Freeway Volume Balancing Excel Tool

Contents

Prepare Files

1. Make a copy of the freeway volume balancing tool file. The tool file is called "**Freeway Volume Balancing Tool_*.xlsm**" (* is the current tool version)

2. Rename the copied file to be relevant to the project and balancing time period (e.x. "I-999_Existing AM Peak.xlsm").
    a. **Tip:** Complete the volume balancing process for one time period, then make a copy of the completed file to use as the basis for additional balancing periods (e.x. complete AM, then copy it and use it as a basis for PM).

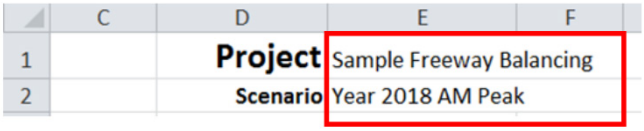
3. Open the file from step 2. The workbook is organized into 5 worksheets that should be filled-out sequentially.

Worksheet	Contents
Corridor	Lists each ramp and mainline location in the freeway network.
Raw-Initial Volumes	Lists actual volume counts, or forecasts, for each location that can be used as initial inputs for volume balancing.
Balancing	Shows computations and provides tools for performing volume balancing
Diagnostics	Provides a sortable list of all locations and compares the raw/initial and balanced volumes
Export to Intersection Balancer	Provides a table for exporting the freeway balanced volumes to the intersection balancing tool.

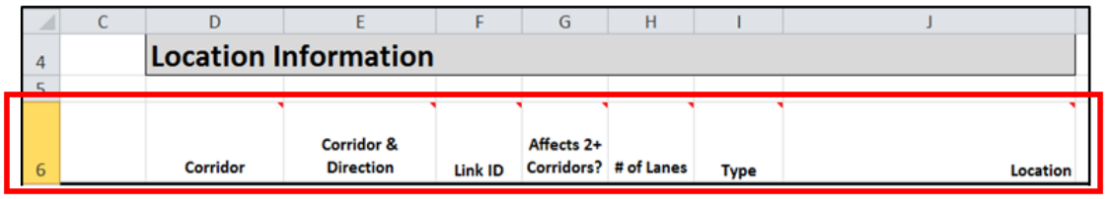
The following sections describe how to fill-out each worksheet.

Plan Network

1. On the Corridor worksheet, fill out the project name and scenario being balanced.



2. Look at a map of the freeway network and develop a plan for dividing the network into multiple *corridors* and *balancing locations*. A *corridor* is a specific direction of a freeway (e.g. NB I-39 is a corridor, SB I-39 is a different corridor). A *balancing location* is needed at every ramp at a minimum. You also need 1 mainline location at the start of every corridor in order for the balancing tool to work.
    a. The Corridor worksheet has columns for *corridors* on the far left and *balancing locations* on the right.



Tip: Hover over each column heading with a red triangle to see a description of how and what to include in each column.

3. In general, filling out the **Corridor** worksheet is just entering names and data for all the mainline and ramp locations on the freeway. See the column tool tips in the Excel file and sample volume balancing files. The columns need to contain:

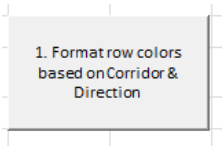
1	Corridor	The name of the corridor, listed only in the 1st row of the corridor. All other cells for the corridor should be blank. This gives a visual separation of where the corridor starts and ends in the list.
2	Corridor & Direction	A continuous version of the Corridor column where every cell contains the corridor name.
3	Link ID	A unique number identifier for each location. If the same ramp is in more than one corridor, it should have the same ID. Consider making a map to help you keep track of the Link ID's
4	Affects 2+ Corridors?	For ramps that are listed more than once in the corridor, typically system interchange ramps, set the cell to "Primary" for the first listing, and "Secondary" for all other listings of the ramp. The example below shows Link ID 1010 which is a ramp affecting volume balancing on both NB I-39/90 and WB WIS 30 corridors.
5	# of Lanes	The number of lanes in the direction of travel. For ramps, the number of lanes at the exit gore.
6	Type	Lists if the location is an on-ramp, off-ramp, CD road or mainline location. Cells contain a drop-down to help you pick. This column is mostly used for formatting purposes.
7	Location	A brief name or description of the location. Every location should have a name.

Location Information

1 Corridor	2 Corridor & Direction	3 Link ID	4 Affects 2+ Corridors?	5 # of Lanes	6 Type	7 Location
NB I-39/90	NB I-39/90	1000		3	mainline	Beltline I/C to Badger I/C
	NB I-39/90	1010	Primary	1	off	off to WB WIS 30
	NB I-39/90	1020	Primary	1	off	off to EB I-94
	NB I-39/90	1170		3	mainline	US 151 to US 51
	NB I-39/90	1210		3	mainline	US 51 to WIS 19
SB I-39/90	SB I-39/90	2000		3	mainline	WIS 19 to US 51
	SB I-39/90	2010		1	off	off to US 51
	SB I-39/90	2180		3	mainline.	b/n ramps
	SB I-39/90	2190	Primary	1	on	on from WB I-94
	SB I-39/90	2200	Primary	1	on	on from EB WIS 30
	SB I-39/90	2210		3	mainline	Badger I/C to Beltline I/C
WB WIS 30	WB WIS 30	6030		2	mainline	EB I-94 to EB WIS 30
	WB WIS 30	2170	Secondary	1	on	on from SB I-39/90/94
	WB WIS 30	1010	Secondary	1	on	on from NB I-39/90
	WB WIS 30	6060		2	mainline	Badger to Thompson Dr
	WB WIS 30	6070		1	on	on from Thompson Dr
	WB WIS 30	6080		3	mainline	Thompson Dr to US 51

a. **Tip:** After assigning Link ID's, the "Affects 2+ Corridors" column can be automatically determined later using the macro button labeled *"2. Set Affects 2+ Corridors based on Link ID"*

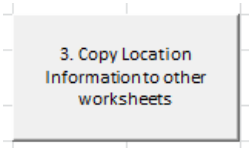
4. The table on the **Corridor** worksheet will initially be uncolored and unformatted as shown below. Use the macro button "Format row colors based on Corridor & Direction" to help do the coloring and formatting.



Location Information						
Corridor	Corridor & Direction	Link ID	Affects 2+ Corridors?	# of Lanes	Type	Location
NB I-39/90/94	NB I-39/90/94	1000		4	mainline	Badger to US 151
	NB I-39/90/94	1001		2	CD	CD off to US 151 / High Crossing
	NB I-39/90/94	1002		1	off	off to High Crossing
	NB I-39/90/94	1003		1	CD	b/n ramps
	NB I-39/90/94	1004	Primary	1	off	off to NB US 151
	NB I-39/90/94	1005	Primary	1	on	on from NB US 151
	NB I-39/90/94	1006		1	off	off to SB US 151

Initialize Worksheets

1. Once the **Corridor** worksheet has been filled out completely and is formatted, use the macro button "3. Copy Location Information to other worksheets." This transfers all of the location information to the remaining sheets in the workbook. The information is copied statically to the other worksheets, i.e. the macro does not create formulas on the other worksheets that reference the Corridor worksheet.



Enter Raw/Initial Volumes

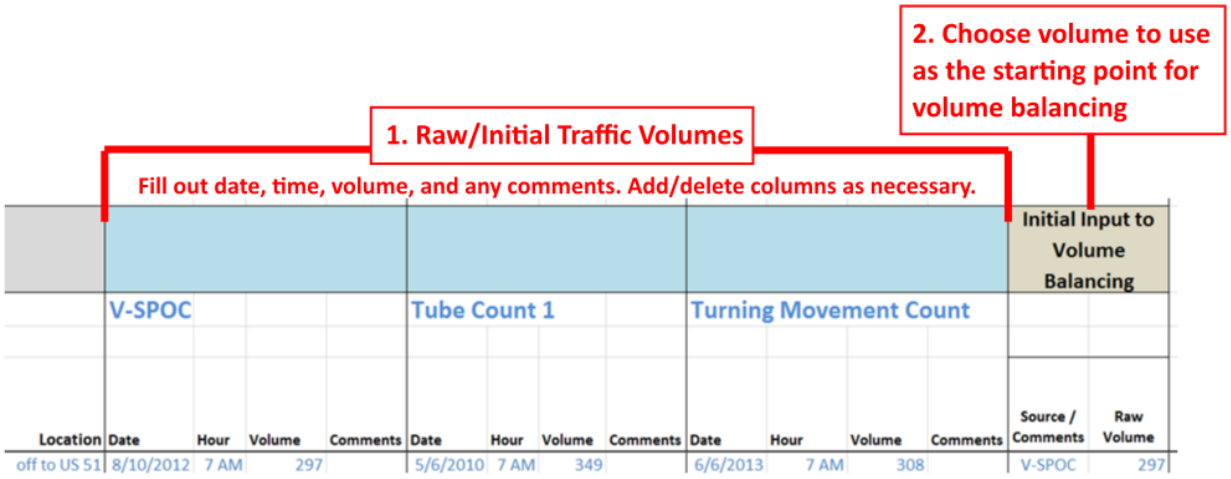
On the **Raw-Initial Volumes** worksheet, there are three sections:

Location Information	Raw/Initial Traffic Volumes	Initial Input to Volume Balancing
Location information copied from the **Corridor** worksheet	Columns for entering unbalanced volumes and any associated metadata (dates, times, comments).	The user enters which volume to use as an input into the balancing process.

1. Fill out the Raw/Initial Traffic Volumes section by entering traffic counts or forecasts, and associated metadata.
   a. Add and delete columns in this section as necessary.
   b. Columns are provided to add the date and time of the count, volume, and any comments you may have about the count.

Sometimes there is more than one relevant count for a location. The figure below shows an example where a location had 3 counts available that could be used for volume balancing (V-SPOC, a tube count, and a turning movement count).

2. Fill out the Initial Input to Volume Balancing column. Enter formulas or copy/paste volumes into this column. Filling out this column is mandatory for the volume balancing to work. It also provides a way to document what count was selected as an input when more than one count was available. In the example below, the V-SPOC count was selected.

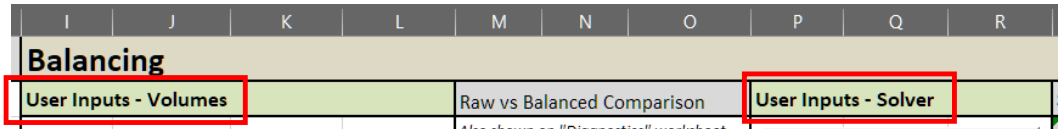


Balance Volumes

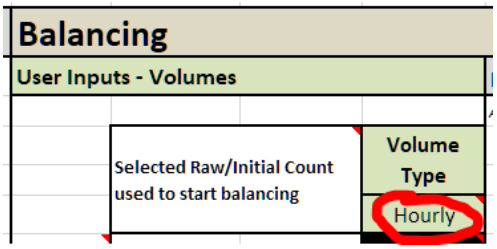
1. The **Balancing** worksheet is where all the traffic volume balancing occurs. Data from the **Corridor** worksheet and **Raw-Initial Volumes** worksheet are automatically transferred.
    a. The worksheet is filled out from left to right. The "FINAL Balanced Volumes" column highlighted in black contains the final results.

    Steps listed below walk you through how to fill out the columns. Also review the tool tips in the column header cells for what each column needs to contain.

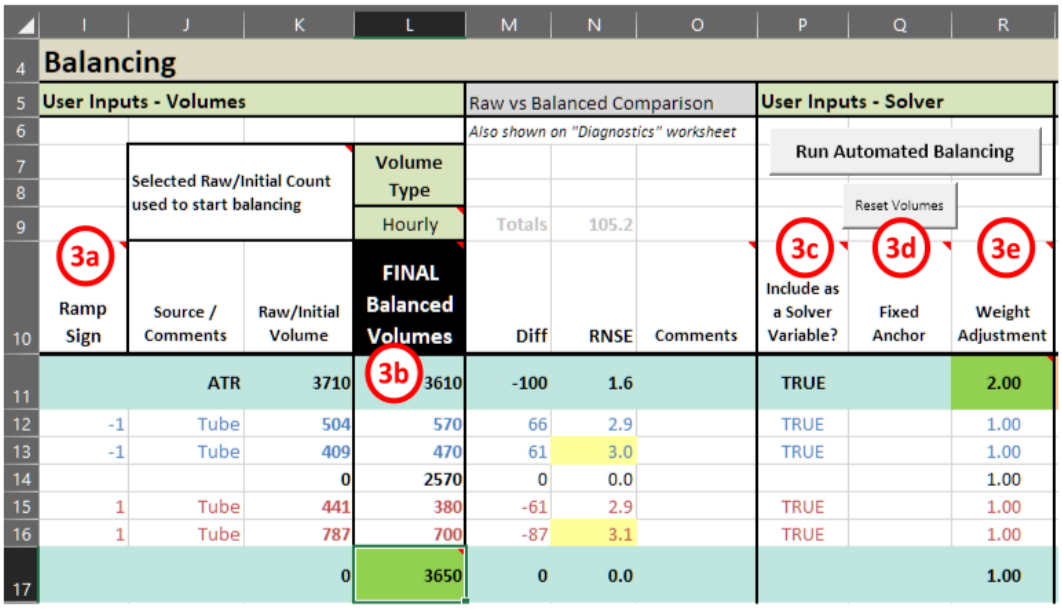
    User Inputs are listed in the green "User Inputs" sections



2. Set Volume Type to **Hourly** or **AADT**, depending on what duration of volumes you are balancing. The Volume Type determines the capacity weighting factor used as a heuristic to estimate what locations are more important during balancing. Locations with volumes near the estimated capacity are treated as "more important" than locations further away from capacity. "More important" means that the balancing procedure will try not to deviate as far from the raw/initial input volume.



3. The remaining user-input columns to fill out include:



	I	J	K	L	M	N	O	P	Q	R
4	**Balancing**									
5	**User Inputs - Volumes**				Raw vs Balanced Comparison			**User Inputs - Solver**		
6					*Also shown on "Diagnostics" worksheet*					
7		Selected Raw/Initial Count used to start balancing		Volume Type				Run Automated Balancing		
8									Reset Volumes	
9				Hourly	Totals	105.2				
10	3a Ramp Sign	Source / Comments	Raw/Initial Volume	FINAL Balanced Volumes 3b	Diff	RNSE	Comments	3c Include as a Solver Variable?	3d Fixed Anchor	3e Weight Adjustment
11		ATR	3710	3610	-100	1.6		TRUE		2.00
12	-1	Tube	504	570	66	2.9		TRUE		1.00
13	-1	Tube	409	470	61	3.0		TRUE		1.00
14			0	2570	0	0.0				1.00
15	1	Tube	441	380	-61	2.9		TRUE		1.00
16	1	Tube	787	700	-87	3.1		TRUE		1.00
17			0	3650	0	0.0				1.00

a. Ramp Sign – Use +1 for on-ramp, -1 for off ramp. The macros should be able to correctly fill out this column automatically for simple corridors. Manually update as necessary.

b. FINAL Balanced Volumes – You will need to enter formulas pointing to either raw/initial volumes, or a formula summing up the on's and off's to determine the volume at this point. Only locations marked TRUE in the Include as a Solver Variable column (3c) are auto-populated with formulas. When calculating the cumulative sum, don't worry too much about if the result is close to raw/initial volumes or not; this is just an initial guess to seed the volume balancing macro.

i. For example, the green highlighted cell L17 above is not indicated as a solver variable in P17. Therefore, L17 needs a formula to determine the cumulative sum at this point:
L17 = L14 – L15 – L16

ii. A fancier formula for L17 could use sumproduct to leverage the ramp sign column and make the formula more generic for copy-pasting to rows below within in the same corridor:
L17 = $L$14 + SUMPRODUCT($I$15:$I16, $L$15:$L16)

c. Include as a Solver Variable – should be set to **TRUE** for all locations where you want the macro to guess a volume. All blank cells are treated as false, and the corresponding cell in the FINAL Balanced Volumes column should contain a formula.

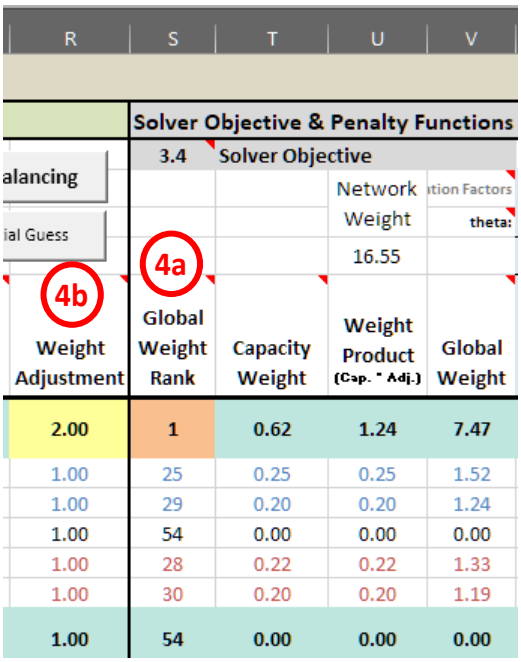
d. **Fixed Anchor** – Type in the word "Fixed" if you want this volume to remain unchanged during the balancing process.

e. **Weight Adjustment** – Typically this is only modified after the first iteration of running the automated balancing tool. See additional info in the next step 4.

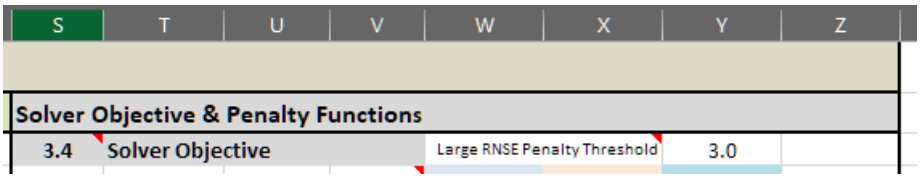
4. Inspect the Global Weight Rank and Weight Adjustment factors.

    a. The Global Weight Rank shows which locations are the "most important" in the eyes of the balancing macro. The screenshot below shows the highest ranked (1st) in the network, so the balancing macro should apply smaller changes when balancing relative to changes with lower ranked (2nd, 3rd,…) locations.

    b. The actual value of the Weight Adjustment is not important. Only the final Global Weight Rank is important. Using higher weight adjustments to increase the global weight rank at a location forces the balancing macro to hold values closer to raw/initial. Conversely, lowering the adjustment de-emphasizes a location where perhaps the raw/initial data is less reliable and you can tolerate more deviation. **Weight Adjustments factors are typically left at 1.0**, especially for the first balancing iteration.

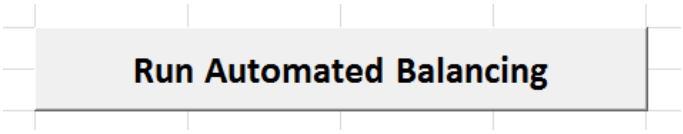


5. The objective penalty function section rarely requires any user inputs. This section contains the objective function that the macro tries to optimize. Consult with BTO-TASU if making any changes.



6. Use the macro button "Run Automated Balancing" to run the automated balancing process.

    a. Tip: the macro tends to run faster when the balancing workbook is the only Excel file open on your computer.



Inspect & Adjust

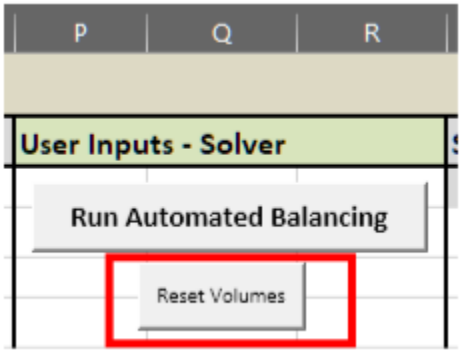
1. Look at the **Diagnostics** worksheet to review and inspect the balancing output. This worksheet compares the raw/initial and balanced volumes and shows the difference as well as the WisDOT root normalized squared error (RNSE) comparison.
    a. Look at locations with large differences between raw/initial and balanced. Generally:

        - RNSE less than 3.0 typically acceptable,
        - RNSE 3.0 to 4.9 may be acceptable,
        - RNSE 5.0 or greater require further investigation

    b. For large RNSE values, check:
        i. For errors in inputs
        ii. For locations with multiple raw/initial volumes available to make sure the selected one was an appropriate initial guess
        iii. That weight rankings are logical (more important locations have higher weights)
        iv. That volumes are marked as "anchors" appropriately (try using anchors or removing anchors)

If any changes are made to the items above in 1b, re-run the automatic balancing and re-inspect the results. After adjusting inputs and running the automatic balancing, users can reset the volumes back to a previous state using the "Reset Volumes" button. The button prompts the user to rest volumes back to one of the following states:

- **Raw/initial** volumes used as inputs to the very first run of the automatic balancing
- **Previous Solver Inputs** used in the previous run of the automatic balancing
- **Previous Solver Solution** from the previous run of the automatic balancing. If the volumes have not been manually modified between runs; the previous inputs and outputs will be the same.



If the balancing macro is unable to improve the results further, modify the results on the **Balancing** worksheet by hand. Make sure the **FINAL** column reflects the final balanced volumes.