



## Appendix A: Volume-to-Capacity Ratio Calculation Methodology for the CMP Network

### Introduction

This memorandum provides step-by-step instructions for estimation of the volume-to-capacity (V/C) ratios for links on the CMP network, which was completed to support the 2019 update to the Congestion Management Process (CMP) Plan. These instructions are intended for inclusion in the *CMP Policy and Procedures Handbook* to provide guidance to Metropolitan Council staff in future CMP updates.

### Volume-to-Capacity Ratio Estimation

The process to develop V/C estimates for links on the CMP network is described below. The instructions are organized into the categories of data sources, network segmentation, spatial analysis, V/C calculation, and link aggregation. While these instructions provide the technical background to complete the analysis in any number of computer applications, it is recommended that a programming platform or statistical package such as R or Python be used for efficiency and consistency.

#### DATA SOURCES

Data	Source	Information	Format
<b>AADT Counts<sup>1</sup></b>	MnDOT	Traffic volumes, location coordinates, count year	Shapefile – points, Point Feature Class
<b>Regional Traffic Demand Model</b>	Met Council	Roadway link capacities, lane assignments	Shapefile – lines, Line Feature Class
<b>Automated Traffic Recorder (ATR) Reports</b>	MnDOT	Hourly traffic volumes within CMP Network Area	Tabular format, excel/csv/txt
<b>CMP Network Roadway centerlines</b>	Prepared through CMP Plan update	Roadway geospatial data	Shapefile – lines, Line Feature Class

<sup>1</sup> Most recent AADT Count information is used at each location.



## Step 1: Segmentation of Network<sup>2</sup>

Input Data: CMP Roadway Centerlines, AADT Count Locations

The CMP Roadway Centerlines shapefile was developed using the “NCompass Technologies Street Centerline and Address Ranges” and the “Functional Class Roads – Existing” shapefiles. The following process was used to create the CMP Network Group:

1. In the “Functional Class Roads” Shapefile: Created new field “CMP\_Desc”
2. In the “Functional Class Roads” Shapefile: Selected field “FC\_NAME = 'Principal Arterial'”, and coded as “NHS Other Principal Arterials” under field “CMP\_Desc”. This was designated as Tier 3.
3. In the “NCompass Technologies Street Centerline” Shapefile: Selected field “RD\_CHAR = 'RC10'” (Freeways), and exported to new Shapefile
4. Joined new Shapefile with “Functional Class Roads” Shapefile on the TLGID field. In the “Functional Class Roads” Shapefile, coded these values as “NHS Non-Interstate Freeway” under field “CMP\_Desc”. This was designated as Tier 2.
5. In the “Functional Class Roads” Shapefile: Selected Interstates (using SQL search on “STREETALL” field) and coded as “NHS Interstate” under field “CMP\_Desc”. This was designated as Tier 1.
6. In the “Functional Class Roads” Shapefile: Coded A-Minor Augmentor, A-Minor Connector, A-Minor Expander, and A-Minor Reliever as “A-Minor and Wright/Sherburne Minor Arterials” under field “CMP\_Desc”. This was designated as Tier 4.
7. In the “Functional Class Roads” Shapefile: Coded Major Collector, Minor Collector and Other Arterial as “Corridors of Concern” under field “CMP\_Desc”. This was designated as Tier 5.

The GIS shapefile included a CMP description field, details on the street name and a Tier designation for each roadway. The detail of the linework included in this shapefile was too granular for use in the next steps of the CMP process. Roadways were grouped into logical segments that spanned between nodes. These nodes were placed throughout the Network using the following methodology;

### Node Placement

Nodes were given unique IDs and placed at set locations across the network. The node ID, X-XXX, is formatted as Tier - 3-digit number, e.g. 1-142, 2-434, 4-487. Locations for placement of nodes included:

Intersections of any Tiered roadway with another roadway within the same Tier or higher, e.g. intersections of Tier 4 roadway with a Tier 4/3/2 roadway, Tier 3 with Tier 3/2/1, Tier 2 with Tier 2/1 and Tier 1 with Tier 1. Nodes were also placed as roadways crossed county lines.

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<sup>2</sup> Segmentation of the CMP network was completed as part of the 2018-2019 CMP Policy and Procedures Handbook Development Process. Re-segmentation of the network should not be necessary in upcoming CMP update cycles except where new roadway miles are added or roadway modifications would trigger a need for changes to segmentation.



## Segmentation of roadways

The segmentation process used these nodes to form the extents and path of each segment. Each segment begins and ends at a node and can traverse multiple nodes. Segments within a specific Tier cannot start or end at a node from a lower Tier. For example, a Tier 1 segment cannot end at a Tier 4 node. Tier 2 segments can end at a Tier 1 roadway.

When determining segmentation of the network, efforts were made during initial segmentation to ensure all segments include at least one AADT count. Rural segments may not include any AADT counts.

Each roadway polyline will now have an added unique Segment ID that details what segment it is assigned to. A new shapefile is created that merges all roadway lines with the same segment ID. All polylines with the same Segment ID are merged into one feature. The ArcGIS geoprocessing tool used is named 'Dissolve' (Data Management Tools → Generalization → Dissolve).

Output Data: Segmented CMP centerlines.

## Step 2: Spatial Join Regional Travel Demand Model to AADT Count Locations<sup>3</sup>

Input Data: Geospatial information of each MnDOT AADT count location. Regional Travel Demand Model (shapefile or line feature class)

The Regional Travel Demand Model has detailed information for all roadways in the metro areas. Details of interest for this process include Area and Roadway types and number of lanes per link. The Area and Roadway types are used to reference the Capacity Lookup table associated with the Model. Each link is assigned a total capacity per lane.

The number of lanes in each link should be verified with aerial imagery to ensure accuracy.

Using the spatial join feature in ArcGIS (Analysis Tools → Overlay → Spatial Join), links in the Regional Travel Demand Model are spatially joined to AADT count locations on a one-to-many basis. A search radius of 50ft is used for the spatial join.

Multiple roadway links may be joined to each AADT location. Review of the joined dataset is required to ensure that the correct ABM link is joined to the correct AADT count locations. When reviewing the joined dataset for accuracy the following are some details to note: Non-matching roadway names, abnormally high or low V/C results (from Step 3), joins to highway on/off ramps.

Output Data: AADT Count locations now including Regional Model Information (capacity and lanes)

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<sup>3</sup> The spatial join process was completed as part of the current update and the correspondence between MnDOT AADT points and CMP network links has been provided as part of the project deliverables. This process should only need to be conducted if CMP network coverage is expanded.



Note: This will include the spatial join properties for the AADT location to the Segmented Network and the Regional Travel Demand Model. Each new iteration of this process should include quality control checks to ensure that roadway geometry, lane counts and AADT count information are accurate.

### Step 3: Calculate V/C ratios for each AADT Count Location

Input Data: AADT Count locations now including Regional Model Information (capacity and lanes)

$$VC \text{ Ratio} = \frac{V \times k}{C \times l}$$

V = Current Year AADT

k = 0.105

C = Regional Travel Demand Model Link Capacity (per lane)

l = Number of Lanes in Link.

The peak hour factor (k) was established as 10.5 percent of daily traffic based on review of ATR reports representing example corridors across each of the CMP network groups. This value was found to be consistently representative of roadways across all groups. ATR data is available from the MnDOT Traffic Forecasting and Analysis website. For each ATR, the 100<sup>th</sup> peak hour directional volume is determined. The k factor is evaluated as the ratio of this peak hour to the annual average daily traffic. The value of 0.105 was determined as an acceptable value that was representative of the majority of ATR stations.

Output Data: V/C ratio for each AADT Count location

### Step 4: Spatial Join MnDOT AADT Locations to Segmented Network<sup>4</sup>

Input Data: Geospatial information of each MnDOT AADT count location. Segmented CMP network from Step 1.

Using the spatial join feature in ArcGIS (Analysis Tools → Overlay → Spatial Join; specify search radius 50ft and one-to-one join), each AADT Count location is spatially joined to its relevant roadway segment. Segments may have multiple AADT Counts within its extents. Review is needed to ensure that only count locations associated with roadway in question are included in the new joined dataset.

Output Data: Each Segment will now include a reference to an AADT count location(s) if one exists.

<sup>4</sup> The spatial join process was completed as part of the 2018-2019 CMP Policy and Procedures Handbook Development Process and the correspondence between MnDOT AADT points and CMP network links has been provided as part of the project deliverables. This process should only need to be conducted if CMP network coverage is expanded.



## Step 5: Aggregate V/C results by Segment

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Input Data: AADT Count Location's V/C results and Segmented Network Table.

Each segment now contains a reference to all AADT count locations assigned to that segment. Each AADT count location has a V/C ratio calculated from Step 4.

The V/C results for each segment can now be aggregated using any metric desired e.g. max, min, mean etc. Within the Segmented Network Table, select the Segment ID field. Using the 'Summarize' feature, the user can then select the field to include in the aggregation, in this case, V/C. Aggregation metrics offered are minimum, maximum, average, sum, standard deviation, variance. This aggregated table can be saved as a flat file (.txt, .csv) and added back to the ArcMap session or exported for further analysis.

Output Data: V/C summary results for each Segment.