WORK ZONE SAFETY & MOBILITY PROCESS REVIEW

For the Federal Highway Administration

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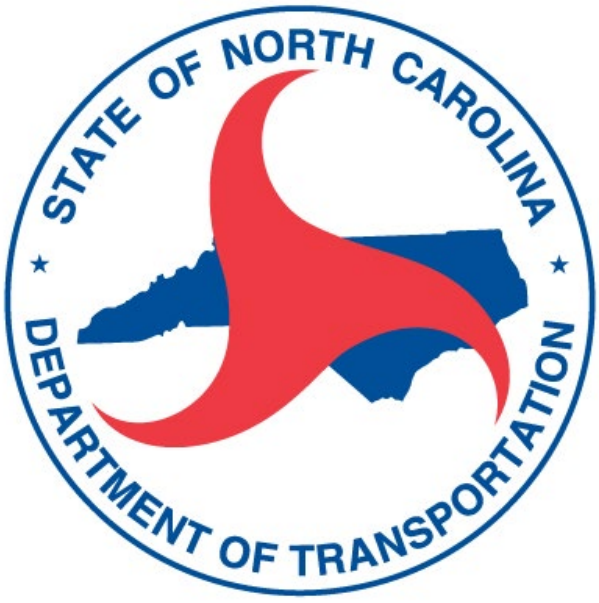

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North Carolina Department of Transportation

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EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) is committed to providing safe work zones for all workers and road users while minimizing traffic congestion and adverse impacts on road users and local communities. In response to changes to the Federal Highway Administration's Work Zone Safety and Mobility Rule 23 CFR 630 Subpart J, NCDOT developed its Work Zone Safety and Mobility Policy in 2007. We continue working to fulfill the intent of this policy, which is to support the systematic consideration and management of work zone impacts related to safety, mobility, operations, and training.

This report is an update to the Process Review that was submitted to FHWA in December 2021. Since then, NCDOT has continued to implement strategies found to be effective and added additional measures to fulfill all the goals and intent of the Rulemaking and NCDOT's Safety and Mobility Policy. In addition, NCDOT continues to enhance some pre-existing process elements while still working on improving others such as the collection and usage of work zone data.

PURPOSE AND OBJECTIVE

In 2007, the North Carolina Department of Transportation (NCDOT) committed to systematic consideration and management of work zone impacts related to safety, mobility, operations, and training through the Work Zone Safety & Mobility Policy. The purpose of this review is to assess the effectiveness of the current practices in managing work zone impacts and to determine where improvements can be made. In addition, the process review will ensure compliance and adherence to FHWA's Work Zone Safety and Mobility Rule.

RESULTS AND RECOMMENDATIONS

Work Zone Traffic Control (WZTC) staff reviewed the 2021 report and evaluated whether any improvements or innovations since then have resulted in changes to safety or mobility in our work zones. The highlights of the successes and areas for improvement are described below, along with recommendations to overcome these challenges.

New Practices

WZTC staff started several initiatives during 2022 and 2023 to improve safety and mobility in NCDOT work zones. Some of the notable initiatives during this time period including:

- Starting to implement the new MASH crash testing requirements which replaced the NCHRP 350 requirements,
- Added sequential flashing warning lights as a standard specification--these previously existed as special provision,
- Disseminating the information that NTPEP (now AASHTO Product Evaluation & Audit Solutions) is no longer required for drums and skinny drums,
- Added Work Zone Installer training requirements,
- Added Work Zone Education Verification App (WZ-EVA) requirements (more detail below),
- Updated requirements for material and equipment storage relative to active travel lanes, and
- Updated the required spacing for cones and skinny drums during lane closures.

During 2022-2023 the WZTC Group also worked on updates that will appear in the 2024 edition of the NCDOT *Roadway Standard Drawings* document. The key updates will include:

- Added an additional advance warning changeable message sign for high-speed lane closures,
- Added a standard drawing for a triple lane closure,
- Added standard drawings for temporary traffic control through roundabouts,
- Added standard drawings for off ramp road closures,
- Added standard truck-mounted attenuator (TMA) roll ahead distances to maintain, and
- Added standard drawings for MASH-approved portable concrete barriers to replace the previous NCHRP 350 portable concrete barriers.

In the hopes of tracking Truck/Trailer Mounted Attenuator crashes we implemented a reporting form that Resident Engineers, Inspectors, or Contractors alike can fill out. The form was kept as simple as possible in hopes of making it very quick to fill out (less than 5 minutes). It begins with two inputs--the

date of the crash and estimated time of crash--and will expand from there with extra fill-ins. The form was placed on our website in 2022 and has had 2 submissions as of 12/1/2023. We have received verbal confirmations of TMA crashes but we are continuing to encourage our field personnel to fill out the online report. Our hope is that as users become increasingly familiar with this form we will see a widespread use of it. From that data we can look for trends as to what operations TMAs are shielding and determine if there is a better way to do that operation. Our assumption is that the most crashes occur while installing or removing lane closure tapers.

Improvements to Current Practices

Mobility Measurements using Intelligent Technology. Over the past several years, WZTC been monitoring the mobility in all major freeway work zones in NC using ClearGuide, a third-party system that collects and processes vehicle probe data. Weekly, single-page snapshots are compiled and distributed to personnel in the NCDOT Traffic Management Unit and to the NC Division FHWA Operations Engineer. We are able to see the ebb and flow of work zone mobility throughout the phases of construction. Over the past two years our monitoring system has been of consistent high quality and we have expanded the scope of the reporting. We have also begun collecting data months before a work zone is deployed, which provides a helpful baseline against which to compare once the work zone is active. Over the past two years, most of the freeway work zones we have been monitoring have performed well with the following exceptions:

- I-440 on the west side of Raleigh has produced considerable delays most weeks,
- I-40 east of Raleigh was performing relatively poorly until early in 2023 when new lanes opened and performance improved dramatically,
- I-26 east of Asheville has seen occasional mobility issues, and
- I-40 west of Asheville has produced congestion during the winter months when bridge replacement work zones have been active.

We also use Streetlight data from mobile phone tracking for work zone applications. NCDOT recently extended its a contract with Streetlight for an additional year. Those data have proven valuable for special event planning, construction phase scheduling, and improved lane closure restrictions, especially in locations with limited available historic traffic count data.

Work Zone Reviews. The Work Zone Traffic Control Section implemented procedures and guidelines for the review of work zones in 2013. We also established a work zone scoring system that objectively evaluates the work zones by scored categories and provides an overall score. Since the 2021 Process Review we have completed over 25 work zone reviews, including 8 nighttime reviews. We have also increased our efforts to review our highest priority work zones by hiring consultants to complete monthly field reviews and provide reports back to us. This ensures we have regular observations of these work zones even with limited internal personnel to do so. Most interstate construction operations happen during the night hours between 9 pm and 5 am. Reviewing work zones at night provides opportunity to evaluate the nighttime work operations procedures including the use of sequential flashing warning lights and work zone presence lighting, as well as review the visibility of the pavement markings and work zone signs. Conclusions from the work zone reviews are provided to the contractors, division personnel, and the NCDOT Construction Office. We use this information to determine if there is any correlation between work zone crashes and the type of work, entity performing the work, and the possibility of training requirements. During most reviews we find that the NCDOT and contractor

personnel are operating good quality work zones, but occasionally we see large issues that need immediate attention.

Smart Work Zones. Smart and connected technology has been implemented in an increasing number of projects throughout North Carolina over the past couple of years. Traveler information systems on I-5111 (I-40 in Wake and Johnston Counties) and on I-3306A (I-40 in Orange County) use a combination of sensors and message boards to notify drivers of traffic conditions in the work zone. Typical messages are "Travel Times Normal", "Delays Exceed xx minutes", or "Major Delays – Follow [Alternate Route]". Due to significant device reliability issues on the I-5111 project, the Department has instituted liquidated damages into the contract for the I-3306 project for any device not repaired within 72 hours after notification to the contractor.

NCDOT has also adopted the Work Zone Data Exchange (WZDx) feed structure and continues to see improvements with the device outputs reaching the motorists. NC was one of the first states to adopt the WZDx.

Dynamic Zipper Merge. In 2019, NCDOT introduced Dynamic Zipper Merge Systems to our work zone strategy toolkit. Dynamic Zipper Merge Systems are similar to the previously used Portable Queue Warning Systems in that they automatically detect traffic conditions, namely slow/stopped traffic, and change the messages on portable changeable message signs to warn drivers before they reach the back of the traffic queue. To take it one step further, Dynamic Zipper Merge Systems are capable of driver merge instructions. Once congested conditions are met and the traffic queue reaches a specified length, the system will no longer tell motorists which lane is closed in advance. This encourages the motorists to use all open lanes up to the merge point and then take turns to merge into a single lane. Once congested conditions are no longer present, the system will revert back to standard lane closure messaging. The Dynamic Zipper Merge System has been a key solution to reduce long queue lengths in effort to decrease the risk of back of queue crashes. NCDOT has only used Dynamic Zipper Merge Systems for projects that require long term lane closures and when the final design does not increase roadway capacity.

Five projects have used these systems between 2020 and Summer 2023. The most recent completed projects include B-6054A in Haywood County on I-40 at Exit 7 and I-6003 in Davie County on I-40 between NC-801 and SR-1436. An active deployment is currently located on I-40 in Haywood County as part of B-6054B&C, with a future deployment scheduled nearby for B-6054D&E.

In August 2023, the NCDOT kicked off a research project to study the effectiveness of dynamic zipper merge systems in NC. Results should be available in 2025.

Nighttime Work Operations. Daily time restrictions for construction activities continue to play a large role in the way we build our roadways and bridges. Working during the night limits the number of motorists exposed to the work zone and limits the number of motorists exposed to the construction hazards. To continue NCDOT's commitment to mobility and safety during construction operations occurring at night, Sequential Flashing Warning Lights and Digital Speed Limit Signs are now standard practice for interstate and/or primarily nighttime construction operations. Sequential Flashing Warning Lights are now a standard item and have been added to the NCDOT Standard Specifications publication. We have included two additional products for sequential flashing warning lights on the NCDOT Approved Products List since the 2021 WZ Process Review indicating the easy acceptance of these devices by the industry and the desire for more options and inventory.

Significant Projects Appearance. NCDOT WZTC remains committed to safe and efficient work zones and continues to improve the appearance of significant work zones. A big part of that is work zone performance pavement markings. Work zone performance pavement markings are long life markings (polyurea, epoxy, thermoplastic, polymer, and cold applied plastic/removable tape) that provide a more durable and higher performing work zone pavement marking, compared to traditional paint, for temporary traffic patterns that will be in place for 12 months or more. The markings are required to last the full duration of a traffic pattern without replacement or reapplication for a period of 12 months. The markings are also required to meet certain retroreflectivity numbers to improve nighttime work zone visibility. Work zone performance pavement markings will also be essential when automated vehicles become common and sensors are used to detect lane and edge lines. NCDOT has an on-call contract with a private company to perform mobile retroreflectivity readings across the state. These scans are completed at typical driving speeds without having to exit the vehicle. Retroreflectivity scans of work zone performance pavement markings across the state have yielded various results. Yellow and white marking retroreflectivity has not always met the numbers required by the contract, but the nighttime visibility is far greater than what we experienced before we began this practice. WZTC has reinforced the retroreflectivity requirements of the pavement markings after much discussion and input from industry partners but there will be a few small changes coming to the specification in the near future.

High visibility devices, including all new drums and stationary and portable work zone signs with fluorescent vertical sign post reflector strips, are required for projects on interstates and freeways with durations of 24 months or more. New devices enhance visibility to improve both safety and mobility through a high-speed work zone. We will continue the use of high visibility devices to enhance our high profile, long duration interstate and freeway projects.

Work zone pattern masking is a flat, black, liquid material applied by spray mechanism to conceal the entire existing pavement surface and provide a uniform, black surface to accept new pavement markings in a revised pattern. After some experimentation, NCDOT has moved away from this practice due to the inability to arrive at a consistent, easy to install material.

NCDOT has been exploring other options to obscure previous pavement markings and provide a more uniform surface to accept new temporary pavement markings. We have completed demonstrations of the Skidabrador pavement treatment on two separate projects--one in Wake County on an interstate reconstruction project and one in Mecklenburg County on an interstate widening/rehabilitation project. Skidabrador is a pavement texturing service that uses a bi-directional shot blast machine to quickly texturize the pavement surface. In the process of that a small amount of material is removed from the pavement surface in effect completing a very fine milled surface. This method has promise and we will continue to explore its capabilities.

Review of Ongoing Successful Practices

Interdisciplinary Coordination. WZTC staff have continued to coordinate closely with our colleagues in the Traffic Systems Management and Operations Unit (TMSO), which is responsible for statewide coordination of incident management and intelligent transportation systems efforts, and others in our efforts to use all available tools to reach motorists with timely and important information about work zones. Most of our major interstates (I-40, I-95, I-26, I-85) are undergoing significant reconstruction and/or resurfacings and we will continue to see that for the next few years. In our regular meetings, we

discuss the best strategies to reach the motoring public including, but not limited to, static signs, changeable message signs, dynamic signs, traveler information apps, social media, websites, billboards, welcome center and rest area handouts, and others. These meetings are held on a semi-monthly basis and help bridge any gap between the traffic management plan (TMP) and how the work zone operates in the field. We have been able to discuss projects two to three years in advance of the let date to foster early involvement by TSMO and prevent last minute issues. We also use the results of these meetings to select candidate projects for our "HAWKS" enforcement program. Most recently, a bridge replacement project on I-40 in Haywood County began a six-month long active lane closure November 2023 and our TSMO group was able to identify a maximum queue length of five miles in both the eastbound and westbound directions and a maximum delay of 48 minutes during the first weekend of operation.

Work Zone Education Verification App. The Work Zone Education Verification app (WZ-EVA) launched in March 2021 and allows inspectors and Resident Engineers to quickly verify the training credentials of work zone flaggers, installers, and supervisors in the field. Approved trainers upload training certifications to WZ EVA and issue official wallet cards generated by the WZ EVA system. Rollout has been successful, and we have just over 30,000 records entered as of 11/30/23. We're still enrolling new training providers every week and assisting them with uploading their records to the database. WZ-EVA also provides us with an easy way to disseminate changes to standards to training providers because we will always have up-to-date email contact information for each trainer registered to upload certifications.

We are pleased to note that we have begun performing training class audits to ensure materials match the latest NCDOT standards. We are also working on a process to suspend and then re-train individuals or training providers who repeatedly score poorly on WZ field audits.

Connected Lane Closure Devices. These devices were introduced on projects in 2018. Connected lane closure devices are essentially small GPS transmitters attached to or adjacent to the merge taper flashing arrow board and attached to or adjacent to the last traffic control device in the lane closure. These devices transmit their location to navigational companies and the NCDOT State Traffic Operations Center (STOC). The goal is to allow motorists to see active lane closure information in any navigational software they are using. This is one of many efforts to increase our vehicle-to-infrastructure resources and prepare NCDOT for automated vehicles.

Traffic Safety and Operations Meetings. Safety and Operation Meetings continue to be added and utilized on most design-build and significant projects. These are held on a biweekly or monthly basis and are planned and executed by the Division Incident Management Engineer. Law enforcement, emergency services, construction staff, traffic engineering staff, contractor staff, public information officers and the Traffic Management Plan design team meet to discuss recent traffic issues including WZ crashes, upcoming schedule, traffic shifts, lane and road closures, incident response issues, etc. In addition, they discuss specific solutions to these traffic related issues to improve the congestion and traffic operations in and around the project. We will continue this practice with all upcoming design-build and significant projects.

Upcoming Improvements to Current Practices

In addition to the initiatives noted above, WZTC should soon begin writing a Transportation Management Plan Design Manual. This book would bring together all the elements needed to assemble the optimum plan; those elements are currently written into many different sources or are simply passed down by experience. We hope to be underway in the Spring/Summer 2024 with the help of a hired consultant.

Areas for Improvement

Work Zone Fatal Crashes. This is by far the main concern of WZTC as of this writing. From reviewing WZ crash data over the past several years, the number of reported WZ crashes has been steady, but the number of fatalities has decreased since the 2021 Process Review. Current 2023 fatalities are also trending down from 2022 numbers. The relevant statistics include:

5 year avg. (2018 - 2022) = 6,732 WZ crashes
5 year avg. (2018 - 2022) = 33 WZ fatal crashes
2023 (as of 11/24/23) = 27 fatalities, 28% lower than 2022 YTD
Statistics are preliminary, as some crashes have yet to be entered into the system/investigations are ongoing.

We monitor and analyze these data regularly to determine whether the work zone directly contributed to the occurrence and/or severity of a given crash. Often, the work zone had no impact on the occurrence and/or severity. Impaired, distracted, and speeding motorists continue to be a concern in work zones. However, if work zone safety is improved for the average motorist it will also improve for the impaired, distracted, or speeding driver.

We concentrate on fatal crashes that were within the limits of a work zone due to limited staff and time. Other work zone crashes are reviewed on a project-by-project basis. As technology improves and government silos are reduced, being able to review more of this information will allow us to be timelier in the assessment of the crashes and may also help drive the content of our work zone training.

Continued Education Efforts. One of the biggest challenges facing work zone traffic control at NCDOT is the need for continued and improved education of all the parties across such a vast system. NCDOT runs a very decentralized system, with hundreds or even thousands of division staff members and contractor employees making large and small decisions all the time that have consequences for the safety and efficiency of motorists and other road users in our work zones. Webinar technology and websites are great tools to reach these actors, and contract provisions help greatly in ensuring some level of compliance, but one does not have to drive far in NC to find some work zone practices that fall far short of ideal. We have improved our frequency and quality of outreach over the last two years. However, we need to continue and strengthen our efforts to educate and encourage our partners across the state at all levels to do the right things for our stakeholders.

CONCLUSION

It has been a challenging couple of years in NCDOT work zones. As Covid receded traffic demands returned largely to normal and projects restarted, labor and material shortages in the construction industry caused prices to soar and experience levels to decrease. Speeds and fatalities remained far too

high. Nonetheless, Work Zone Traffic Control personnel at NCDOT continued to try to manage and innovate and do what we could to mitigate the negatives. We improved our practices in several ways, including several brand new innovations and several improvements to previous procedures. We also put more resources into things that were previously shown to be working. We have a long way to go before we will be satisfied, but with stable (or even increased) funding prospects in the next few years and no shortage of promising ideas to try, we feel optimistic about our chances to mitigate the negatives in the next couple years.

REFERENCE MATERIAL

- FHWA Work Zone Safety & Mobility Final Rule Effective October 12, 2007, available at http://ops.fhwa.dot.gov/wz/resources/final_rule.htm.
- FHWA Temporary Traffic Control Devices Final Rule Effective October 4, 2008, available at http://ops.fhwa.dot.gov/wz/resources/policy.htm.
- NCDOT Work Zone Safety & Mobility Policy Effective October 12, 2007, available at https://connect.ncdot.gov/projects/WZTC/Documents/WZSafety_and_Mobility.pdf.
- NCDOT Maintenance / Utility Traffic Control Guidelines, available at https://connect.ncdot.gov/projects/WZTC/Pages/Manuals-Guidelines.aspx.