NCDOT Congestion Management
CAPACITY ANALYSIS GUIDELINES

TIP Project Traffic Analyses

The values and information below serve as standard practices and default input values for traffic analysis reports as they relate to TIP Projects. Changes or deviations from these standards are allowed, but should be discussed, justified and documented. Failure to properly justify and document changes and deviations may result in the analysis being returned for changes, corrections and justification without a detailed review and the additional analysis will be performed at the consultant's expense. A meeting regarding a scope of study is encouraged where significant deviations from standard practice are anticipated. They are also encouraged before scope is agreed to when contracting with other Branches of the Department.

By reviewing reports, plans, and submittals, the North Carolina Department of Transportation (NCDOT) in no way relieves the Team / PEF of possible claims or additional work resulting from errors or omissions. The reviews and comments by NCDOT are cursory in nature and do not involve in-depth analysis and design review.

General

When submitting a traffic analysis for a TIP Project, all available documentation that would prove beneficial in review of said analyses should be included in the submittal. This includes but is not limited to, available plans, traffic forecast used in the analysis, appropriate software printouts, any assumptions used in the analysis, etc. Information regarding existing conditions should be provided where applicable.

All submittals must be in latest version of the software that NCDOT is utilizing.

When performing analyses for Build Conditions providing an adequate overall level of service alone is not sufficient. Items such as volume to capacity ratio, queuing, and intersection movement level of service should be evaluated and addressed.

Documentation should be provided to justify any change in default values.

When new developments or schools are located along a TIP Project, coordination with the Access Management Group and Municipal and School Transportation Assistance Group is required, accordingly.

For median divided facilities, the Department's Median Crossover Guidelines should be used. Any median openings not adhering to these guidelines will require a design exception. These guidelines are provided on our webpage.

Before beginning a review, the corridor should be checked to see if it is a Strategic Highway Corridor. If so, the vision for the corridor should be maintained. Interim

measures, such as signalized intersections on expressways for identified interchange locations, may be required due to scoping limitations for a specific project.

Where feasible alternate intersection treatments should be evaluated, including various treatments of median U-turns as described in the memorandum from the State Highway Administrator dated January 6, 2006 on the Implementation of Directional Crossover with Median U-turns.

Signalized Intersections

Coordinated Signal Systems

- When analyzing multiple signalized intersections, the default should be to analyze as a coordinated signal system. If the analysis procedure indicates that coordination is not recommended that information should be included in submittals.
- For coordinated signals, under recall, the usual condition will specify none for minor streets or movements, and the coordinated phase should be the main street through movement, typically phases 2+6.
- Cycle lengths for individual intersections in coordinated systems should be equal; double or half cycles can be used with justification if the minimum cycle lengths are accommodated.
- For existing conditions, the existing system cycle length should be used where known.

General Information

- For analysis of future improvements, when protected left-turns are used, use protected only phasing not protected / permitted phasing. This analysis will identify the maximum queuing storage necessary in the event that protected-only phasing is necessary. In the design of the traffic signal, the use of protected/permitted phasing may be allowed.
- When analyzing existing signalized intersections, only use a leading phase sequence for protective/permitted phasing left turn movements, to prevent the yellow trap. Lagging operation is allowed for protective left turn movements only.
- Check for the possibility of using overlapping right-turn phasing where appropriate.
- For analysis of future operations, Right-Turn-On-Red (RTOR) operation should not be included. In the design of the traffic signal RTOR may be allowed. Exceptions will require justification and approval. To provide for a proper comparison, do not use RTOR for existing conditions.
- If an intersection is not anticipated to be signalized as part of the T.I. P. Project but may warrant signalization by the design year, both signalized and unsignalized analyses should be performed to ensure adequate laneage and storage is provided for both signalized and unsignalized operations in the future. The recommended storage lane lengths should reflect the maximum queue from both analyses. Signal recommendations should be obtained from the Regional Traffic Engineer (RTE).
- Due to uncertainty in determining between Rural and Urban conditions and predicting future land use, a PHF of 0.90 should be used, which is a median value between the 0.88 for Rural and the 0.92 for Urban conditions listed in the 2000

HCM. If field traffic counts have been acquired, the resulting PHFs should be used for existing conditions.

- Use the AADT, K (DHV), % Trucks, and D (directional split) provided by the Transportation Branch's forecast. Percent trucks used in the analysis should be the total of TTST and Duals divided by two.
- Where appropriate pedestrians should be considered and accommodated. This can include but is not limited to pedestrian phases, adequate pedestrian clearance, and potential conflicts with phasing, such as overlapping phases.

Signal Timing and Phasing

- Total Lost Time – 5.0 sec/phase for most intersections, and increase clearance as needed for large cross sections such as a single point urban interchanges (SPUI).
- For existing traffic use yellow = 5 sec., red = 2 sec or existing timings. For analysis purposes, rounding up to the nearest second is preferred.
- For future No-Build and Build traffic use yellow = 5 sec., red = 2 sec. Clearance times using NCDOT criteria may also be used. If design plans are available, the clearance calculation spreadsheets provided by the Signals and Geometrics Section is acceptable. The calculation for these clearance times shall be included and the spreadsheets may be found on our website.
- The minimum initial green time for all protected left turn movements and all side street movements is 7 seconds.
- The minimum initial green time for the main street through movements is dependent on the speed limit and policy provided in the NCDOT Signals and Geometrics Design Manual. For 35 mph or less, use 10 seconds; for 36-45 mph use 12 seconds, for 46 mph or higher use 14 seconds.
- All cycle lengths should be rounded to the nearest 5 seconds.
- Phasing should remain consistent for all time periods. As an example, if split phasing is used for the AM peak, it must be used for the PM peak. Changing the phasing sequence such as altering left-turn phasing from leading left to lagging left is dependent on the traffic signal controller equipment.
- Laneage should be identical for all time periods for the same alternative.
- Intersections with combination through/left-turn lanes should have a split phase left-turn treatment for that approach. This is not a recommended geometric configuration, try to avoid if at all possible.

Recommended minimum cycle lengths by phase	
Number of Phases	**Minimum Recommended (seconds)**
2	60
3	90
4	110
5	110
6	140
8	140
Note: Maximum recommended cycle length is 180, but certain circumstances may warrant cycle lengths up to 240 seconds.	

Left Turn Treatment

Use protected left turn treatment not protected/permitted when (a) dual left turn lanes are present, (b) when left-turn lanes are crossing 3 or more opposing through lanes of traffic, or (c) when a condition is satisfied in the table below:

Number of Opposing Lanes (Through and Right)	Condition
1	Left Turn Volume * Opposing Volume > 50,000
2	Left Turn Volume * Opposing Volume > 90,000
3 or more	Left Turn Volume * Opposing Volume > 110,000

Additional Guidelines

The use of field values may be used in lieu of these standard values where conditions are not likely to change from the current operation.

- Full storage for queue lengths should be rounded up to the nearest 25 feet with a minimum of 100' for both right-turn and left-turn lanes.
- Ideal Saturated Flow Rate = 1900 vphpl
- The Plan Review Group will provide traffic breakout spreadsheets provided by the Transportation Planning Branch to assist in the conversion of forecasted AADT to Peak Hour Volumes. If this spreadsheet is not used, justification should be provided for any alternate method chosen. This spreadsheet is available on our website. The Plan Review Group will also provide an interpolation spreadsheet to determine intermediate year traffic volumes.
- The Intersection Analysis Utility (IAU) spreadsheet should be used only when traffic forecast volumes are displayed with two-way arrows. The Intersection Analysis Utility for Directional Data (IAU_directional) spreadsheet should be used only when traffic forecast volumes are displayed with one-way arrows.
- AM and PM Peak hour analysis should be performed for all reports; explanation should be provided for alternate time periods or to not perform an analysis for the AM or PM peak. The requirement to review other key analysis periods, such as a seasonal peak, lunch peak, or weekend peak, should be discussed with NCDOT prior to completion of the traffic analysis.
- System analysis software (such as Synchro) should be used for arterials and multiple signalized intersections. Analyses for roundabouts should use aaSIDRA. For unsignalized intersections, analysis based on HCM procedures should be used.

Synchro and SimTraffic

To facilitate review of the traffic analysis, electronic copies of the Synchro data file should be submitted along with the appropriate printouts.

The values stated previously should be correctly applied to the Synchro capacity analyses. Provided below are additional methodologies and inputs in Synchro that should be incorporated into the analyses.

- If there are existing protected/permitted left-turn treatments, lead/lag optimization should be fixed for lead operation for the respective phases.
- Any approaches or movements whose queue length are flagged by a "#" or a "m" should be reviewed for improvements given there may be serious delay and queuing problems for this approach or in the vicinity. These problems will need to be addressed in order for the intersection to operate properly. In these cases, it is recommended the Synchro output should be compared to the SimTraffic output and /or other analysis tools such as CORSIM, VISSIM, or the Red Time Formula. Red Time Formula should only be used for protected phasing when operations are under capacity.
- When creating a Synchro output report, the 'Intersection: Lanes, Volumes, and Timings' report will provide all necessary information for review. The data selection "Actuated Green Times" is not necessary information for our review.
- SimTraffic should be utilized to aid in verifying geometry, determining storage lengths and spotting other trouble areas. A SimTraffic queue analysis report should be included for review.
- Networks should be seeded for a period long enough to traverse the network including stops prior to recording. We typically use 10 minutes as a default seed time for the network. Also, the simulation should record for the entire one (1) hour period.
- When evaluating facilities with U-turns, the U-turns should be modeled both as left-turns to obtain an estimation of level of service and as U-turns in SimTraffic to compare to the left-turn level of service and to help determine operations and required storage.

Highway Capacity Software (HCS2000)

General HCS Guidelines

- Due to uncertainty in determining between Rural and Urban conditions and predicting future land use, a PHF of 0.90 should be used, which is a median value between the 0.88 for Rural and the 0.92 for Urban conditions listed in the 2000 HCM.
- Provide output by means of the formatted report.
- Enter f_P = 1.00, unless in a tourist area, then use 0.95.
- Appropriate terrain should be used depending on location.

- Use the AADT, K (DHV), % Trucks, and D (directional split) provided by the Transportation Branch's forecast. Percent trucks used in the analysis should be the total of TTST and Duals divided by two.
- When U-turns are present, they should be modeled as left-turns to obtain a level of service estimation. This should be compared to a simulation of the U-turns to determine operations and required laneage and storage.

HCS Unsignalized Analysis

- Median storage should be zero as a standard unless there is sufficient width to provide adequate storage. Do not enter a storage exceeding one vehicle. No median storage should be used for TWLTL's.
- Enter appropriate information from upstream (per direction) signalized intersections.
- Do not provide an overall level of service (LOS) for unsignalized intersections. According to the 2000 *HIGHWAY CAPACITY MANUAL*, LOS for an unsignalized intersection is determined by the computed or measured control delay and is defined for each minor movement. LOS is not defined for the intersection as a whole.

HCS Freeway Analysis

- Use the Base Free Flow Speed unless measured flow speeds are available. Base Free Flow Speed for an ideal freeway segment is 70 mph for urban conditions or 75 mph for rural conditions. However, this can be limited by design constraints. Therefore, this should be compared to the design speed of the facility and adjustments made to these inputs, as appropriate.

HCS Weaving Analysis

- The Weaving Section Analysis applies to weaving segments up to 2,500 feet maximum.
- Enter the Freeway Free Flow Speed (use the design speed or the posted speed plus 5 mph). Note: typical freeway situations have free-flow speeds of 65mph, collector-distributor (C-D) facilities are 45mph. The analyst can also use the base free flow speed to obtain an estimated free flow speed.
- Check Weaving Area Limitations to ensure that none of the limitations specified are exceeded. Where any limits are exceeded, consult the appropriate notes near the bottom of the output. These situations should be eliminated where feasible and addressed in the included report.

HCS Ramp Analysis

- For Freeway Free Flow Speed use the design speed or the posted speed plus 5 mph. Note: typical freeway situations = 65mph. You can also use the base free flow speed to obtain an estimated free flow speed.
- Typical Free Flow Speed for Ramps = 45 mph, and for Loops = 25 mph. These can be adjusted as needed based upon designs if that information is available.
- Enter appropriate information for any adjacent ramps that exist within 6,000 feet of an analyzed on-ramp or within 1,400 feet of an analyzed off-ramp.
- If analysis indicates an LOS F and the freeway is not over capacity, extending the ramp acceleration/deceleration lengths could improve the LOS.

- If the freeway operation is the limiting factor, a failure year and the required number of lanes for adequate level of service should be provided.

HCS Multilane Analysis

- This methodology does not address highways that have one of the following categories: Signal spacing of 2.0 miles or less, significant presence of on street parking, heavily used bus stops, significant pedestrian activity. Facilities falling under one or more of these categories may be analyzed evaluated with the methodology of Urban Streets (HCS Arterials or Synchro Arterials)
- If no information is available for access points per mile, use 12 for rural sections and 25 for urban sections. If there is potential for rural section to become urban by design year, use 25. This includes right-side only access points. For a one-way roadway it is appropriate to include intersections and driveways on both sides of the roadway. Existing and proposed driveways and intersections may be used where known for specific conditions.
- Use the base Free Flow Speed unless measured flow speeds are available. For Multilane Highways, Base Free Flow Speed may be estimated by increasing the speed limit by 7 mph for 40 and 45 mph, and increasing the speed limit by 5 mph for 50 and 55 mph.

HCS Two-Lane Highway Analysis

- This methodology does not address two-lane highways with signalized intersections. Two-lane highways in urban and suburban areas with multiple signalized intersections at spacings of 2.0 miles or less can be evaluated with the methodology of Urban Streets (HCS Arterials or Synchro Arterials)
- Enter 100% no passing zones.
- If no information is available for access points per mile, use 12 for rural sections and 25 for urban sections. If there is potential for rural section to become urban by design year, use 25. This includes access points on both sides of the roadway segment. Existing and proposed driveways and intersections may be used where known for specific conditions.
- Use the Base Free Flow Speed unless measured flow speeds are available. For Two-Lane Highways, Base Free Flow Speed may be estimated by increasing the speed limit by 7 mph for 40 and 45 mph, and increasing the speed limit by 5 mph for 50 and 55 mph**.**

HCS Arterial Analysis

- Free Flow Speed may be estimated by the speed limit or default values found in the 2000 *HIGHWAY CAPACITY MANUAL.*
- Used when Urban Street criteria are met.

HCS Signalized Analysis

- Enter Right-turn-on-red (RTOR) as 0.
- Unless you have progressed movements use Arrival Type = 3.
- Enter Unit Extension (normally 3 seconds).
- Enter Start-up Lost Time (normally 2 seconds).

- Enter the Phasing Design. (use 5.0 seconds of yellow time and 2.0 seconds of red time).
- Note that HCS Signalized analysis is recommended only for isolated intersections and even in these cases, it is recommend an optimization software package is used to provide the recommended signal timing.

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aaSidra

General aaSidra Guidelines

- When creating an aaSidra output report, the S7 and S15 reports will provide all necessary information for review.
- For proposed roundabouts a minimum lane width of 13 feet should be used.
- For proposed one-lane roundabouts a minimum of 120 feet should be used for the inscribed diameter (88-foot island diameter and 16 foot circulating road width). For proposed two-lane roundabouts a minimum of 148 feet should be used for the inscribed diameter (88-foot island diameter and 30 foot circulating road width).
- If the roundabout operation is a limiting factor, a failure year should be provided. This can be determined by calculating a variable Flow Scale run for the intersection.

References

The *POLICY ON STREET AND DRIVEWAY ACCESS TO NORTH CAROLINA HIGHWAYS* is the dictating standard related to all aspects of development access for the State of North Carolina. All pertinent standards found within this document shall be implemented during the analysis to provide for the safe, efficient, consistent treatment of the traveling public.

Most signal standards can be found in the *TRAFFIC MANAGEMENT SYSTEMS UNIT DESIGN MANUAL*.

Congestion Management Website:
http://www.ncdot.org/doh/preconstruct/traffic/congestion/CM/default.html