Mapping Diesel Particulate in Portland, Oregon

Recently, Portland's air quality has become a heated topic of concern, driving collective action and legislative proposals to curb emissions from dangerously high levels. A study released by the EPA in 2017 revealed Multnomah County's air quality is among the worst 1.2% in the nation (Portland Clean Air, n.d.). With heightened awareness of air quality issues in Portland, the concern about the sources of harmful emissions has prompted fervent research. Diesel particulate is among the 19 pollutants of concern identified by the Oregon DEQ, and is the pollutant of focus for the following map model, which aims to advance our understanding of diesel particulate emissions from heavy duty trucks on roads in the Portland Metro area.

"No one has mapped Portland diesel particulate like this before. The EPA modeling study was low resolution like an Atari video game - ours is using data the EPA didn't have access to."

-Greg Bourget, Lead Researcher, Portland Clean Air

Air Quality Data from the EPA
The following model of diesel particulate begins with data supplied by the EPA in the National Air Toxics Assessment Data (NATA Data). This data was created using a sophisticated modeling technique and took into account a vast amount of pollution sources. This analysis includes only the on road sources of diesel in Portland.

What the NATA Data tells us
The map to the right displays the concentration of diesel particulate matter from heavy duty trucks aggregated by census tract. The measurement is in micrograms per cubic meter, and is averaged for each tract area.

The limitation of aggregating the data by census tract is that the resolution is deceivingly low. Since this model represents diesel emissions from road sources, we can get a more accurate visualization by mapping the concentration of particulate matter on the roads themselves. We did this by way of dasymetric mapping which requires each road type to have a weight based on the level of diesel traffic.

Using ODOT Data for road density weights.
We used ODOT (Oregon Department of Transportation) traffic volume data to calculate the Annual Average Daily Traffic (AADT) figures for the roads in Portland. The data is organized by vehicle type, and for this analysis we included only "heavy duty" trucks which are prone to emit diesel. The data collection was done at every point represented on this map, larger points representing higher truck counts.

Click on the dots to learn the location of the point, the AADT, and the heavy duty truck AADT measured at that location.

The next step was to classify the roads by type and find the average traffic volume for each road type. Then we were able to assign relative densities to each road type.

Determining Relative Densities
In order to compute relative densities for the streets using traffic volume data, the streets were classified according to type. Using Metro RLIS data, which classifies streets by number codes, we identified the types of streets we want to include. This analysis includes freeways, highways, major arterials, minor arterials, tertiary streets, and residential streets. Specific road classifications were chosen by evaluating the number of traffic volume monitors on each road type. These six types were the only road types with over 30 monitors total. Once streets were categorized by type and linked to the ODOT data, the heavy duty truck AADT was calculated for each street type. With those averages we determined a relative density (or weight) to assign to each street type to use for ancillary data for the dasymetric map. Here you can see the weights as assigned to each street type (zoom in to activate the residential streets layer).

Dasymetric Map of Diesel Particulate

Once relative weights are assigned to each street type, the dasymetric map can be created. This is a model offers a finer resolution by disaggregating the census level data to the road network. More importantly, it's assigned to roads with weighted values so you see the highways with much higher values of particulate matter, and residential streets with relatively low values. Off road areas have no particulate matter as the analysis includes only on road sources.

Click on the census tracts for information regarding aggregate measurements of diesel particulate matter, and particulate matter from heavy duty diesel on road sources.

The problem with this map is that diesel particulate does not stay uniformly on the road. Rather, it disperses over varying distances. The next, and final, step is to use a fuzzy overlay to model the dispersion of diesel as it moves away from the road.

Mapping diesel dispersion.

We simulated a fuzzy overlay to model the rate in which diesel particulate disperses from the road. According to Zhu et. al. (2002) in a study of diesel dispersion from the highway, diesel particulate dissipates to roughly 50% of its original concentration at 300 meters from the source. This map represents the aforementioned dispersion model uniformly over every road type.

The DEQ's Portland Air Toxics Study of 2012 cites diesel particulate ambient benchmark concentrations as .01 micrograms per cubic meter or below. Any reading above this level is considered hazardous due to risk of exposure to cancer causing agents (Oregon DEQ, 2012). The map created with our model indicates an alarming proportion of area exceeding the benchmark for health standards.

Please keep in mind that this is a model for heavy duty truck diesel emissions from on road sources only. There are off road sources of diesel emissions which affect the total measures of diesel particulate present in the air.

Points of Interest

This map includes points of interest to help reference air quality around schools*, hospitals, and parks. You can use the location finder tool to locate your home address (be sure to include the city and state when searching), or use the links below to activate layers of interest, and view the modeled diesel particulate matter in that area.

*Schools are indicated by the purple icon when zoomed out. At a certain point when zooming in the icon disappears and the school zone itself is represented.

Portland's Future in Diesel Particulate mapping

It's important to keep in mind that current levels of particulate matter concentration are directly related to regulations regarding emissions, as well as programs in place to aid in curbing emissions. The mission of raising awareness for air quality continues to advance with local organizations dedicated to the study and sharing of information related to emissions. Portland Clean Air is a non-profit organization making strides in advancing our understanding of diesel particulate in our neighborhoods. A project is currently underway to use portable diesel particulate monitors, and bicyclists to gather data in the Portland area. With the ability to produce and analyze current data, our understanding of diesel particulate matter and Portland's air quality will advance far beyond the capabilities of the model presented in this map.

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Parks Layer Provided By: City of Portland Bureau of Parks and Recreation Joshua Darling 503-823-2783 Josh.Darling@portlandoregon.gov 1120 SW 5th Avenue, Suite#1302 Portland, OR 97204-1933 City of Portland - PPR 503 823-7529 503 823-6007 ParksGISSupport@portlandoregon.gov

PORTLAND DIESEL PARTICULATE DISPERSION MAP
Summary of Methods

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INTRODUCTION

Every GIS mapping project begins with, and can be limited to, the available data regarding the subject matter. The authors of this analysis employed methods in an attempt to model the data in a fashion as realistic and true to life as possible. The following sections will outline sources of data used, the method for determining the study area, the methods employed in modeling the data including limitations to this model.

DATA

For diesel particulate matter we utilized the 2014 National Air Toxics Assessment (NATA) Data provided by the United States Environmental Protection Agency (EPA) (EPA 2014). The NATA data models air particulate using data from major and minor stationary sources, on-road and non- road mobile sources, fires, and biogenic sources. For this analysis we singled out "heavy duty on network sources of diesel particulate matter" in the Portland Metro Area.

We used data from the Oregon Department of Transportation to determine the Average Annual Daily Traffic for the designated road types we included in our model (ODOT 2017a, 2017b). This data was collected throughout the year in 2017. The data separates vehicle count by vehicle type (determined by vehicle axle length), and for our analysis, we included only heavy-duty diesel trucks. These included vehicle classes 5-13 as assigned by the Highway Performance Modeling System.
To categorize the road types for the ancillary data in the dasymetric map we used the Metro RLIS data available to us through the Portland State University data sharing drive. This data includes, among many things, number classification systems for each road type represented in the streets of Portland.

We also used Metro RLIS data to define our study area and map out census tracts.

STUDY AREA

To begin with we designated a study area. The Portland Metro area as defined in RLIS data includes some large regions off to the east and west which made the map less approachable for viewing convenience. We decided to focus on census tracts included in the urban growth boundary to focus on a more compact, and pertinent, study area. Each layer created after this point was clipped to the aforementioned study area. This also helped to model traffic data, as it excluded some rural areas outside of the metro area.

METHODS/LIMITATIONS

We then began working with the ODOT data to compute relative densities for the road types designated for the model. This began with a spatial join of the ODOT data (which was mapped using measurements of latitude and longitude) to the streets layer provided by the RLIS data. This associated each AADT measurement with a corresponding road.

From this point, we consulted the attribute table to determine which road types had a sufficient number of traffic volume counts to include in our analyses, at least thirty measurement stations. This constraint lead us to exclude some possibly pertinent road types (for example: highway on and off ramps) due to lack of sufficient counts to ensure a representative mean. The road types ultimately included in the analysis are freeways, highways, major arterials, minor arterials, tertiary, and residential roads.
Then we ran summary statistics to determine the mean and median for each designated road type. We analyzed the statistics using histograms (**See**

APPENDIX: figure 01) and excluded extreme outliers in an attempt to avoid skewed means. At this point we were faced with the decision between using the mean or the median values to represent the traffic volume weight for the street types. We deferred to some researchers in the field from Portland Clean Air and determined the mean would be the best representation.

**Upon further consultation it was determined that, in fact, the median would have been a better representation due to the skewed nature of the data. We recognize this as a shortcoming of our current map, and an opportunity for future improvement.

Once the relative densities were determined we adjusted the weights to reflect the presence of interstate travel and the heightened presence of diesel filtered trucks on freeways. We did this by multiplying all other road types by a factor of 1.2. This figure is an educated estimate provided by researchers at Portland Clean Air. At this point we contacted the research team at Portland Clean Air to confirm the validity of the relative densities as they had been calculated, and received an affirmative response (**See APPENDIX: figure 02)**.

With relative densities calculated we proceeded with the dasymetric mapping. This is a process by which aggregate data is given a higher resolution by assigning data to weighted sources. This map the relative densities were determined through the methods stated above, and then applied as ancillary data to create the dasymetric map. The product is a map that shows diesel particulate matter concentration, weighted by traffic volume, assigned to the sources from which it was emitted (the roads themselves).

The dasymetric map is misleading, however, because it maps diesel particulate as if it were contained only on the road on which it was emitted. In reality, diesel disperses from the source and becomes less concentrated with distance from the source*. In order to model this we needed to simulate a fuzzy membership. We created and ran this tool (**See APPENDIX: figure 03)** for each road classification type and added the resultant layers together. This calculated the expected diesel particulate matter at a point, considering the effect of the nearest road types and their expected diesel emissions. This map represents the aforementioned dispersion model uniformly over every road type, considering the effects of the nearest road of each classification type.

*Upon researching how diesel particulate disperses from a vehicle source we found a wide range of studies, some including multiple wind factors, the direction of vehicle travel, time of day, and temperature. The conclusions did not offer a consensus. We decided to base our model off of a study by Zhu, et al (2002) which modeled diesel dispersion from a highway at approximately 50% of the source concentration at 300 feet from the source. The authors recognize that there is likely a difference in dispersion rates as they relate to varying traffic volumes, and that this variation is not represented on this map. The scope of the project, along with the lack of consensus in the literature, did not permit a more accurate, research-based model.

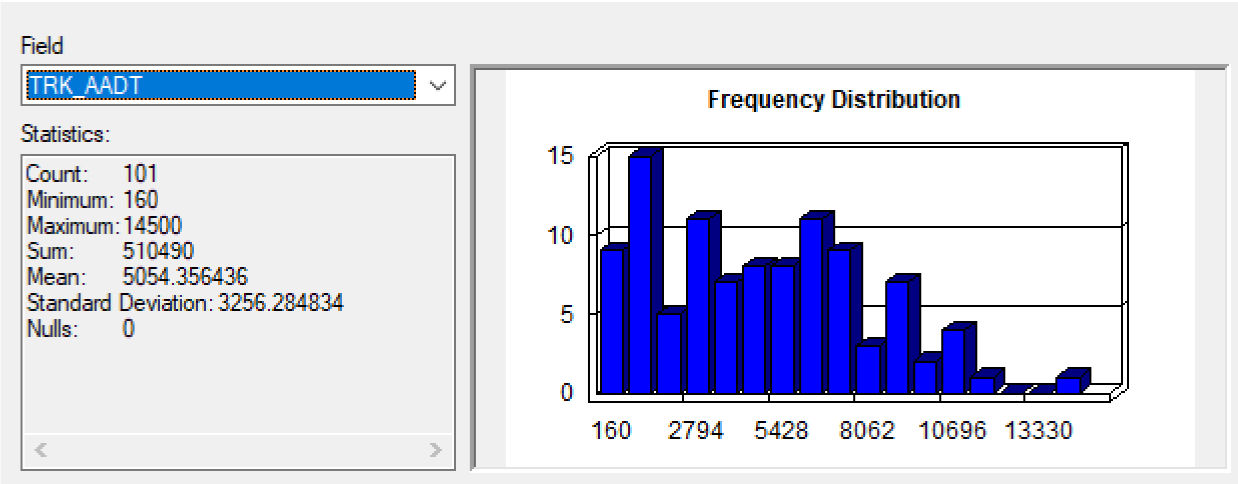
The resulting map is a raster of heavy-duty truck diesel particulate matter as it disperses from the road source weighted by traffic volume for six road types.

Lastly we included interactive layers of schools, hospitals, and parks for users to examine potential points of interest on the map and the corresponding diesel particulate as modeled in the map. By including points of interest we hope to give pertinent reference points to engage our audience in how diesel particulate affects places they may regularly visit. In this online model you can also search for specific addresses. However, it is important to note that this is a model of diesel particulate matter dispersion from road sources only, it does not include background concentration or other diesel sources, nor does it represent the concentration of diesel particulate matter at a particular point. Rather, it models the relative impact of nearby roads to diesel concentrations in that area. Therefore, this model should be used with caution at any precise point, and is probably best used to inform policy decisions.

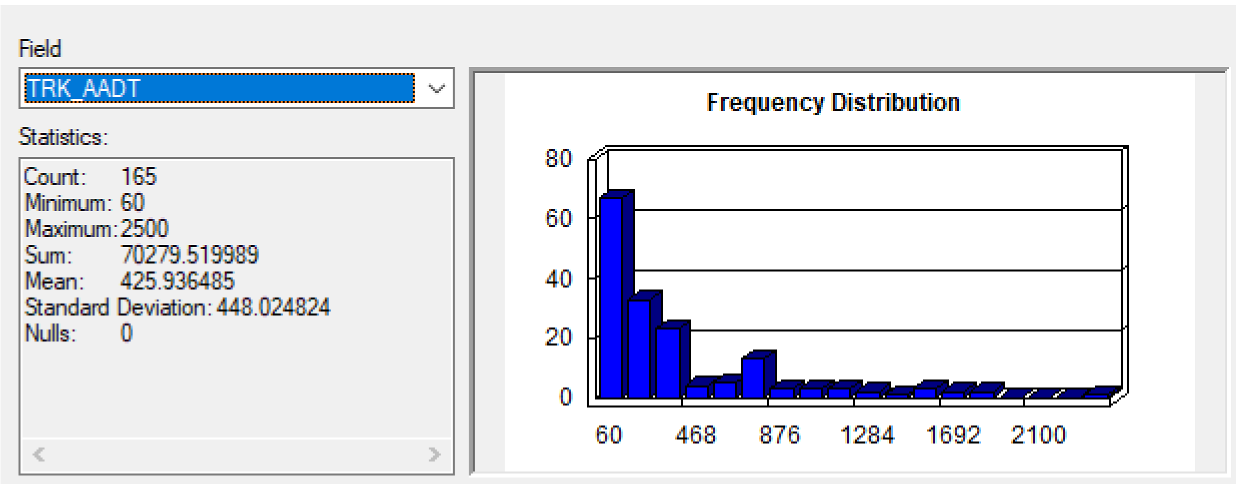
APPENDIX

Figure 01

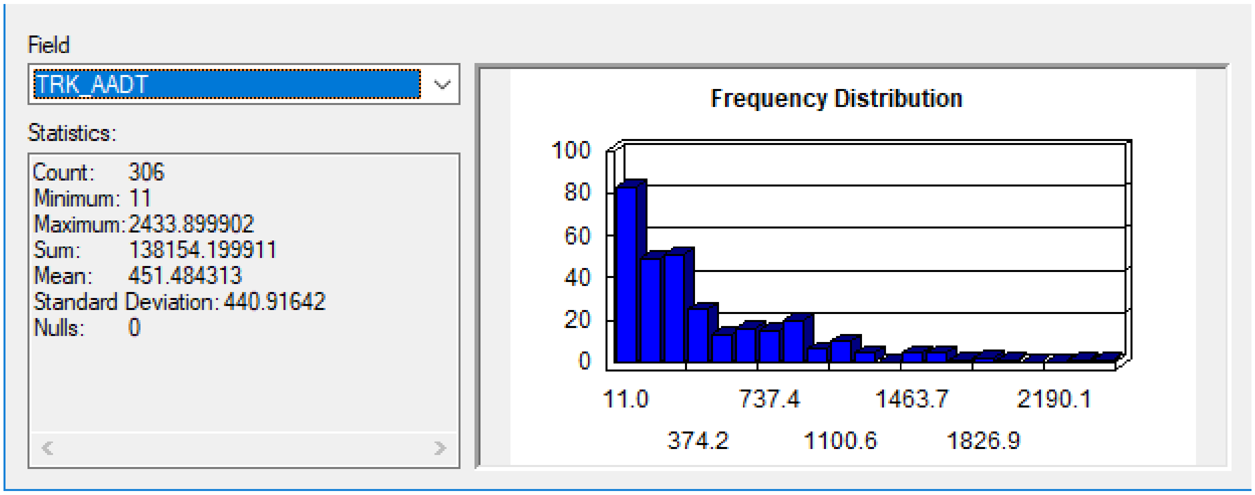
1110 Freeway Statistics



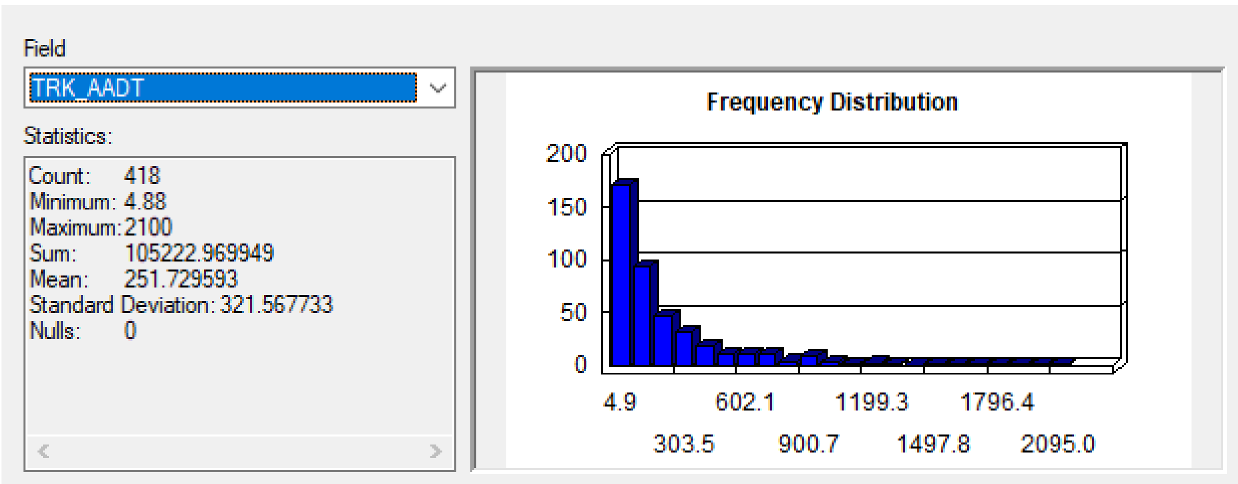
1200 Highway Statistics



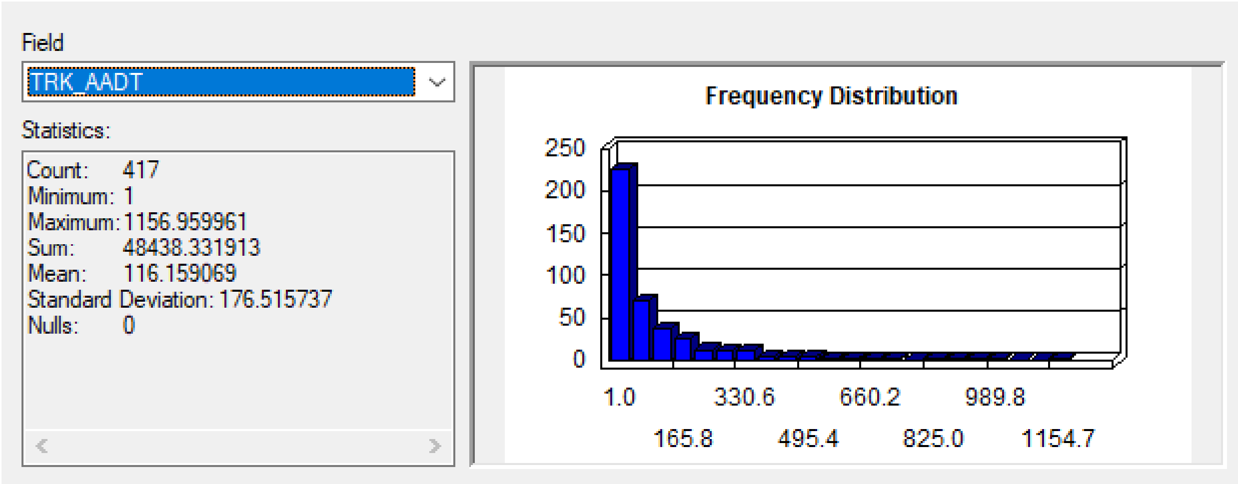
1300 Primary Arterial Statistics



1400 Arterial Statistics



1450 Tertiary Statistics



1500 Minor Residential Statistics

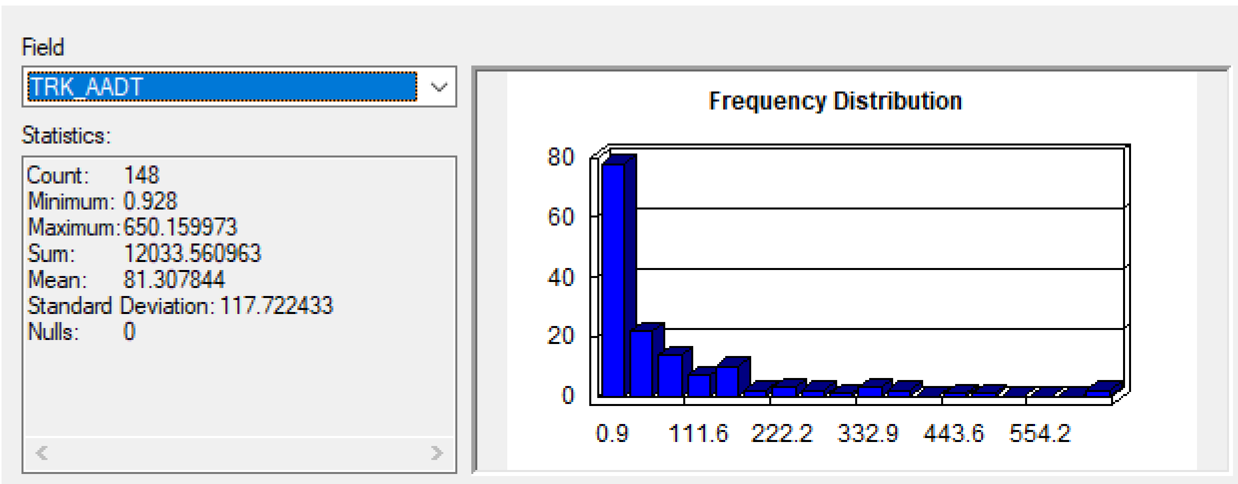
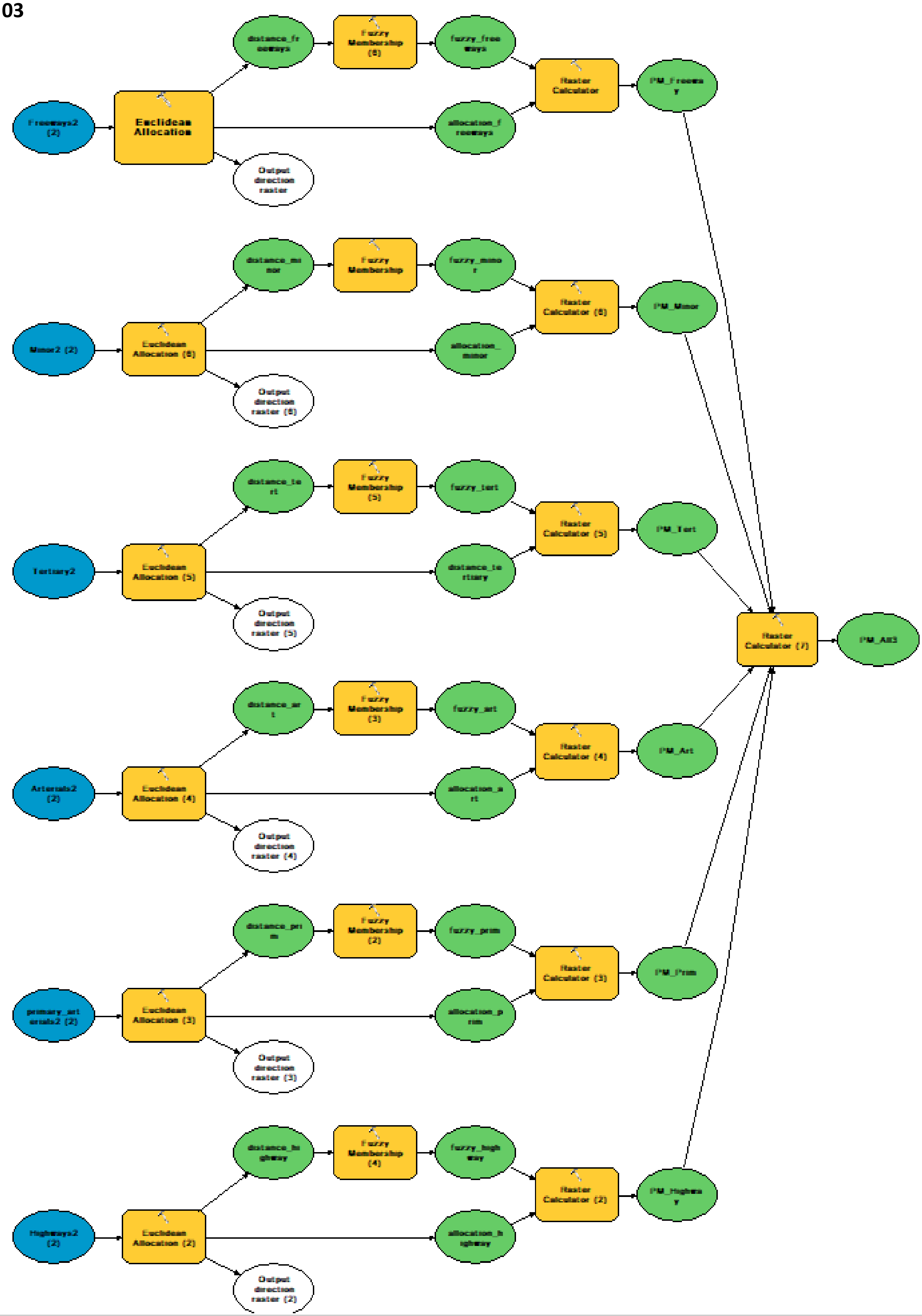


Figure 02

Relative Truck Density by Road Classification (Based on Average Versus Median Truck Volumes)

Type	Classification	Count	Min	Max	Average Truck Volume	Weighted Average Truck Volume (Surface truck * 1.2)	**Relative Density (Based on Average)**	Median Truck Volume (calculated in Excel)	Weighted Median Truck Volume (Surface truck * 1.2)	**Relative Density (Based on Median)**
1110	Freeway	101	160	14500	5054	5054	**76.0%**	4300	4300	**82.5%**
1200	Highway	165	60	2500	426	511	**7.6%**	250	300	**5.8%**
1300	Primary Arterial	306	11	2434	451	541	**8.1%**	286	343	**6.6%**
1400	Arterial	418	5	2100	252	302	**4.6%**	143	172	**3.3%**
1450	Tertiary Street	417	1	1157	116	139	**2.1%**	50	60	**1.2%**
1500	Minor Residential	148	1	650	81	97	**1.5%**	32	38	**0.7%**

Figure 03



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Fuzzy Membership (6)
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Raster Calculator
PM_Freeway
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Euclidean Allocation (6)
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Fuzzy Membership
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Raster Calculator (6)
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Output direction raster (6)
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