smaller utilities to overcome that could be made more difficult through the loss of experienced employees. Standards for data sharing among N.C. utility providers should recognize these challenges and how they apply to all utility providers in the state.

Department of Environmental Quality, Division of Water Infrastructure

BUSINESS PROCESS

The Division of Water Infrastructure (DWI) does not use water and sewer infrastructure data directly, but the Division recognizes that the availability of infrastructure data is critical for local utilities in their continued viability. In supporting viable water and wastewater utilities the DWI offers local governments loans and grants to conduct asset inventory and assessment studies that may include mapping of the local infrastructure and condition assessment, and creation of GIS data layers to help them manage their systems. The maps and associated data are typically housed by the utility, or with support from the county. NC rural communities face many challenges in managing viable water and sewer utilities and having reliable and up to date infrastructure data is a fundamental need for all of them. Any steps that would help relieve the financial burden of managing and maintaining infrastructure data would be helpful.

BUSINESS PROCESS JUSTIFICATION

Accurate and up to date water and sewer infrastructure data is key in developing long-term financial plans, capital improvement plans, and accurate rate setting for water and sewer utilities.

INFRASTRUCTURE DATA REQUIRED

Local government needs water line and sanitary sewer line locations and service areas. Component age, condition, and design attributes are also essential for developing asset management and capital improvement plans.

INFRASTRUCTURE DATA OBTAINED

Water and sewer infrastructure data is available for many communities but not all. Formats are variable as well as accuracy.

DATA SECURITY

Local governments would need to make the data available.

IDEAL INFRASTRUCTURE DATA

Ideally water and sewer infrastructure data would include accurate (mapping grade) locations of pipes, manholes, pump stations, etc, including age and condition assessment, but the Division recognizes that location data and size of pipe data would be a great initial step. Attribution for infrastructure may include sizes of various components, condition, and age, materials.

PROJECT IMPACT

Impacts will be highly variable for different utilities. Some have very robust data sets and mapping tools designed for their system. It is unlikely that they would benefit for a state-wide tool. Others have very limited resources and would benefit greatly.

Department of Environmental Quality, Division of Water Resources

BUSINESS PROCESS

- Stream mapping: Stormwater Infrastructure (SWI) is closely related to intermittent and perennial streams. In many cases the stormwater infrastructure includes these waters of the state.
- Stream restoration: Stormwater infrastructure is perhaps the best opportunity to address impaired waters in urban areas.
- Flood mitigation: Through implementation of practices upstream/street of stormwater infrastructure can help to reduce downstream/street flooding.
- Service area identification: Water and sewer infrastructure can help in prioritizing areas for septic system removal and in estimating contributions of on-site versus sanitary sewer.

BUSINESS PROCESS JUSTIFICATION

Having stormwater infrastructure included or associated with the stream network will allow for spill tracking from streets to creeks. This information is also very important in stream restoration to identify and prioritize retrofits and to implement practices to reduce stormwater flow into the SWI prior to reaching surface waters. SWI information will also help in greening of watersheds providing climate resiliency as well as mitigation for flooding. The SWI dataset would also be very important and pollution prevention and in flood mitigation.

INFRASTRUCTURE DATA REQUIRED

Stormwater infrastructure, Water lines and sanitary sewer lines and service areas.

INFRASTRUCTURE DATA OBTAINED

SWI is available for many communities but not all. Formats are variable as well as accuracy.

DATA SECURITY

So far local governments have made these data available.

IDEAL INFRASTRUCTURE DATA

Ideally SWI would include accurate (mapping grade) locations of inlets outfalls and connecting pipes as well as channels. City of Raleigh is a good example dataset. But anything is better than nothing. Attribution for SWI may include sizes of various components, condition, and if the SWI is conveying waters of the state as well as stormwater. Useful would be actual upstream/street impervious cover for each inlet to help prioritize where to focus restoration efforts and flood mitigation.

PROJECT IMPACT

Community scientists and others would benefit from being able to be directly involved in urban areas in the restoration programs as it would allow them to connect runoff from home to street to creek. Hopefully this association will increase willingness to implement practices on private property to help restore local water quality and reduce/prevent flood events.

Potential case studies can be developed with dollar amounts on a case-by-case basis using a DWR Project Economic Evaluation Tool.

United States Marine Corps, GEOfidelis Utilities Viewer

BUSINESS PROCESS

Enterprise level Internet GEO*Fidelis* Utilities Viewer provides communication; electrical; natural gas; petroleum, oils, and lubricants (POL); thermal; storm water; wastewater; and water data in a secured web application. Utilities are controlled on the DoD "Critical Infrastructure List," therefore additional security measures are required for this service.

BUSINESS PROCESS JUSTIFICATION

The GEO*Fidelis* Utilities Viewer provides facility managers, planners, maintenance workers, emergency operations personnel and responders, environmental staff, telecommunication personnel, and other installation staff with communication and utility network. It also provides the same information to Marine Corps Installation Command (MCICOM), Washington, DC and its subordinate regional commands for a common framework and understanding of where to focus resources to improve infrastructure. The GEO*Fidelis* Utilities Viewer is also assisting the Marine Corps with the Department of Defense's Financial Improvement and Audit Readiness (FIAR) audit to identify and locate linear real property assets that cannot be visually located by the audit team.

INFRASTRUCTURE DATA REQUIRED

Data nomenclature based on the Department of Defense Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE) 3.0 and GEO*Fidelis* Data Model 3.0.0.2.

Communication: CommUtilityNode; CommUtilitySegment
Electric: ElecUtilNode, ElecUtilNode_eCapacitorBank; ElecUtilNode_eDynaProtectDevic; ElecUtilNode_eExteriorLight; ElecUtilNode_eFuse; ElecUtilNode_eGenerator; ElecUtilNode_eGroundingPoint; ElecUtilNode_eMeterPoint; ElecUtilNode_eMiscNetworkFeatu; ElecUtilNode_eOpenPoint; ElecUtilNode_eSwitch; ElecUtilNode_eTransformer; ElecUtilNode_eVoltageRegulator; ElecUtilSegment
Gas: GasUtilNode; GasUtilNode_gControlFitting; GasUtilNode_gDrip; GasUtilNode_gGasLamp; GasUtilNode_gMeterPoint; GasUtilNode_gNonContrFitting; GasUtilNode_gOdorizer; GasUtilNode_gPressMonitorDevic; GasUtilNode_gRegulator; GasUtilNode_gRegulatorStation; GasUtilNode_gReliefValve; GasUtilNode_gRuralTap; GasUtilNode_gTownBorderStation; GasUtilNode_gValve; GasUtilSegment
POL: POLUtilNode; POLUtilNode_oDispenser; POLUtilNode_oFillStand; POLUtilNode_oFilterSeparator; POLUtilNode_oHydrantOutlet; POLUtilNode_oInjector; POLUtilNode_oLoadingArm; POLUtilNode_oMeter; POLUtilNode_oPump; POLUtilNode_oRelaxationTank; POLUtilNode_oStrainer; POLUtilNode_oTank; POLUtilNode_oValve; POLUtilSegment
Thermal: TherUtilNode; TherUtilNode_tAquastat; TherUtilNode_tCondensateCollec; TherUtilNode_tControlValve; TherUtilNode_tExpansionJoint; TherUtilNode_tExpansionLoop; TherUtilNode_tExpansionTank; TherUtilNode_tFitting; TherUtilNode_tMeterPoint; TherUtilNode_tProdStruc; TherUtilNode_tPump; TherUtilNode_tReliefValve; TherUtilNode_tStrainer; TherUtilNode_tSystemValve; TherUtilNode_tTrap; TherUtilSegment
Storm water: StormwaterUtilityNode; StormwaterUtilityNode_swCleanOut; StormwaterUtilityNode_swDownSpout StormwaterUtilityNode_swFitting; StormwaterUtilityNode_swGate; StormwaterUtilityNode_swInlet; StormwaterUtilityNode_swManhole; StormwaterUtilityNode_swMeterPoint; StormwaterUtilityNode_OilWateSepa; StormwaterUtilityNode_swPump; StormwaterUtilityNode_swPumpSta; StormwaterUtilityNode_swReleaseValve; StormwaterUtilityNode_swSystemValve; StormwaterUtilityNode_swTreaPlan; UndefinedStormwaterUtilityNode; StormwaterUtilitySegment; StormwaterUtilityBasin; Impoundment_Stormwater
Wastewater: WastUtilNode; WastUtilNode_sCleanOut; WastUtilNode_sFitting; WastUtilNode_sManhole; WastUtilNode_sMeterPoint; WastUtilNode_sPump; WastUtilNode_sPumpStation; WastUtilNode_sReleaseValve; WastUtilNode_sSystemValve; WastUtilNode_sTreatmentPlant; WastUtilSegment
Water: WateUtilNode; WateUtilNode_wBackflwPrvDevice; WateUtilNode_wControlValve; WateUtilNode_wFitting; WateUtilNode_wHydrant; WateUtilNode_wMeterPoint; WateUtilNode_wPressReduStation; WateUtilNode_wProdStructure; WateUtilNode_wPump; WateUtilNode_wReliefValve; WateUtilNode_wStorageStructure; WateUtilNode_wSystemValve; WateUtilSegment; Well

INFRASTRUCTURE DATA OBTAINED

Data are maintained by each Marine Corps installation using their local projection, scale, and accuracy requirements based on the State or country geodetics. The 17 installation geodatabases are “rolled up” into a single geodatabase using WGS 1984 Web Mercator (Axillary Sphere). Data gaps may occur due to resource constrains or other local factors.

DATA SECURITY

All GEO*Fidelis* data is considered Controlled Unclassified Data (CUI) and must follow DoDI 5200.48 and other guidelines. The local Installation Geospatial Information and Services (IGI&S) Managers vets all requests for access to utilities data. Non-disclosure and authorization letters are standard operating procedures when releasing data to outside organizations (e.g., DoD-affiliated contractors). Internal access the GEO*Fidelis* Utilities Viewer requires Common Access Control (CAC) authentication and an Active Directory entry. Remote desktop access is control through the ArcSDE roles and permissions security.

IDEAL INFRASTRUCTURE DATA

The Marine Corps is moving to a Federated SDE environment which should reduce the requirement to "roll up" the individual installation geodatabases into the single Portal geodatabase. The Federated environment should also allow on-line editing to improve data quality. The Federated environment requires all Marine Corps installation migrate their data to SDSFIE 4.0.

Marine Corps wants to implement network analyst to simulate impacts to utilities systems. Currently implementing tracking usage over time to estimate future utilities cost through operational dashboards and other linkages to utilities viewers and systems.

Incorporating smart sensors and control systems to preemptively maintain facilities and utility systems using targeted maintenance on equipment and systems to reduce costs and ensure installation resilience.

PROJECT IMPACT

The Marine Corps' SDSFIE 4.0 migration and ArcGIS 10.8.1 upgrade should be completed by Sep 2021. Disruption to installation management and the associated cost has not been calculated since the migration is a DoD mandated requirement.

Town of Cary

BUSINESS PROCESS

Cary provides 911 services for our Municipality and two adjoining Municipalities, Apex and Morrisville. Collectively it is called CAM 911 for short. We also provide utilities to Morrisville, but not Apex. As part of our standard Map within our CAD system and MDCs (Mobile Data Computers) we include Hydrants.

We will need hydrant information from Apex and Holly Springs in the areas where Apex provides Mutual Aid into Holly Springs.

BUSINESS PROCESS JUSTIFICATION

By including the hydrants, we allow dispatchers to show if a hydrant is out of service and allow fire personnel on fire calls to preplan where they can drop hoses to set up to fight a fire.

INFRASTRUCTURE DATA REQUIRED

Hydrants

INFRASTRUCTURE DATA OBTAINED
I was able to obtain the data from Apex using a web service. Scale and accuracy were good. To my knowledge their data is map grade GPS. I was able to get data for the entire municipality.
Data from Holly Springs was received by email upon asking. I am not sure of the accuracy of their data. I was able to get data for the entire municipality.

DATA SECURITY
There were no constraints placed on the data. I do not share the data outside of our CAD system. Our 911 center is in a secure area with restricted access. MDCs (Mobile Data Computer) are password protected.

IDEAL INFRASTRUCTURE DATA
Ideally receiving the data as supplied by Apex would be optimal. I like working with web services. It allows me to automate processes to pull the data for at-will updates to the CAD system.

PROJECT IMPACT
The time and effort it takes to reach out to Holly Springs to get a new file.

Town of Cary, Infrastructure Data Provider

BUSINESS PROCESS
Developer/Engineering Firm is looking to develop a parcel of land. Prior to developing plans for the site, they wish to obtain GIS data that includes existing infrastructure (Water, Sewer, Reclaimed Water and Stormwater).

BUSINESS PROCESS JUSTIFICATION
For our organization, can existing infrastructure support the intended future development? For the developer knowing the existing infrastructure can reduce construction costs and provide construction timeline efficiency.

INFRASTRUCTURE DATA REQUIRED
Water, Sewer, Reclaimed Water and Stormwater for the area surrounding the proposed development area.

INFRASTRUCTURE DATA OBTAINED
We ask the requestor for a shapefile that contains a polygon outlining the area of interest. We deliver the data in either a shapefile or file geodatabase format. Accuracy is relative to the source documentation of the data.

DATA SECURITY
No constraints are placed on the data provided.

IDEAL INFRASTRUCTURE DATA

Provide the data in a File Geodatabase where the data is supported by accurate source documentation (Signed Sealed As-builts, Signed Sealed and Classified Surveyed Documents).

PROJECT IMPACT

Level of confidence in the data provided.

North Carolina Railroad, Data Provider

BUSINESS PROCESS

The North Carolina Railroad Company owns a 317-mile railroad corridor from Charlotte to Morehead City and manages encroachments along that corridor to protect this valuable asset. Encroachments can come in the form of utilities, structures, property conflicts, or unauthorized access. If encroachments along a rail corridor are not managed, they can impact the railroad's ability to operate safely and preserve the corridor for future rail uses. NCRR employs a strategy to manage encroachments which includes a proactive approach to sharing corridor boundary data in order to assist others in understanding exactly where the corridor boundary is located.

BUSINESS PROCESS JUSTIFICATION

NCRR is a private business corporation, with one hundred percent of stock owned by the state of North Carolina. The railroad corridor is a rich asset, which is protected and managed for the good of North Carolina's citizens. It reaches from the State Port at Morehead city through the interior of the state to Charlotte and is a major part of the overall rail system in the North Carolina. Rail corridors obstructed by encroachment operate less safely and efficiently and do not have room for expansion, which may lead to loss of economic growth opportunities for the state. The data sharing component to corridor management assists local governments and real estate professionals (surveyors, engineers, developers, etc.) understand where the corridor boundary is located in order to effectively make, or avoid, decisions that may lead to adverse impact on the railroad corridor or their constituents (general public or clients).

INFRASTRUCTURE DATA REQUIRED

The data needed to achieve the goal of protecting the railroad corridor is not infrastructure, specifically. It is the boundary in which the infrastructure is contained. Data shared with those who need it consists of railroad corridor boundary information which is available in several different formats depending on the application of the data (survey quality, GIS quality, etc.). NCRR may share surveyed corridor centerline data from which a 200-foot-wide boundary can be extrapolated or non-surveyed data of irregularly shaped areas of the corridor in a GIS format. In any case, NCRR strives to continually improve the accuracy of the data and share the most applicable data on a case by case basis.

INFRASTRUCTURE DATA OBTAINED

NCRR shares corridor centerline and/or boundary data in either CAD or shapefile format. The extent of the data shared depends on what the requestor requires and how it is being applied. It is either project specific for surveyor and engineers, or county-wide for local governments. Accuracy and scale depend on the specific application of the data.

DATA SECURITY

NCRR requires any recipient of the data to sign a data sharing license agreement. Separate forms are used for private and public sector as the data is often applied at a project specific level in the private sector and much more broadly in the public sector. Each have different risks for NCRR and limitations for the end user. Basic constraints include the inability to sub-license the data with third parties, acknowledgement of accuracy limitations, acceptance of risk in using the data, release NCRR from having to update the data, etc. Additionally, the local government agreement provides and pathway to display or use the NCRR data in a manner that benefits the public without being considered a third party sub-license.