Appendix H

System Dynamics Representation of the PM_{10} Proportional Rollback Model

December 2006 (Draft)

System Dynamics Representation of the PM_{10} Proportional Rollback Model

Process and Model Description, Users Guide, and Discussion of Key Parameters

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Prepared by UNLV for the Department of Air Quality and Environmental Management

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Executive Summary

The purpose of this project was to translate and update the modeling tool used by the Clark County Department of Air Quality and Environmental Management (DAQEM) in support of the 2001 PM_{10} State Implementation Plan (SIP). The previous model, called the PM_{10} Proportional Rollback Model, consisted of nine partially linked spreadsheets. Emissions were calculated based on either land area or acres constructed in a given year, driven by the change in population, and emission factors per acre of land or construction type. The PM_{10} Proportional Rollback Model required manually moving calculated emissions from one spreadsheet to another to complete final calculations. This process made human error likely because the process was difficult to follow and it required a considerable amount of time to perform projections. In addition, the ability to perform policy tests was limited and required saving an additional set of files for every change to parameters.

The purpose of updating the modeling tool was to remove many of the mechanical issues of the PM_{10} Proportional Rollback Model, while maintaining the same EPA-approved, rollback methodology as presented in the 2001 PM_{10} SIP.

Two new models were created. The new models are based on the same mathematical and conceptual foundation as the original rollback model, and include:

1. Milestone Achievement Report (MAR) model which replicates the spreadsheet outputs by using the same inputs; and,
2. The Updated MAR model, which calculates updated outputs using updated inputs.

Using a system dynamics representation, these models differ most notably in their treatment of material flows (as stocks and flows) and strict maintenance of dimensional consistency in all calculations. The first model is simply a translation of the original calculations and formulas as contained in the Excel spreadsheets of the PM_{10} Proportional Rollback Model. The resulting output of this model is compared to the original results provided to the EPA to validate that it produces similar results. The second model allowed DAQEM to update parameter values based on new information to see the effects on estimated emissions. Parameters modified include: 1) population, 2) the area of the Bureau of Land Management (BLM) disposal boundary, 3) average vehicle weight for calculating trackout emissions, and 4) density.

Introduction

Purpose of the Project

The purpose of this project was to update the decision support system used by the Clark County Department of Air Quality and Environmental Management (DAQEM) to support the 2001 PM_{10} State Implementation Plan (SIP). DAQEM needed a modeling tool that was easier to communicate to others and allowed for updates to the input values. The rollback methodology behind the calculations was previously approved by the Environmental Protection Agency (EPA) and remains the basis for the final updated versions of the model. Although able to calculate results using the approved methodology, the prior tool consisted of several spreadsheets, was difficult to modify, required intensive manual manipulation of values, and did not lend itself easily to conducting policy tests. A system dynamics representation was desired as an alternative, with the final goal of a more flexible modeling tool. The project was not intended to change the mathematical process by which emissions are calculated, but rather to improve the usability of the original model which reflects the underlying rollback methodology.

Approach

The project included several stages, beginning with examining the data and calculations represented in the PM_{10} Proportional Rollback Model spreadsheets. The second stage was translating the individual spreadsheets into a system dynamics representation, which differ most notably in their emphasis on causality, tracking material flows as either stocks or flows and their adherence to dimensional units in all calculations. The results of the new representation were compared to the original results to ensure that the model structure replicated the original results. After validating the system dynamics representation of the model, the final stage was to update key parameters and determine the change in projected emissions.

Two models were produced, using the same mathematical and conceptual foundation as the original rollback model. The first model is the PM_{10} Proportional Rollback Model used to generate the Milestone Achievement Report (MAR model), which replicates the spreadsheet outputs using the same inputs. The second model is the PM_{10} Proportional Rollback Model updated to reflect the newest available information for selected parameters (Updated MAR model).

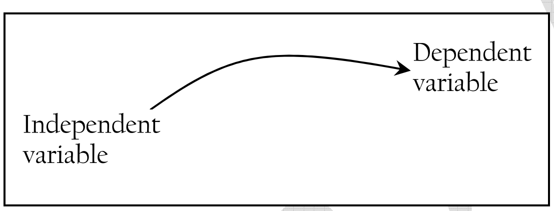
Model Purpose

Each model is intended to show future PM_{10} emissions based on a growing population and its demand for land. Changes in population are projections from external sources; they are not determined within this model's structure. These values are directly inserted into the model to drive annual construction. Moreover, because the new model is based on the same methodology as the previous model, it does not answer policy questions about spatial components or other options not included in the previous tool. The MAR model is used to show the model reproduces the original output given the original input values. The original spreadsheets were based on estimates of population for 1998 to 2007 and other parameters which could be better estimated (or given an actual value) using current information. The second model, the Updated MAR, therefore incorporates this additional information. The changes made in the Updated MAR include: 1) newest actual and estimated values for population, 2) an increase in the Bureau of Land Management (BLM) disposal boundary of approximately 26,000 acres, 3) a reduced average vehicle weight (used to calculate trackout emissions) from 3 to 2.4 tons based on a recent DAQEM report, and 4) the base density value was changed to allow model users to fill in a value. This model is intended to show the change in results when parameters are updated or changed.

Why Use a System Dynamics Representation?

A system dynamics model is a decision support system used for evaluating the consequences of policy changes in a system. It represents cause-and-effect relationships occurring in the real world in the form of mathematical equations. Causal connections between variables are depicted using arrows. Changes in the variable shown at the tail of the arrow affect the value of the variable at the head of the arrow. The relationship is visually represented as shown in Figure 2.

Figure 2 Causal diagram



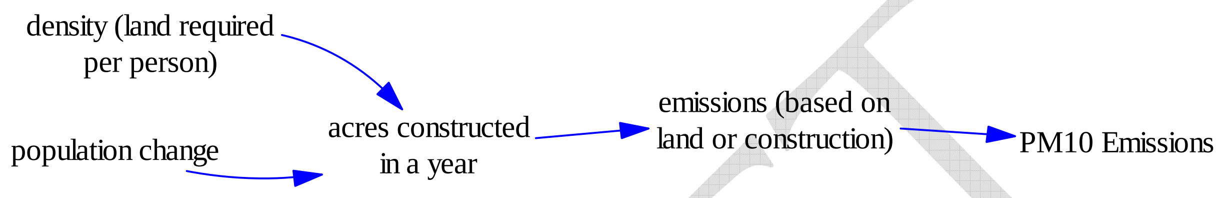
A causal diagram shows the general relationships and dependencies among variables, while the underlying mathematical operations further specify the relationship. System dynamics differentiates between stock variables (accumulations), their flows (rates which add or take from those accumulations), and auxiliary or calculated variables. The stock-and-flow formulation allows for integration of accumulations over time.

System dynamics models help us examine the way a system changes over time and focuses on trends rather than specific point data. System dynamics models can be simulated using various software packages. The MAR and Updated MAR models were developed using Vensim® PLE Plus version 5.4 (Ventana Systems, 2003). The software checks that all equations are dimensionally consistent and adhere to laws of conservation of matter. Different policy scenarios can be easily simulated and saved. Finally, system dynamics models can be easily updated as systems become better understood or quantified, both for parameter values and new structural aspects to the system.

Understanding the PM_{10} Proportional Rollback Model

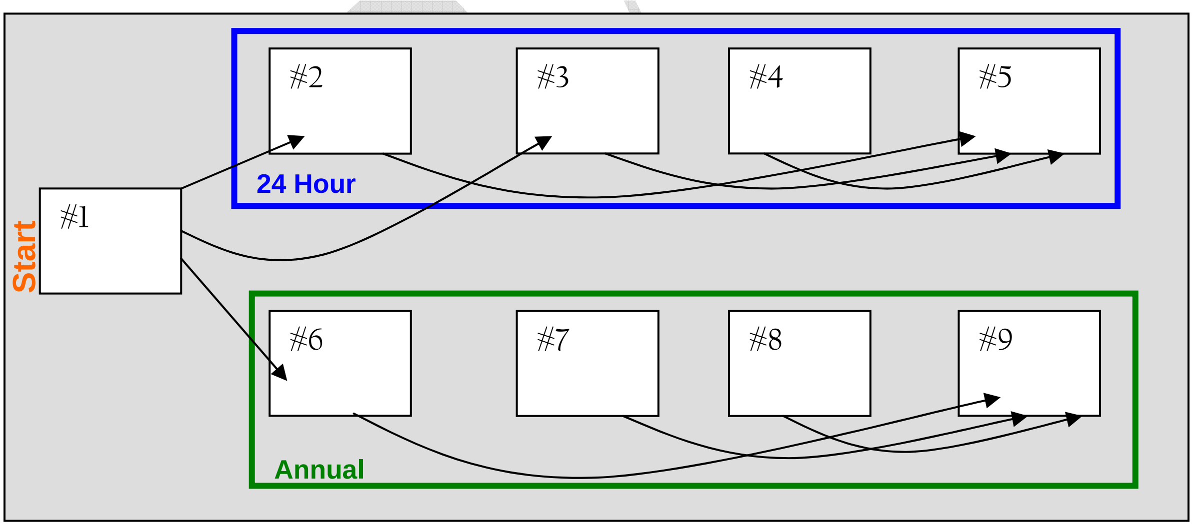
The general formulation of the PM_{10} Proportional Rollback Model is shown in Figure 3. Projected population values are used to determine the change in population, which is then used with density to determine how many acres are to be constructed in any given year. All emissions are then calculated either from the remaining vacant land or acres under construction. These are modified, either by controls or when converted to a concentration, to determine the final emissions.

Figure 3 General calculation process of the PM_{10} Proportional Rollback Model



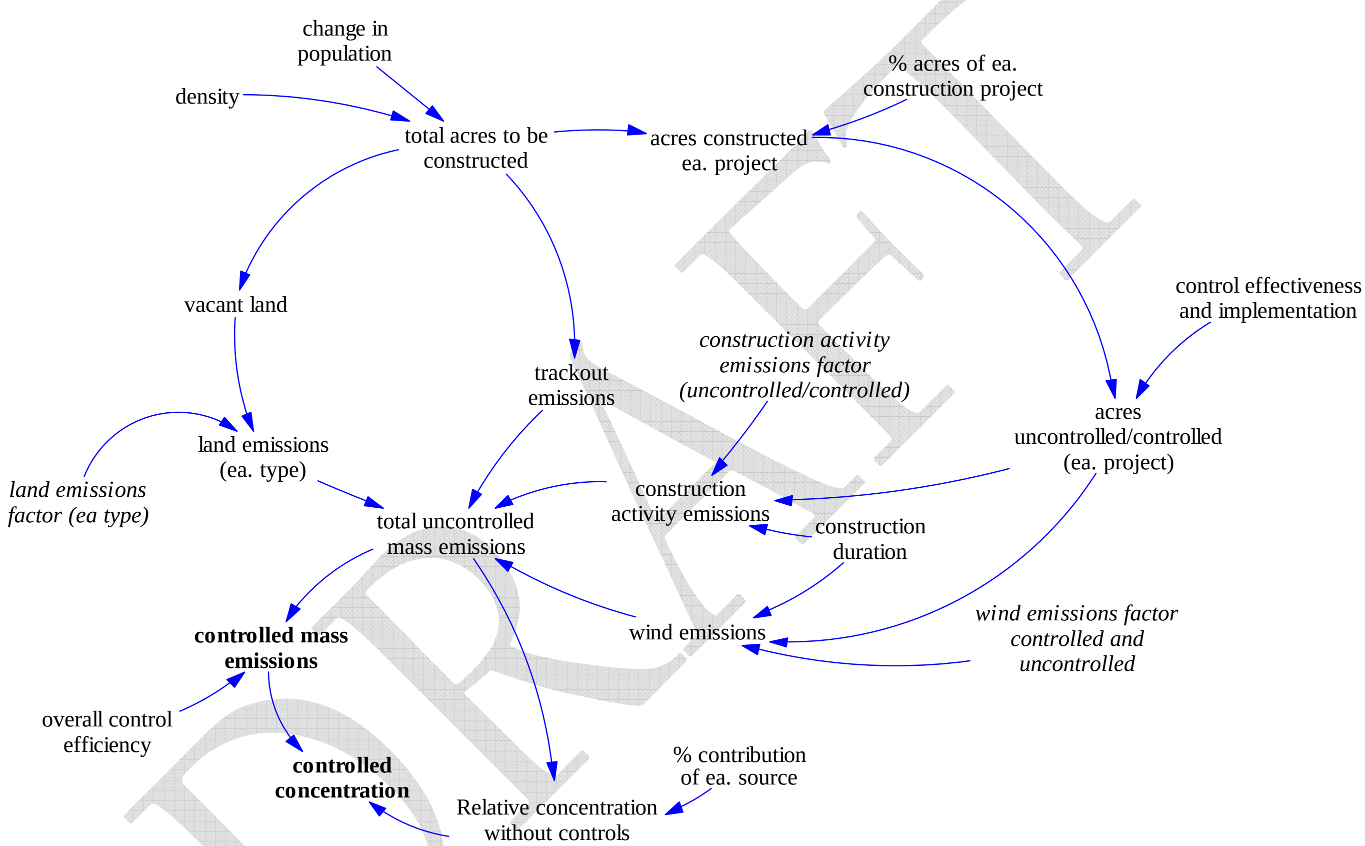
Within the PM_{10} Proportional Rollback Model, there are 9 spreadsheets used to track certain emissions categories for both the 24-hour and annual standards. The tool requires manually copying information from the previous spreadsheet and carrying those calculated values over to the final spreadsheet as shown in Figure 4. These file numbers are cross-listed with the original names in part 1 of the Appendix.

Figure 4 High level map of PM_{10} Proportional Rollback Model



Spreadsheet #1 uses historic values of acres constructed and changes in population to determine a density factor. This density is then used to drive further construction of land using estimated values of population. Vacant land is tracked and categorized into three types: Native Desert, Stabilized Land, and Unstable Land. Acres to be constructed are then allocated into those categories, the majority of which occurs on Native Desert using the Clark County Multi-Species Habitat Conservation Plan. In the intermediate spreadsheets (2-4 and 6-8), different categories of emissions are calculated using the acres constructed on each land type in that year. Types of emissions include: land emissions, windblown construction dust, trackout, and construction activities fugitive dust. The final spreadsheets, sheets #5 and #9, show all of the emissions calculated within the model, as well as emissions determined from other modeling tools used by DAQEM. Certain emissions are then reduced by calculating the effect of implementing controls. Total uncontrolled mass emissions (in tons) are used to determine the percent contribution for each source, by taking the total tons and dividing each source by this amount. The percent is multiplied by the design concentration (without controls) to determine the concentration for

Figure 5 Causal diagram of calculations in PM_{10} Proportional Rollback model



each source. Emission reductions from controls are then applied, and a final mass emissions and relative concentration is determined. The calculation process is similar for both the annual and 24-hour standard. The general causal links embedded in the calculations of the PM_{10} Proportional Rollback Model can be seen in Figure 5.

Figure 6 is an example of the final annual spreadsheet (#9) and shows how these steps are taken. Column #1 contains each emissions category and its sources, the mass emissions (in tons per year) for these sources are shown in #2 (column 3 and 4 are calculated outside of the current model). Each column is totaled at the bottom of the table. Emission totals from columns 2, 3, and 4 are then added across and divided by the total emissions to determine the percent contribution, #5. The design value is in the final row of column 6, which is multiplied by column 5 to determine each relative contribution. Controls are applied in column 8 and a final concentration is given in #9. The percent reduction values used in column 7 are described in the controls section of the Discussion.

Figure 6 Example of spreadsheet calculating final emissions

1	2	3	4	5	6	7	8	9
SOURCE	PM10 (TPY)	NOX (TPY)	SOX (TPY)	% Contrib-ution	Relative Mass Contribution w/o Controls (ug/m3)	Overall % Reduct-ion	2006 Controlled Emissions	Relative Mass Contribution w/ Controls (ug/m3)
Stationary Point Sources (1)								
Sand & Gravel Operations	627	294	22	0.44%	0.16		943	0.17
Utilities - Natural Gas	199	5,319	2	0.14%	0.05		5,520	0.05
Asphalt Concrete Manufacture	171	60	26	0.12%	0.04		257	0.05
Industrial Processes	80	437	124	0.06%	0.02		641	0.02
Other Sources	124	126	5	0.09%	0.03		255	0.03
Total	1,201	6,236	179	0.83%	0.30		7,616	0.32
Stationary Area Sources								
Small Point Sources	184	1,825	25	0.13%	0.05		2,034	0.05
Residential Firewood	101	0	0	0.07%	0.03		101	0.03
Residential Natural Gas	89	0	0	0.06%	0.02		89	0.02
Commercial Natural Gas	33	537	3	0.02%	0.01		573	0.01
Industrial Natural Gas	14	182	1	0.01%	0.00		197	0.00
NG - Purchased at the source - Carried by SWG	210	2767	17	0.15%	0.05		2,994	0.06
Structural / Vehicle Fires / Wild Fires	23	0		0.02%	0.01		23	0.01
Charbroiling / Meat cooking	1,005			0.70%	0.25		1,005	0.27
Soil Microbial Activity / Biological Sources	0	0		0.00%	0.00		0	0.00
Disturbed Vacant Lands / Unpaved Parking Lots	35,866			24.91%	9.09	72	10,042	2.55
Native Desert Fugitive Dust	3,999			2.78%	1.01		3,999	1.01
Stablized Vacant Lands Dust	3,948			2.74%	1.00		3,948	1.00
Construction Activity Fugitive Dust	10,250			7.12%	2.60	68	3,280	0.83
Windblown Construction Dust	8,259			5.74%	2.09	71	2,395	0.61
Total	63,981	5311	45	44.44%	16.22		30,680	6.45
Nonroad Mobile Sources								
Airport Support Equipment	50	0	0	0.03%	0.01		50	0.01
Commercial Equipment	0	0	0	0.00%	0.00		0	0.00
Construction & Mining Equipment	484	0	0	0.34%	0.12		484	0.13
Lawn & Garden Equipment	17	0	0	0.01%	0.00		17	0.00
Railroad Equipment	19	0	0	0.01%	0.00		19	0.00
Recreational Equipment	1	0	0	0.00%	0.00		1	0.00
McCarran International Airport	335	0	0	0.23%	0.08		335	0.09
Henderson Executive Airport	7	0	0	0.00%	0.00		7	0.00
North Las Vegas Municipal Airport	31	0	0	0.02%	0.01		31	0.01
Nellis Airforce Base	32	268.6	396.5	0.02%	0.01		697	0.01
Total2	976	269	396	0.68%	0.25		1,641	0.25
Onroad Mobile Sources								
Paved Road Dust (Includes Const. Trackout)	55,717	-	-	38.70%	14.13	13	48,474	12.29
Unpaved Road Dust	19,082	-	-	13.26%	4.84	71	5,534	1.40
Highway Construction Projects Activities	1,250	-	-	0.87%	0.32	63	463	0.12
Highway Construction Projects - Wind Erosion	659	-	-	0.46%	0.17	71	191	0.05
Vehicular Sulfate PM	496	-	-	0.34%	0.13		496	0.12
Vehicular Tire Wear	102	-	-	0.07%	0.03		102	0.02
Vehicular Brake Wear	166	-	-	0.12%	0.04		166	0.04
Vehicular Exhaust3	326	22,035	491	0.23%	0.08		22,852	0.08
Total	77,798	22,035	491	54.04%	19.73		78,277	14.12
TOTALS	143,956	33,851	1,112		36.5		118,215	21
				Background	16.5			15.75
				Total	53.00			37

MAR Model Development

Identifying Stocks and Flows

The first requirement of translating the spreadsheet's calculation method into a system dynamics representation was identifying the stocks and flows within the system. We started with the amount of land available for development (vacant land) because it is a physical quantity that decreases over time as acres are constructed. Figure 7 shows how land is further classified into Native Desert, Stabilized, and Unstable Land. Although the calculations are not visible in Figure 7, the amount of land in these three categories is determined by multiplying the initial acres of land by the percent of land in each category. Vacant land is then calculated simultaneously to show the overall amount of acres available.

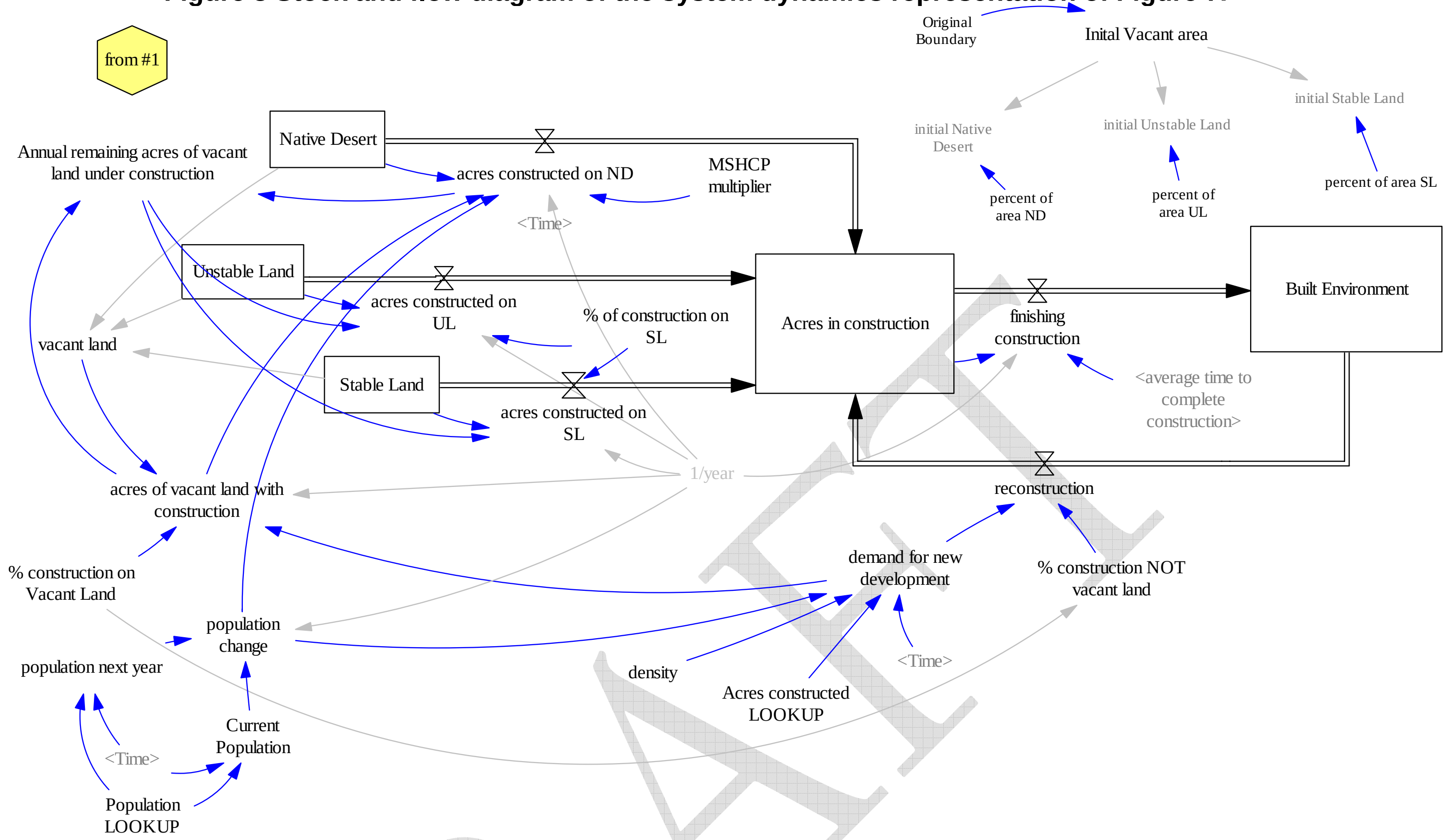
Figure 7 Selected portion of Spreadsheet #1, showing land classifications and how they decrease with time.

Year	Population (RTC)	Change in Population	Acres Constructed (24hr & annual stds)	Acres of Vacant Land With Construction (95.4%)	Acres of Native Desert Disturbance Using the MSHCP	Remaining Acres of Vacant Land with Construction	Acres of Vacant Land (24hr & annual stds)	Acres of Native Desert (Annual)	Acres of Stabilized (24hr & annual stds)	Acres of Unstable Land (24hr & annual stds)
1998	1,183,883	71,370	19,449.30	18,554.63	13,674	4,880	209,189.00	127,176.45	61,091.04	20,918.90
1999	1,255,253	102,003	20,417.00	19,477.82	19,478	**0**	190,634.37	113,501.96	57,430.93	19,698.86
2000	1,357,256	66,109	19,040.00	18,164.16	12,666	5,498	171,156.55	94,023.96	57,430.93	19,698.86
2001	1,423,365	81,433	21,749.00	20,748.55	15,603	5,146	152,992.39	81,357.48	53,307.68	18,324.45
2002	1,504,798	50,922	14,033.42	13,387.88	9,757	3,631	132,243.84	65,754.91	49,448.19	17,037.95
2003	1,555,720	46,039	12,687.73	12,104.10	8,821	3,283	118,855.96	55,998.26	46,724.77	16,130.14
2004	1,601,759	42,404	11,685.97	11,148.42	8,125	3,024	106,751.86	47,177.19	44,262.50	15,309.39
2005	1,644,163	39,497	10,884.84	10,384.14	7,568	2,817	95,603.44	39,052.58	41,994.64	14,553.43
2006	1,683,660	36,997	10,195.88	9,726.87	7,089	2,638	85,219.30	31,484.95	39,882.25	13,849.31
2007	1,720,657		-	-						
			growth factor dervived from population growth deltas from 1998-2001							

In converting this information into the system dynamics format shown in Figure 8, the three types of land (*Native Desert, Stable, and Unstable Land*) were identified as stocks which can only decrease with time. Outflows from these three stocks of land add to the stock of *acres in construction*. Once construction is completed, these acres become part of a stock of developed acres (not represented in Figure 7), called *built environment*.

Figure 8 also shows a material flow, or pipe, from the stock of *built environment* to *acres in construction*, representing that fraction of land that is reconstructed every year (although not specifically tracked in the original model). In order to determine the total acres of *vacant land*, all of land sub-categories are added together. Therefore, instead of looking at *vacant land* as a simultaneously decreasing stock of land, it is determined by adding up the acres in the sub-category stocks. As discussed previously, the initial number of acres for each sub-category stock is determined by multiplying the land area (*initial vacant area*) by the percent of the total land in each category. This can be seen in the top right-hand corner of Figure 7.

Figure 8 Stock and flow diagram of the system dynamics representation of Figure 7.



Population could be captured as a stock that increases or decreases with inflows such as births and in-migration and outflows of deaths and out-migration. However, since this conceptualization uses the same format as the prior model, population is an exogenous variable.

The names used for the described stocks differ slightly from the names listed in the spreadsheet (*stable land* instead of stabilized). Variable names were modified throughout the model, to a varying degree of divergence, for better consistency and clarity. Where they differ, the new variable name was documented and cross-listed with the original name used in the PM_{10} Proportional Rollback Model. A selection of these variable name changes is included in the first section of the Appendix.

Representation of Other Calculations

All spreadsheets were maintained as individual views in the MAR model to maintain the same visual structure as the PM_{10} Proportional Rollback Model. Each view of the model, therefore, is named according to the spreadsheet it represents and is identified by the spreadsheet number in a hexagon in the upper left-hand corner. Spreadsheets #4 and 7 are actually the same spreadsheet, and so are represented only one time in the new representation.

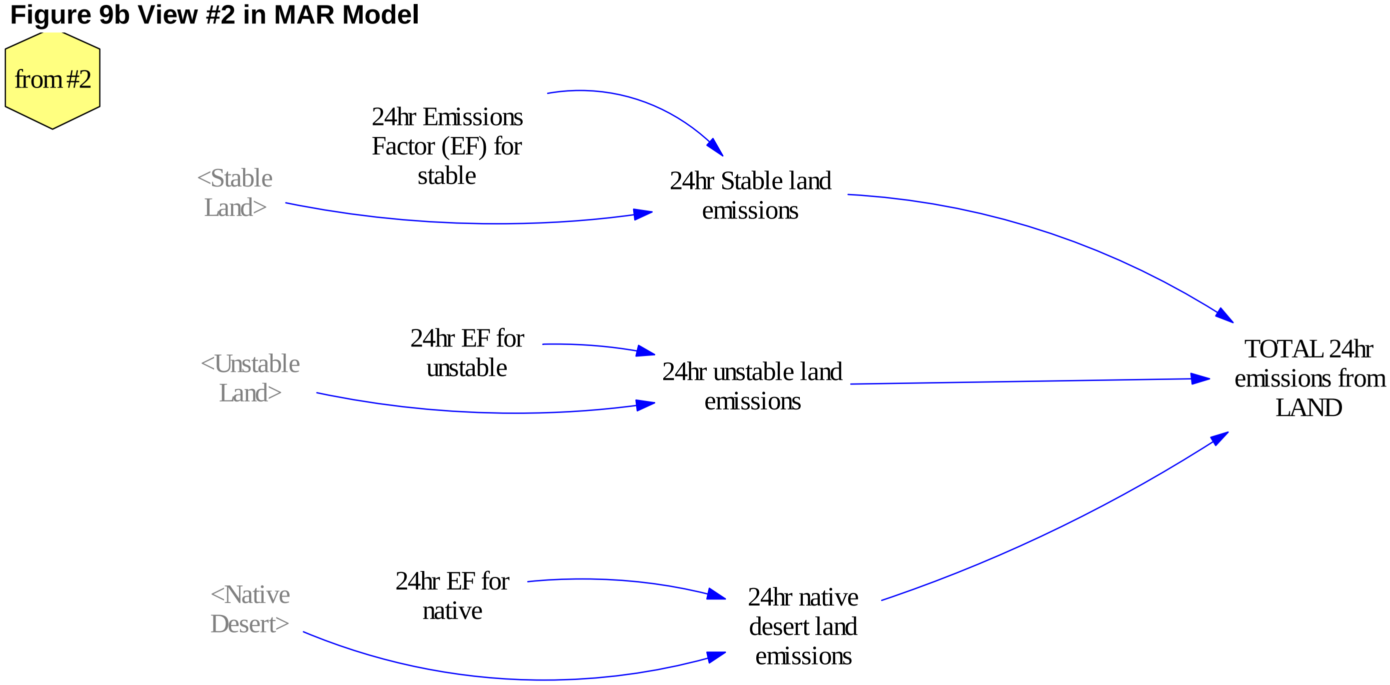
Land area emissions are calculated in spreadsheet form in Figure 9a, alongside the causal representation of the MAR model in Figure 9b. All additional views are shown in the Technical

Documentation. Some calculations can be more completely and explicitly captured using the system dynamics representation; however, there are also instances where the repetitive nature of the calculations requires a more confusing and crowded structural representation.

Figure 9a Proportional Rollback Model spreadsheet # 2, used to calculate land emissions for the 24-hour value

Acres of Vacant Land	Acres of Native Desert	Acres of Stabilized Land	Acres of Unstable Land	24-Hour Native Desert Emission Factor (ton/acre)	24-Hour Stabilized Land Emission Factor (ton/acre)	24-Hour Unstable Land Emission Factor (ton/acre)	Emissions from Native Desert (tons)	Emissions from Stabilized Land (tons)	Emissions from Unstable Land (tons)	Total Emissions for 24-Hour Period
85,219	31,485.00	39,882.00	13,849.00	0.0000	0.00076	0.0198	0	30.31032	274.2102	**304.52**

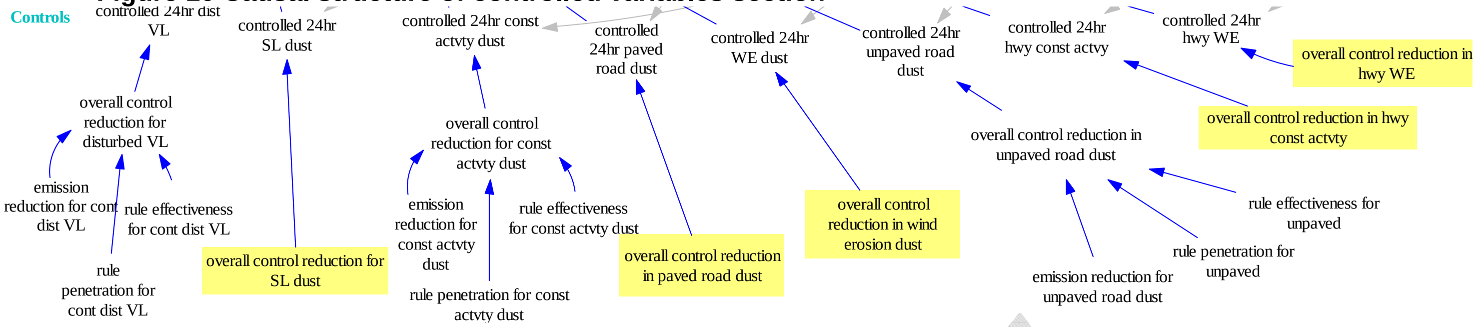
Figure 9b View #2 in MAR Model



Controlled Reduction Calculation

The percent controlled reduction used in the PM_{10} Proportional Rollback Model was listed as a final calculated reduction with no reference to the other sets of information it was derived from. In order to make the controls section as comprehensive as possible, these controls were traced back to their original sources in the SIP. For reduction values which were consistent in all references, the variable was broken out and calculated in the model. If there was any discrepancy between the sources, the reduction value used in the PM_{10} Proportional Rollback Model was used as a constant. The structure representing these changes is shown for the 24-hour Standard in Figure 10. The variables highlighted in yellow show some discrepancy from other sources, further described in the section on controls in the Discussion.

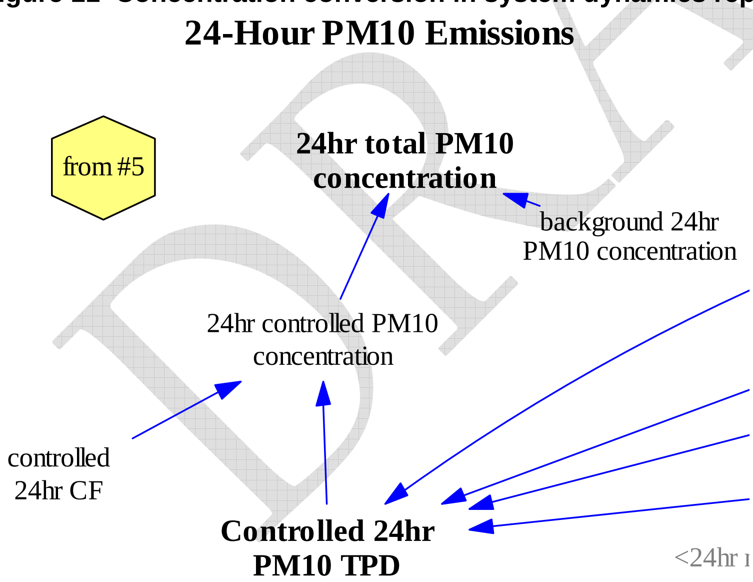
Figure 10 Causal structure of controlled variables section



Concentration Conversion

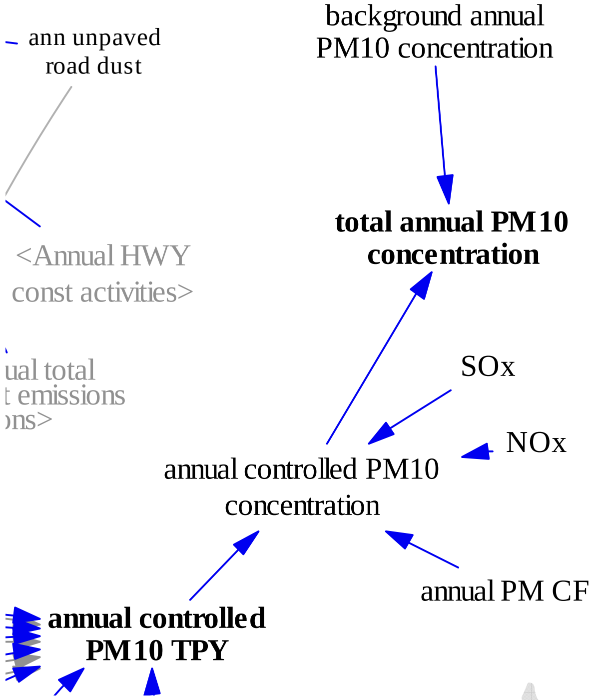
In the Proportional Rollback Model, the concentration of PM_{10} was derived by dividing every source by the total tons of mass emissions. This gives a relative percent contribution of total emissions for every source. This relative contribution was then multiplied by the desired or design concentration to allocate emissions. However, in the system dynamics representation, we instead defined a conversion factor for both the annual and the 24-hour standards to allow a direct conversion from mass PM_{10} in tons to PM_{10} concentration in micrograms per cubic meter ($\mu g/m^3$). The specific values used for these conversion factors are derived in the concentration section of the Appendix (part 2). As shown in Figure 11, the controlled mass emission total is multiplied by the conversion factor to determine a concentration. Background levels are then added to the concentration to determine the final concentration.

Figure 11 Concentration conversion in system dynamics representation



Calculations for the annual standard differ slightly in that they first add in values for nitrous oxides (NOx) and sulfurous oxides (SOx) depicted in Figure 12, which are not calculated specifically within this model.

Figure 12 Conversion to concentration for annual emissions



Results and Validation to PM_{10} Proportional Rollback Model

The results of the MAR model are shown in Figure 13 for the 24-hour standard (a) and the annual standard (b).

Figure 13a 24-hour Emissions Results

24-hour Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total __________		
Stationary Area Sources		
Disturbed VL Dust	230.65	64.42
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	25.43	1.02
Construction Activity Fugitive Dust	28.45	9.05
Windblown Construction Dust	63.15	27.15
Nonroad Mobile Sources		
Total __________		
Onroad Mobile Sources		
trackout emissions	1.72	1.72
excludes Paved Road Dust		
Hwy Construction Activites	3.42	1.58
Hwy Construction Wind Erosion	5.04	2.22
____		
Total 24hr PM10 Emissions	587.34	254.08
controlled 24Hr concentration		121.96
background concentration		10.5
Total 24Hr PM10 concentration		**132.46**

Figure 13b Annual Emissions Results

Annual Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	30171.34	8426.25
Native Desert Land Dust	2300.10	2300.10
Stabilized VL Dust	3312.25	3312.25
Construction Activity Fugitive Dust	10384.45	3301.43
Windblown Construction Dust	8261.10	2367.30
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	298.59	298.59
excludes Paved Road Dust		
Hwy Construction Activites	1250.05	462.52
Hwy Construction Wind Erosion	658.92	191.09
Total Annual PM10 Emissions	136067.63	79298.33
	before Nox and SOx	
Controlled Annual concentration		20.45
background concentration		15.75
Total Annual PM10 concentration		**36.20**

To validate the model, the resulting output was compared to the Proportional Rollback Model spreadsheet values. Table 1a shows the comparison of land acres remaining in each category with less than one percent difference in values. Table 1b shows the final calculations for all categories for both the Annual and 24-hour standards. The extra information below the annual PM_{10} is required to incorporate the nitrous oxides and sulfurous oxides, not calculated in the specific spreadsheets translated here, to obtain a total mass emissions value. The 2006 values in the final spreadsheet (#9) are shown to the left of the MAR model results for comparison purposes.

Table 1a Validation of Acres of Land Results from MAR model

Spreadsheet-original boundary only				MAR Model						
YEAR	**Acres of Native Desert (Annual)**	**Acres of Stabilized (24hr & annual stds)**	**Acres of Unstable Land (24hr & annual stds)**	**Time (Year)**	**Native Desert**	**Stable Land**	**Unstable Land**	% diff- ND	% diff- SL	% diff- UL
1998	113,801.55	54,666.21	18,718.90	1998	113801.55	54666.30	18718.90	0.00%	0.00%	0.00%
1999	100,127.06	51,006.11	17,498.86	1999	100127.05	51006.20	17498.87	0.00%	0.00%	0.00%
2000	80,649.06	51,006.11	17,498.86	2000	80649.23	51006.20	17498.87	0.00%	0.00%	0.00%
2001	67,982.58	46,882.85	16,124.45	2001	67982.56	46883.08	16124.49	0.00%	0.00%	0.00%
2002	52,380.01	43,023.36	14,837.95	2002	52380.57	43023.16	14837.85	0.00%	0.00%	0.00%
2003	42,623.36	40,299.94	13,930.14	2003	42624.30	40299.79	13930.06	0.00%	0.00%	0.00%
2004	33,802.29	37,837.67	13,109.39	2004	33803.04	37837.41	13109.27	0.00%	0.00%	0.00%
2005	25,677.68	35,569.81	12,353.43	2005	25679.20	35569.71	12353.37	0.01%	0.00%	0.00%
2006	18,110.05	33,457.43	11,649.31	2006	18111.00	33457.11	11649.17	0.01%	0.00%	0.00%

Table 1b Validation of Acres of Land Results from MAR model

	24-hour				Annual							
	modified spreadsheet-original boundary only		MAR Model Result		modified spreadsheet-original boundary only		MAR Model Result		validation to spreadsheet			
Stationary Area Sources	PM10 (TPY)	Cntrld PM10 (TPY)	unctrld	cntrld	unctrld	cntrld	unctrld	cntrld	% diff-24hr uncntrld	% diff-24hr cntrld	% diff-ann uncntrld	% diff-ann cntrld
Disturbed Vacant Lands / Unpaved Parking Lots	230.66	64.58	230.65	64.42	30171.71	8,448	30171.34	8426.25	0.00%	-0.26%	0.00%	-0.26%
Native Desert Fugitive Dust	0.00	0.00	0	0.00	2299.98	2299.98	2300.10	2300.10	-	-	0.01%	0.01%
Stablized Vacant Lands Dust	25.43	1.02	25.42	1.02	3312.29	3312.29	3312.25	3312.25	-0.03%	-0.28%	0.00%	0.00%
Construction Activity Fugitive Dust	28.45	9.10	28.45	9.05	10,384	3,323	10384.45	3301.43	0.01%	-0.64%	0.01%	-0.64%
Windblown Construction Dust	63.14	27.20	63.14	27.15	8,259	2,395	8261.10	2367.30	0.00%	-0.17%	0.03%	-1.16%
Onroad Mobile Sources												
Hwy Construction Activites	3.42	1.57	3.42	1.58	1,250	463	1250.05	462.52	0.14%	0.49%	0.00%	0.00%
Hwy Construction Wind Erosion	5.04	2.22	5.04	2.22	659	191	658.92	191.09	0.01%	-0.18%	-0.01%	-0.01%
Total PM10 Emissions	**584.02**	**254.43**	**587.34**	**254.08**	**136,061**	**114,328**	**136405.98**	**79298.00**	0.57%	-0.14%	0.25%	-0.06%
							sox and nox	**34962.655**				
							total	**114260.66**				

The percent difference of model results from values in the spreadsheets is shown for each category on the right. Results for total emissions differ slightly, due in part to rounding and the addition of explicit values for controls. For variables which were not calculated within the particular spreadsheets translated here, their values (from the final spreadsheets, #5 and #9) were made into explicit variables which condense all itemized sources. For example, in the final spreadsheet, various stationary point sources are listed, such as "sand and gravel operations" and "industrial processes", but these are not calculated in the included Proportional Rollback spreadsheets. Therefore, in the MAR model, all of these detailed items are collapsed into one variable ("stationary point sources") representing the entire category. These variables are unsurprisingly static because they use only the value for the year 2006 from the spreadsheet, which is calculated and documented elsewhere in the SIP.

Table 2 Concentration Validation

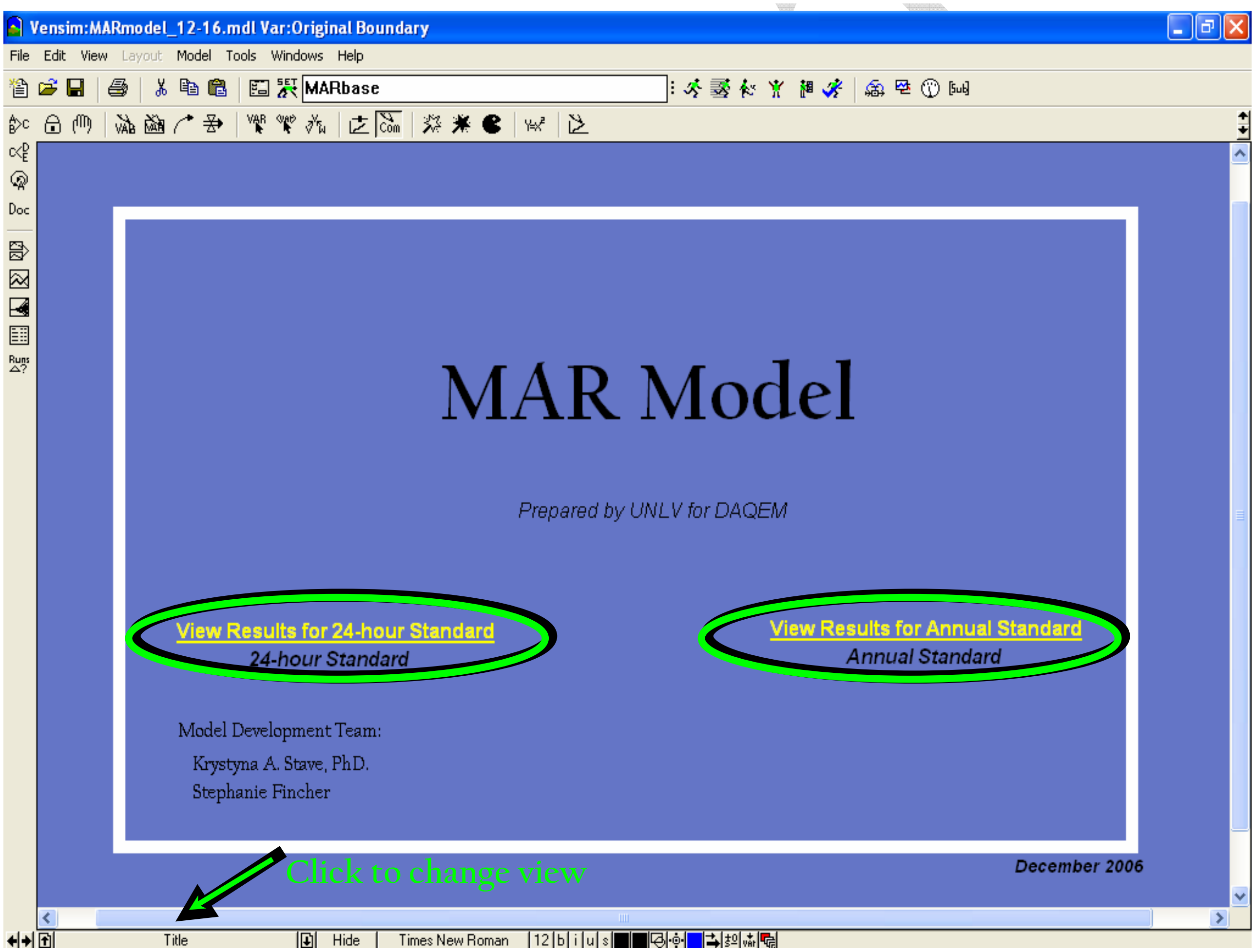
24-hour	Spreadsheet	MAR Model
controlled 24Hr concentration	**128.60**	121.96
Background concentration	10.5	10.5
Total 24Hr PM10 concentration	**139.10**	132.46
Annual		
Controlled Annual concentration	**21**	20.72
Background concentration	**15.75**	15.75
Total Annual PM10 concentration	**37**	36.47

Concentration values are shown in Table 2. The differences in concentrations are due both to rounding of the conversion factor, as described above and, for the 24-hour standard, smaller numbers overall lead to greater variations. As Table 1b shows, the variation between each individual calculation is less than one percent, so the largest impact occurs when converting the mass emissions into concentrations.

How to Use the MAR Model

The model files will need to be opened in either the Vensim® Reader (Ventana Systems, 2006) application or a complete version of the program. Files either use the *.vmf or *.mdl extension and are named according to the specific model (MAR or UpdatedMAR) as well as the date. The software uses a graphical user interface to allow easier maneuverability throughout the model. Figure 14 shows the title screen which will appear when the model is opened. To view the results of the model, click on either the 24-hour standard or Annual standard link (circled below). To ease model use, the specific causal structure and calculations are hidden, but can still be accessed manually, by pressing the **Page Up**, **Page Down** buttons or selecting the view icon in the lower left-hand corner of the screen.

Figure 14 MAR Model title screen

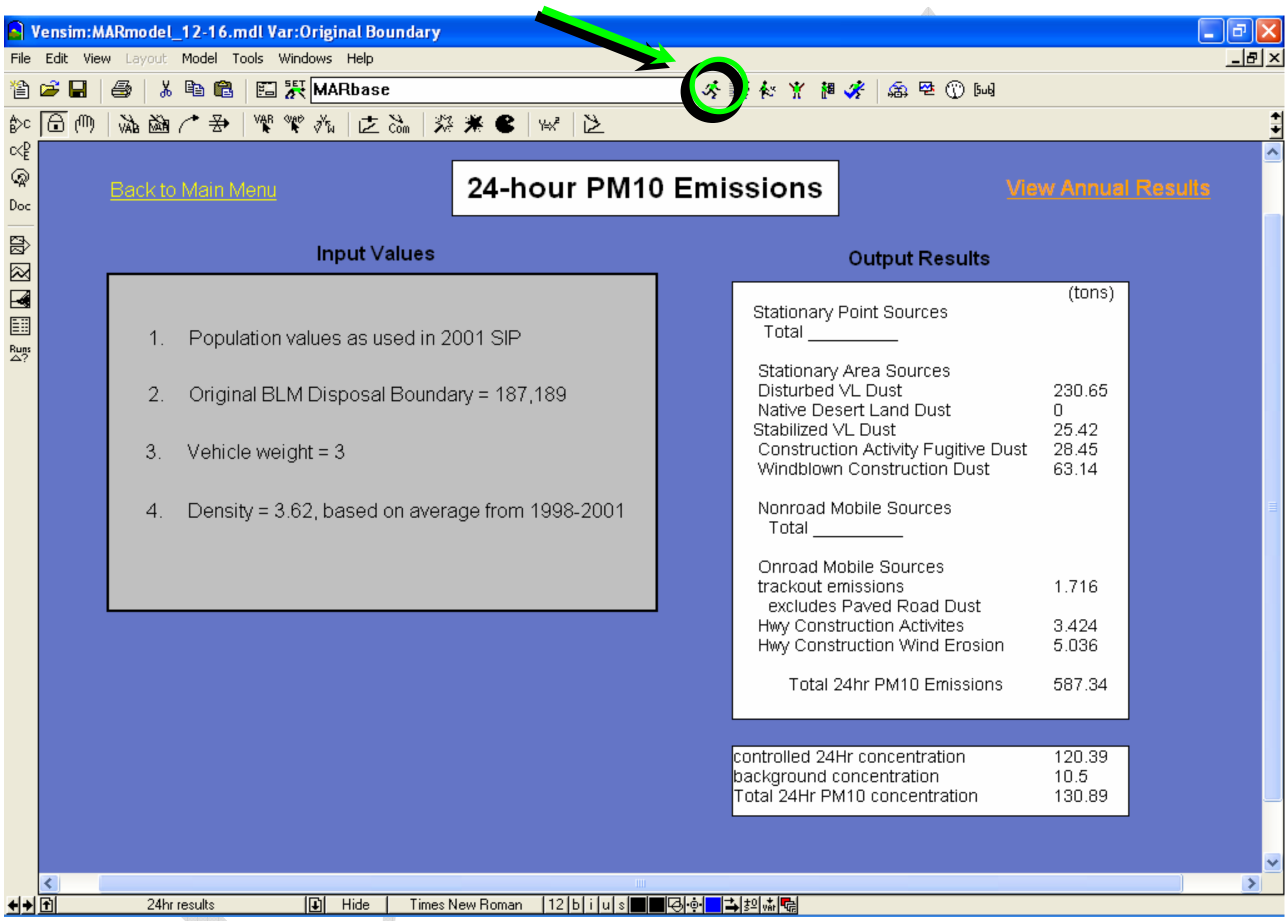


The two standards follow the same steps in order to display graphs and export data. Details described in the following sections are specific to 24-hour emissions, but can be applied to the annual emissions.

Viewing Emissions

The emissions screen, shown in Figure 15, is divided into two parts. Input values are shown on the left and the resulting output (emissions) on the right. The key parameter values used in the current simulation are listed in the grey box. To run the simulation, click on the running man icon (circled below). The name listed in the white box to the left (currently says "MARbase") of this icon will be the name saved and displayed on all graphs. The output table, currently set to the controlled values will be updated automatically.

Figure 15 24-hour emissions screen



Exporting Results

To export the output from the built-in output table to another program, you must open the table file in the control panel. Click on the control panel icon in the top toolbar as shown in Figure 16. It does not matter which screen is currently active; the control panel can be accessed from all views.

Figure 16 Control panel icon

The control panel interface, Figure 17, will appear. Select the Graphs tab if it is not already selected. The tables are organized according to the standard, either 24-hour (prefix of "24hr") or annual ("ann"). From the list of tables, select from the tables for the mass contribution ("sources"), controlled or uncontrolled, or the calculation of the concentration ("totals"). After the desired graph is selected, select the Display.

Once the graph displays, click on the export button (circled below in Figure 18) on the top left side of the toolbar. Next, open the program you want to bring the data into, such as a spreadsheet or a word processing program, and follow the paste procedures for the chosen program.

Figure 17 Control panel interface

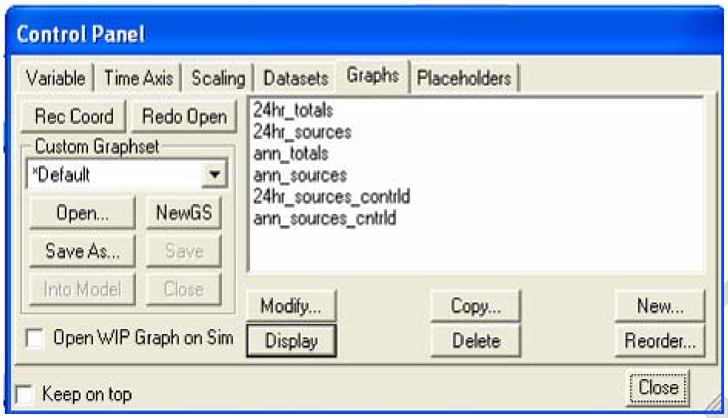
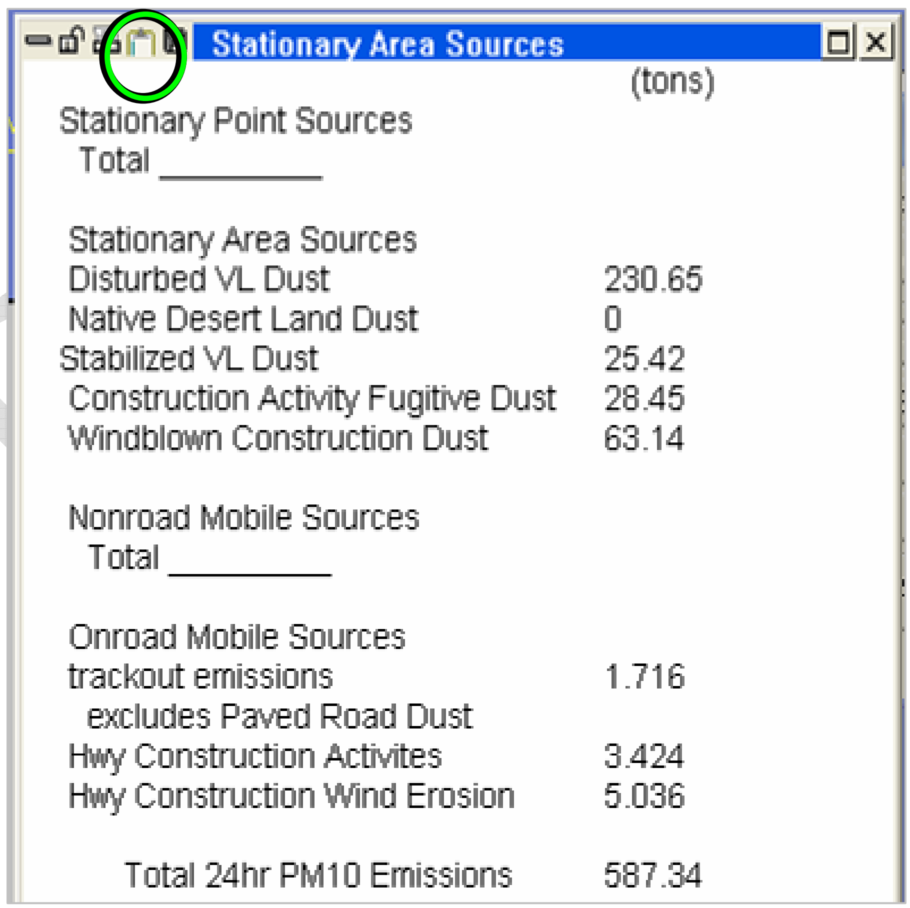
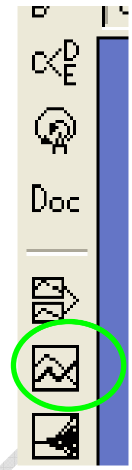


Figure 18 Floating graph window



Graphing Variables as Trends Over Time

Figure 19 Graph icon on left toolbar



To see a variable as a behavior over time graph, double-click on the variable of interest within the table (either the built-in table on the screen or one opened from the control panel). The selected variable will then be listed in the program toolbar as "Vensim: modelfilename.mdl var: Selected Variable," (for example, the topmost bar on the screen in Figure 15 shows that the variable "Original Boundary" was selected). Next, click on the graph icon on the left-hand side of the screen, shown in Figure 19 to display the graph. Once the graph displays, it can be copied or exported in the same fashion as the table above. Notice that the output line in Figure 20 is labeled in the key at the bottom of the screen with the same name that is shown in the white box at the top of the screen ("MARbase").

Figure 20 Graph over time of selected variable

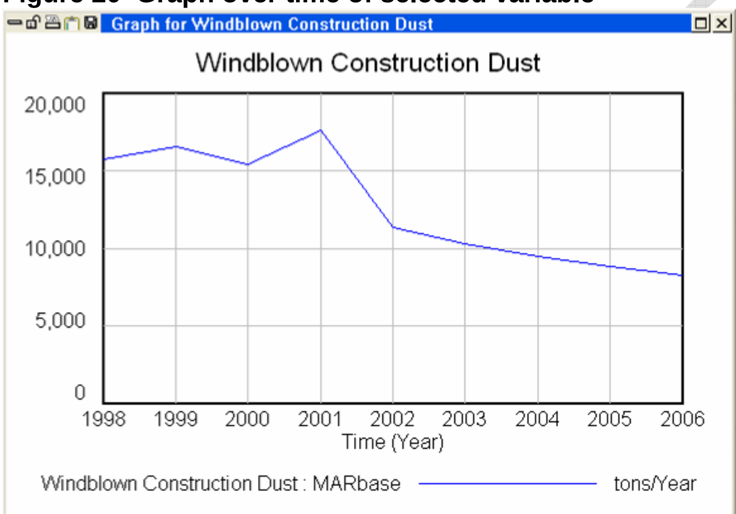
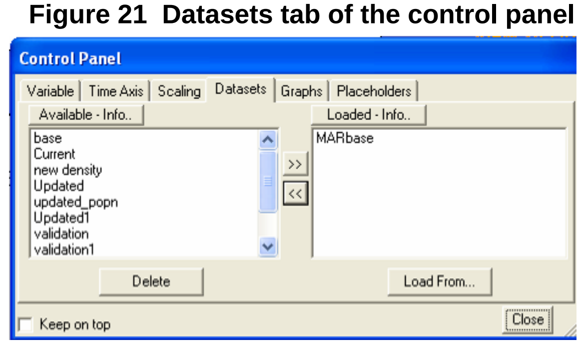


Figure 21 Datasets tab of the control panel



To remove extra names from this key, simply access the control panel, and select the Datasets tab. The dataset window is shown in Figure 21. Choose the dataset you wish to remove and select the "**<<**" button to move it out of the active datasets (right window) and into the available datasets. To delete this dataset, you must then select the dataset from the window on the left and press the Delete button. This process also works in reverse to load previous runs. You do not have to rerun a previous simulation manually but can simply load datasets from the inactive/available window (left) by selecting one or more files and pressing the "**>>**" button. To select individual files hold the **ctrl** button on your keyboard, or to select a range, hold the **shift** key.

The Vensim Help files contain information on how to use other features of the Vensim software.

Updated MAR Model Development

Modifications from MAR

The Updated MAR model uses the same basic structure as the MAR model described in the preceding sections. Deviations from the MAR model occur only where the following variables were updated: 1) Population, 2) Disposal boundary acres, 3) Average vehicle weight, and 4) Density. Structural changes were made to expand the population and disposal boundary, but all other updates were made by simply changing the values of the given parameters.

Population

Population data, used previously in the PM_{10} Proportional Rollback Model, are shown in the two rightmost columns in Figure 22. The population values used in the Updated MAR model are shown in the fifth column of the table, under the heading Las Vegas Valley. For projections beyond 2005, the population estimates for the entire county (CBER 2006) are multiplied by the average share of the county population made up by the Las Vegas Valley (96.07%), circled below in Figure 22.

Figure 22 Comparison of population data from Clark County Comprehensive Planning (2005)

Historic Population and Growth Rates
Clark County / Las Vegas Valley
(1990-2005)

	Clark County			*Las Vegas Valley*			
Year	**Population**	**Added Population**	***Growth Rate***	**Population**	**Added Population**	***Growth Rate***	***Share of County Population***
1990	797,142	-	-	764,464	-	-	95.90%
1991	829,839	32,697	4.10%	794,622	30,158	3.94%	95.76%
1992	870,692	40,853	4.92%	834,446	39,824	5.01%	95.84%
1993	919,388	48,696	5.59%	880,716	46,270	5.54%	95.79%
1994	986,152	66,764	7.26%	945,620	64,904	7.37%	95.89%
1995	1,040,688	54,536	5.53%	998,254	52,634	5.57%	95.92%
1996	1,119,708	79,020	7.59%	1,074,362	76,108	7.62%	95.95%
1997	1,170,113	50,405	4.50%	1,123,932	49,570	4.61%	96.05%
1998	1,246,193	76,080	6.50%	1,195,376	71,444	6.36%	95.92%
1999	1,321,319	75,126	6.03%	1,266,680	71,304	5.96%	95.86%
2000	1,428,690 *	107,371	8.13%	1,366,916 *	100,236	7.91%	95.68%
2001	1,498,279 *	69,589	4.87%	1,445,791 *	78,875	5.77%	96.50%
2002	1,578,332 *	80,053	5.34%	1,522,117 *	76,326	5.28%	96.44%
2003	1,641,529 *	63,197	4.00%	1,583,172 *	61,055	4.01%	96.44%
2004	1,747,025 *	105,496	6.43%	1,685,197 *	102,025	6.44%	96.46%
2005	1,815,700 *	68,675	3.93%	1,752,240 *	67,043	3.98%	96.50%
Average	**-**	**67,904**	**5.65%**	**-**	**65,852**	**5.69%**	**96.07%**

Source: Clark County Department of Comprehensive Planning
Note: Local estimates of July 1 resident population based on housing methods.
* Southern Nevada Regional Planning Coalition Consensus Population Estimate began in 2000.

Values used in Rollback spreadsheet

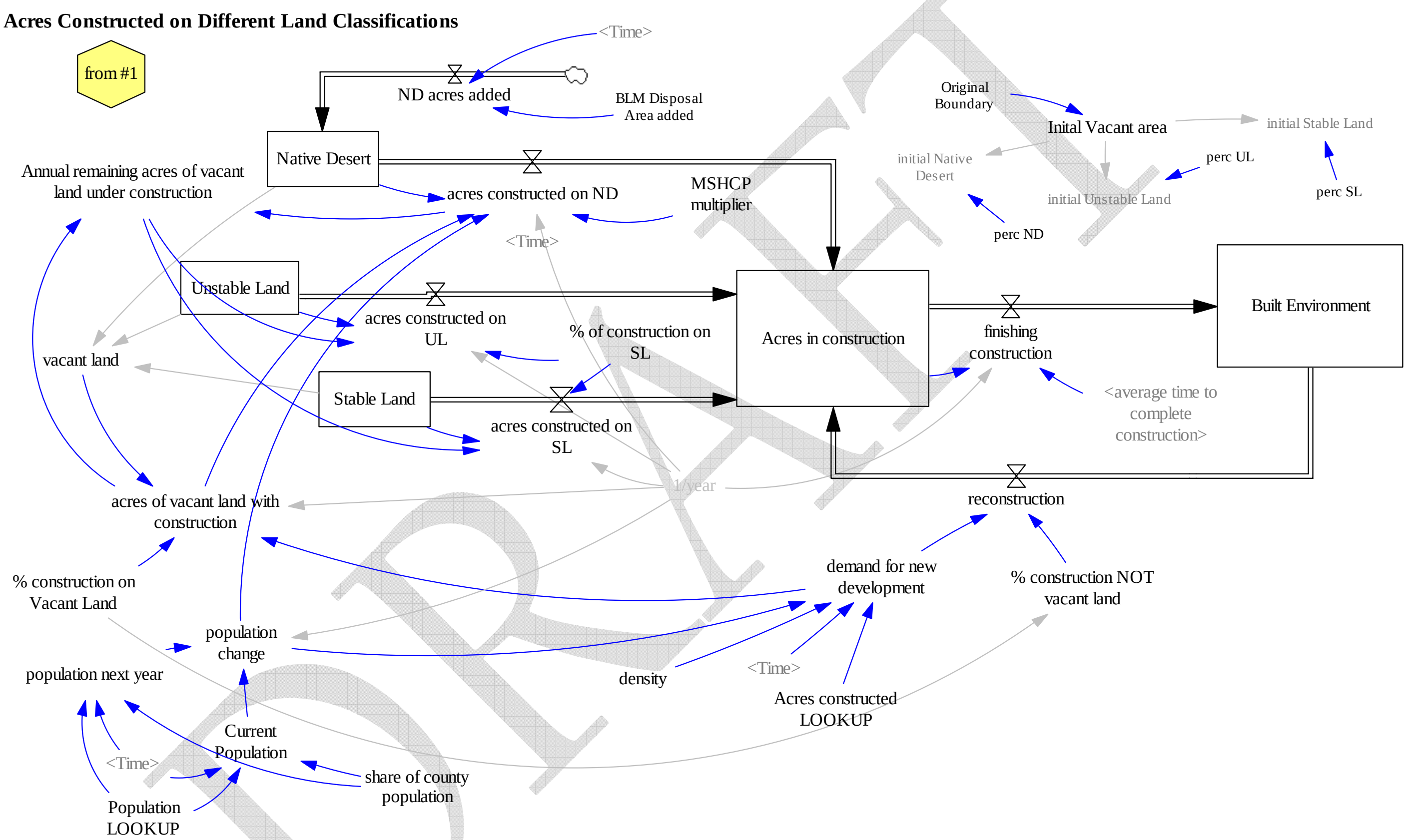
	Population (RTC)	**Change in Population**
1998	1,183,883	71,370
1999	1,255,253	102,003
2000	1,357,256	66,109
2001	1,423,365	81,433
2002	1,504,798	50,922
2003	1,555,720	46,039
2004	1,601,759	42,404
2005	1,644,163	39,497
2006	1,683,660	36,997
2007	1,720,657	

The addition of this calculation is represented explicitly in the new structure of the UpdatedMAR model, as shown in the lower left of Figure 23 as the variable "share of county population."

Disposal Boundary

In the MAR and PM_{10} Proportional Rollback models, the Bureau of Land Management (BLM) disposal boundary area was 187,189 acres. For the Updated MAR model, this value was modified to include the additional 26,440 acres to be included in the calculated particulate matter emissions. These acres were considered entirely part of the Native Desert classification and so the structure in the land view was slightly modified to represent this one-time flow of land in 2003. Figure 23 shows the new flow being added to the stock, “Native Desert.” The amount of acres can be changed by the user and the model will automatically add in the specified acres in the year 2003.

Figure 23 New Structural Representation of Land View (#1)



Vehicle Weight

Based on a report by DAQEM (2006), the average vehicle fleet weight was reduced to 2.4 tons from the previous default value of 3 tons. This parameter is used in the calculation of construction trackout emissions. In the original model, a variable called average daily traffic was the only variable tracked. This value was set at 10,000 vehicles, but there was no calculation using vehicle weight (and units were not explicitly defined). Vehicle weight previously had no effect, as the product of vehicle weight times average daily traffic is divided by 3. The formula used to derive trackout emissions is described in further detail in the Discussion.

Density

The value for density used in the Proportional Rollback spreadsheet was based on only three years of historic data from 1998 to 2001 (one year, 1999, was excluded). This gave a density of 3.63 persons/acre. However, because density has not remained constant throughout this time the Updated MAR allows the user to change the value for density. In the policy analysis here, density was doubled to 7.26 persons/acre, although meeting notes and data from Clark County Comprehensive Planning support a value for density up to as far as 14 persons/acre.

Results

The results for the changes described above are demonstrated in compilation, starting with updating the population values to the newer information and adding each change in succession. The results of changing population information are shown in Table 3. Annual Native Desert Land Dust is zero because by the year 2006, the model calculates that all Native Desert acres have been constructed.

Table 3 Results of Updating Population Values Only

24-hour Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total __________		
Stationary Area Sources		
Disturbed VL Dust	55.71	15.56
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	5.28	0.21
Construction Activity Fugitive Dust	63.53	20.20
Windblown Construction Dust	141.02	60.64
Nonroad Mobile Sources		
Total __________		
Onroad Mobile Sources		
trackout emissions	3.83	3.83
excludes Paved Road Dust		
Hwy Construction Activites	7.65	3.52
Hwy Construction Wind Erosion	11.25	4.95
Total 24hr PM10 Emissions	517.76	255.24
controlled 24Hr concentration		122.51
background concentration		10.50
Total 24Hr PM10 concentration		**133.01**

Annual Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total __________		
Stationary Area Sources		
Disturbed VL Dust	7287.29	2035.19
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	688.10	688.10
Construction Activity Fugitive Dust	23190.09	7372.59
Windblown Construction Dust	18448.32	5286.55
Nonroad Mobile Sources		
Total __________		
Onroad Mobile Sources		
trackout emissions	666.79	666.79
excludes Paved Road Dust		
Hwy Construction Activites	2791.56	1032.88
Hwy Construction Wind Erosion	1471.48	426.73
Total Annual PM10 Emissions	133974.44	76099.77
Controlled Annual concentration		19.88
background concentration		15.75
Total Annual PM10 concentration		**35.63**

Combining these new population values with the updated vehicle weight gives the results shown below in Table 4.

Table 4 Results for Updated MAR—Population Values and Vehicle Weight

24-hour Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	55.71	15.56
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	5.28	0.21
Construction Activity Fugitive Dust	63.53	20.20
Windblown Construction Dust	141.02	60.64
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	3.07	3.07
excludes Paved Road Dust		
Hwy Construction Activites	7.65	3.52
Hwy Construction Wind Erosion	11.25	4.95
Total 24hr PM10 Emissions	516.99	254.69
controlled 24Hr concentration		122.25
background concentration		10.50
Total 24Hr PM10 concentration		**132.75**

Annual Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	7287.29	2035.19
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	688.10	688.10
Construction Activity Fugitive Dust	23190.09	7372.59
Windblown Construction Dust	18448.32	5286.55
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	533.43	533.43
excludes Paved Road Dust		
Hwy Construction Activites	2791.56	1032.88
Hwy Construction Wind Erosion	1471.48	426.73
Total Annual PM10 Emissions	133841.08	75983.76
Controlled Annual concentration		19.86
background concentration		15.75
Total Annual PM10 concentration		**35.61**

The next change was updating the disposal boundary area to include an additional 26,440 acres of BLM land. The results of adding these acres to the previous changes are shown in Table 5. Although additional acres are added in 2003 to the Native Desert category, they are still constructed by the final year thus they do not contribute to emissions.

Table 5 Results of UpdatedMAR—Population, Vehicle Weight, and BLM Acres

24-hour Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	187.63	52.40
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	20.31	0.81
Construction Activity Fugitive Dust	63.53	20.20
Windblown Construction Dust	141.02	60.64
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	3.07	3.07
excludes Paved Road Dust		
Hwy Construction Activites	7.65	3.52
Hwy Construction Wind Erosion	11.25	4.95
Total 24hr PM10 Emissions	663.94	292.14
controlled 24Hr concentration		140.23
background concentration		10.50
Total 24Hr PM10 concentration		**150.73**

Annual Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	24543.29	6854.45
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	2646.03	2646.03
Construction Activity Fugitive Dust	23190.09	7372.59
Windblown Construction Dust	18448.32	5286.55
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	533.43	533.43
excludes Paved Road Dust		
Hwy Construction Activites	2791.56	1032.88
Hwy Construction Wind Erosion	1471.48	426.73
Total Annual PM10 Emissions	153055.02	82760.94
Controlled Annual concentration		21.07
background concentration		15.75
Total Annual PM10 concentration		**36.82**

Doubling the density in addition to the above changes gives the results in Table 6. The greater density causes land to be consumed slower, which means that there are still Native Desert acres remaining in 2006.

Table 6 Results of UpdatedMAR—Population, Vehicle Weight, BLM Acres, and Double Density

24-hour Emissions

(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	299.64	83.68
Native Desert Land Dust	0.00	0.00
Stabilized VL Dust	33.37	1.33
Construction Activity Fugitive Dust	31.77	10.10
Windblown Construction Dust	70.51	30.32
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	1.53	1.53
excludes Paved Road Dust		
Hwy Construction Activites	3.82	1.76
Hwy Construction Wind Erosion	5.62	2.47
________________________________		
Total 24hr PM10 Emissions	675.76	278.20
controlled 24Hr concentration		133.54
background concentration		10.50
Total 24Hr PM10 concentration		**144.04**

Annual Emissions

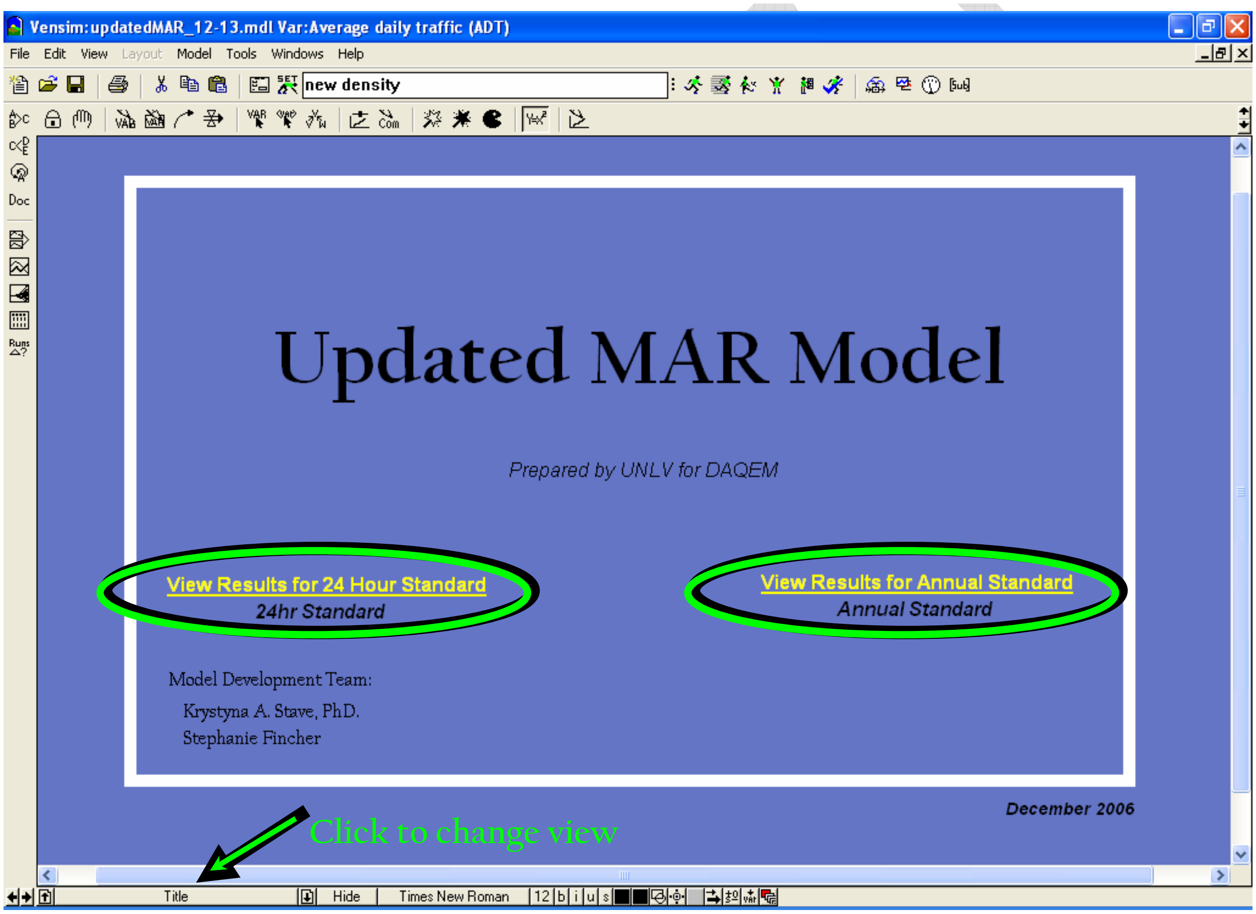
(tons)	uncontrolled	controlled
Stationary Point Sources		
Total _________		
Stationary Area Sources		
Disturbed VL Dust	39195.65	10946.56
Native Desert Land Dust	3479.73	3479.73
Stabilized VL Dust	4347.09	4347.09
Construction Activity Fugitive Dust	11595.05	3686.30
Windblown Construction Dust	9224.16	2643.28
Nonroad Mobile Sources		
Total _________		
Onroad Mobile Sources		
trackout emissions	266.72	266.72
excludes Paved Road Dust		
Hwy Construction Activites	1395.78	516.44
Hwy Construction Wind Erosion	735.74	213.36
Total Annual PM10 Emissions	149670.72	84742.41
Controlled Annual concentration		21.43
background concentration		15.75
Total Annual PM10 concentration		**37.18**

Additional policy tests can be simulated following the instructions in the following section.

How to Use the Updated MAR Model

The model files will need to be opened in either the Vensim Reader application or a complete version of the program. Files either use the *.vmf or *.mdl extension and are named according to the specific model (MAR or UpdatedMAR) as well as the date. The software uses a graphical user interface to allow easier maneuverability throughout the model. Figure 24 shows the title screen which will appear when the model is opened. To view the results of the model, click on either the 24-hour standard or Annual standard link (circled below). To ease model use, the specific causal structure and calculations are hidden, but can still be accessed manually, by pressing the **Page Up**, **Page Down** buttons or selecting the view icon in the lower left-hand corner of the screen.

Figure 24 Updated MAR Model title screen

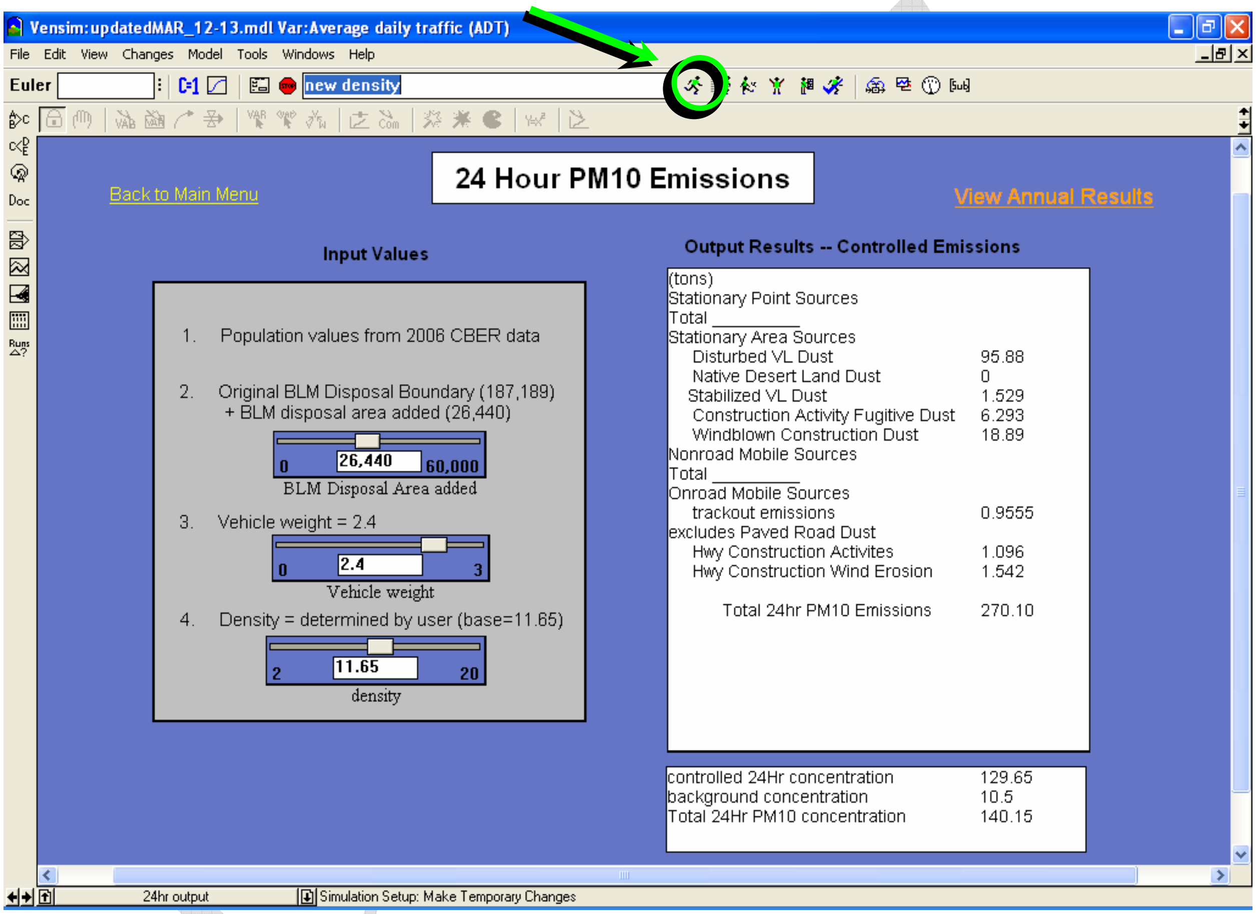


The two standards follow the same steps in order to display graphs and export data. Details described in the following sections are specific to 24-hour emissions, but can be applied to the annual emissions.

Viewing Emissions

The emissions screen, shown in Figure 25, is divided into two parts. Input values are shown on the left and the resulting output (emissions) on the right. The key parameter values used in the current simulation are listed in the grey box, along with several slider bars. To run the simulation with updated values for these variables, click on the running man icon (circled in Figure 25). The name listed in the white box to the left of this icon (which reads “new density” in Figure 25) will be the name saved and displayed on all graphs. The controlled emissions output table, currently set to the default values will be updated automatically.

Figure 25 24-hour emissions screen



What happens when a slider bar is moved?

Moving a slider bar changes the value of an input variable from the default value (displayed when the “set” button is selected, to the left of the white simulation name box) to a new user-defined value. When the “run” button is selected again, the model simulates the changes in the behavior and refreshes the output table.

For any simulation, the following variables may be changed:

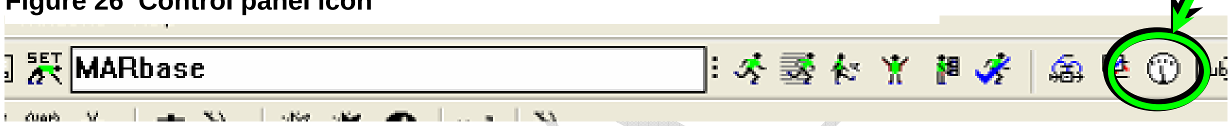
BLM Disposal Area added	This value can be changed to incorporate additional acres into the disposal area.

Vehicle Weight	The average vehicle weight can be modified between its previous value in the MAR Model of 3 and a value of zero (although a zero weight is not realistic, it can be used to test an extreme case).
Density	The population density of the valley in persons/acre can be changed by the user. The original value used in the MAR Model is 3.63. The default value listed here is based on the amount of acres constructed, using Clark County Comprehensive Planning acres constructed and population estimates to determine density.

Exporting Results

To export the output from the built-in output table to another program, you must open the table file in the control panel. Click on the control panel icon in the top toolbar as shown in Figure 26. It does not matter which screen is currently active; the control panel can be accessed from all views.

Figure 26 Control panel icon



The control panel interface, Figure 27, will appear. Select the Graphs tab if it is not already selected. The tables are organized according to the standard, either 24-hour (prefix of "24hr") or annual ("ann"). From the list of tables, select from the tables for the mass contribution ("sources"), controlled or uncontrolled, or the calculation of the concentration ("totals"). After the desired graph is selected, select the Display.

Once the graph displays, click on the export button (circled below in Figure 28) on the top left side of the toolbar. Next, open the program you want to bring the data into, such as a spreadsheet or a word processing program, and follow the paste procedures for the chosen program.

Figure 27 Control panel interface

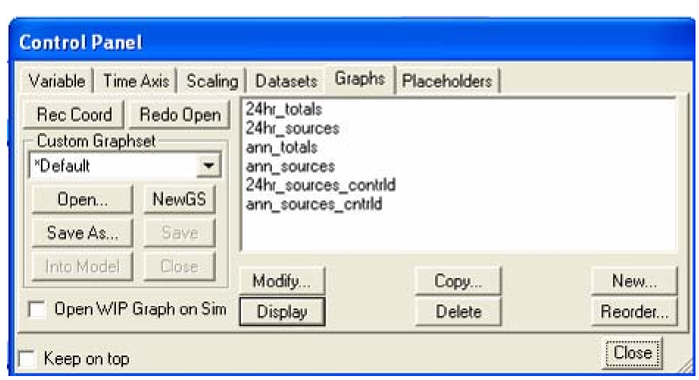


Figure 28 Floating graph window

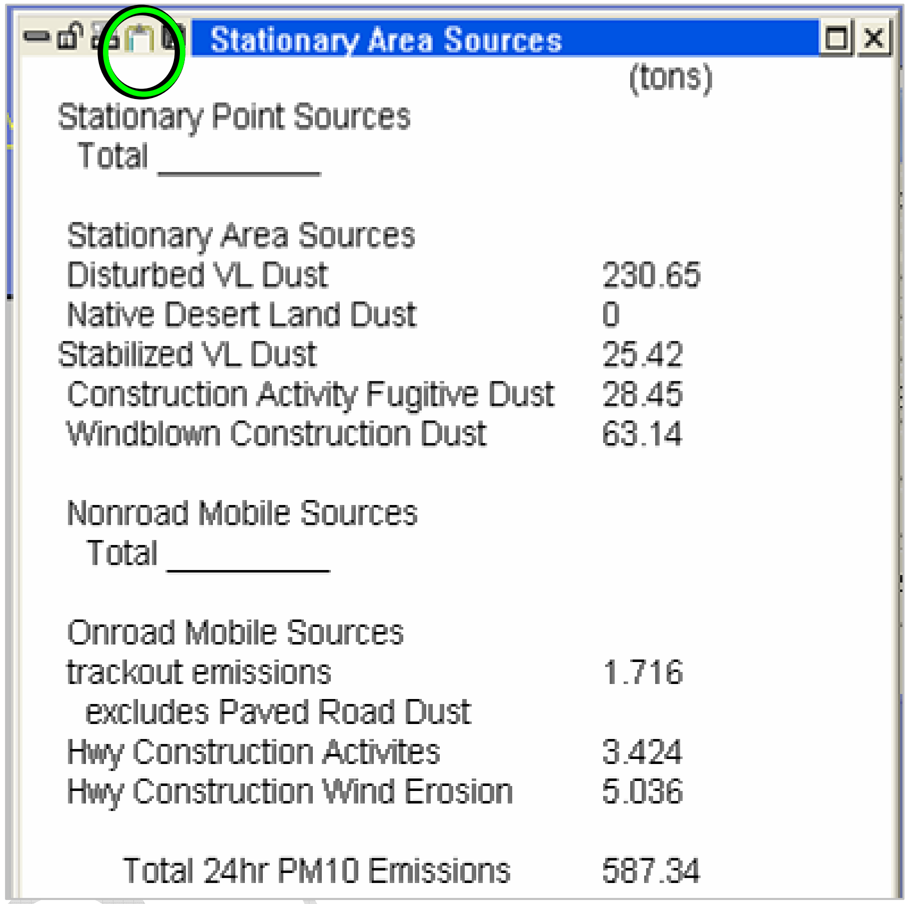
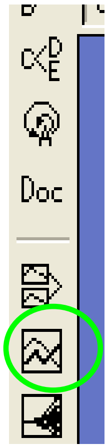


Figure 29 Graph icon on left toolbar



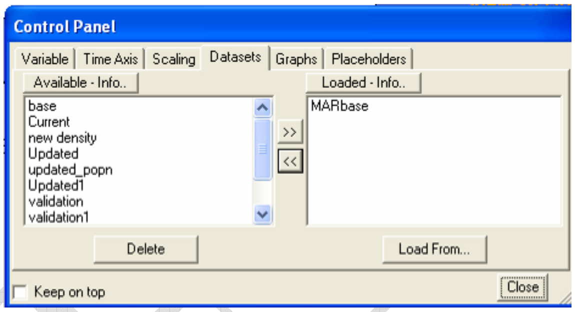
Graphing Variables as Trends Over Time

To see a variable's values as a graph, double-click on the variable of interest within the table (either the built-in table on the screen or one opened from the control panel). The selected variable will then be listed in the program toolbar as "Vensim: modelfilename.mdl var: Selected Variable," (for example, the topmost bar in Figure 26 shows the selected variable "Average Daily Traffic (ADT)"). Next, click on the graph icon on the left-hand side of the screen, shown in

Figure 29 to display the graph. Once the graph displays, it can be copied or exported in the same fashion as the table above.

All graphs will show the behavior of the selected variable, labeled by the name listed in the white simulation name box at the upper part of the screen. After several runs have been simulated, the graphs may start to look busy, with an extensive list of simulation names in the legend or key of the graph.

Figure 30 Datasets tab of the control panel



To remove extra names from this key, simply access the control panel, and select the Datasets tab. The dataset window is shown in Figure 30. Choose the dataset you wish to remove and select the "**<<**" button to move it out of the active datasets (right window) and into the available datasets. To delete this dataset, you must then select the dataset from the window on the left and press the Delete button. This process also works in reverse to load previous runs. You do not have to rerun a previous simulation manually but can simply load datasets from the inactive/available window (left) by selecting one or more files and pressing the "**>>**" button. To select individual files hold the **ctrl** button on your keyboard, or to select a range, hold the **shift** key.

The Vensim Help files contain information on how to use other features of the Vensim software.

Discussion

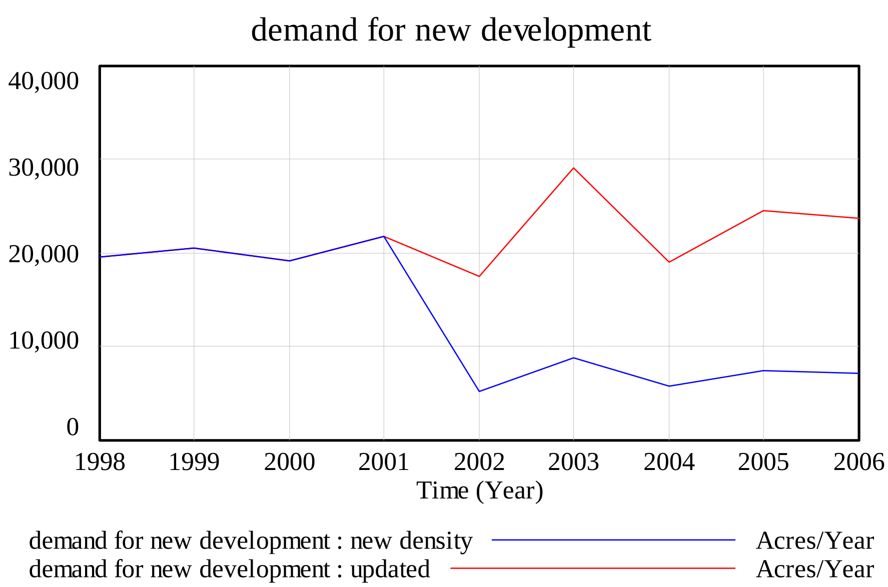
The process of translating these spreadsheets has led to a number of observations about variables and key assumptions within the model. These questions will ultimately need to be answered or addressed in order to improve the consistency of the methodology. The major issues needing to be addressed include:

1. What value of population density to use in the model
2. Discrepancies between the number of acres constructed per year reported by DAQEM and the Clark County Department of Comprehensive Planning
3. Difficulties in interpreting spreadsheets
    - variable naming conventions, as in the terms “controlled acres” versus “stabilized acres”
    - inconsistencies/errors in formulas
4. Potential double-counting of emission controls
5. Problems with the trackout emissions calculation

Density

The value of population density determined in the December 8, 2006 meeting with DAQEM (11.65 persons/acre) is so high that it underestimates the land acres constructed and significantly reduces emissions when used in the Updated MAR model. The previous value for density was 3.63 people/acre and the value used for policy analysis was only 7.26 (double the original density) in order to be conservative. The graph of acres constructed in a given year (called “demand for new development” in the model), is shown in **Error! Reference source not found.**Figure 31 and is calculated based on the population change and population density. The top line is the number of acres constructed using a density of 3.63 people/acre and the bottom line is the number of acres constructed using a density of 11.65 people/acre. These graphs should be compared to the number of acres actually constructed in the indicated years (see following section). If the drop in acres constructed does not reflect historic values, it would be greatly underestimating emissions.

Figure 31 Comparison of acres constructed for different density values



Acres Constructed

The number of acres constructed reported by the DAQEM are significantly different from the acres added to development reported by Clark County Comprehensive Planning (CCCP, 2004). DAQEM's numbers are greater than the CCCP (2004) values by an average factor of 3.63, calculated using the actual data for the years 1998 through 2001. In a meeting (Dec. 8, 2006), we discussed the possibility that acres constructed according to DAQEM includes all acres which will have an effect on air quality, while CCCP may only track the additional acreage added to the "Built environment." If this is the case, then the actual numbers of acres constructed, according to DAQEM, would have to be used with historic values of population to determine a more accurate density. Otherwise, the acres constructed according to the DAQEM needs to be updated to reflect the CCCP (2004) values and emissions factors may have to be increased.

The model currently shows the movement of land from vacant status into a built environment which would imply that these acres should be the same. If more land is actually being reconstructed, then the percent of construction on vacant land could be reduced to reflect this backflow of land from previously built land into acres in construction and finally back into the built environment. Table 7 compares the acres added to the built area according to CCCP (2004, left) to what is used in the model.

Table 7 Discrepancy between DAQEM (2001) and Clark County Comprehensive Planning Acres Constructed (2004)

Year	CCCP-Development within Disposal Boundary (acres)	Proportional Rollback model (ss#1) (acres)	*multiplier (cccp*mult=acres constructed) [factor difference between values]*	Average (actual values)
1998	5,556	19,449.30	3.50	
1999	5,062	20,417.00	4.03	
2000	5,358	19,040.00	3.55	3.63
2001	6,325	21,749.00	3.44	
2002	9,465	*14033.42*	*1.48*	
2003	4,969	*12687.73*	*2.55*	
2004	3,931	*11685.97*	*2.97*	
2005	5,670	*10884.84*	*1.92*	
2006	5,811	*10195.88*	*1.75*	
2007	5,952	**calculated*		

The DAQEM values may be over-estimating acres constructed, especially considering that the calculations show Native Desert land going to zero by the year 2006. At the very least, looking at historic values for acres constructed according to DAQEM (Proportional Rollback Model spreadsheet #1) and comparing them to the values reported by CCCP (could give a better average factor of the difference. CCCP's projected acres to be constructed could then be multiplied by this factor to determine the total construction acres for the projected increase in built environment.

Interpreting Spreadsheets

Variable Naming Conventions—Controlled Versus Stabilized Acres

The spreadsheet in Figure 31 shows one of the difficulties we had interpreting the names of variables. Although the emissions are listed as stable and unstable land emissions, the way this is determined is by using the implementation rate and control effectiveness rather than the initial categorization percentages of land in each type. Therefore, the "stabilized" and "unstable" description here was interpreted to mean controlled or uncontrolled acres (different from the land classifications of stable and unstable which make up part of vacant land). Further justification for why these are not the same comes from looking at spreadsheet #1's values for acres constructed on stable or unstable land in the year 2006 and comparing that value to "acres uncontrolled" and "acres stabiized" in spreadsheet #8. Figure 32 and Figure 33 show this comparison.

Figure 32 Spreadsheet #1 selected columns for the year 2006

Year	Acres Constructed (24hr & annual stds)	Acres of Vacant Land With Construction (95.4%)	Number of Acres of Native Desert Disturbance Using the MSHCP	Number of Remaining Acres of Vacant Land with Construction	Stabilized Constructed on (24hr & annual stds)	Unstable Constructed on (24hr & annual stds)
2006	10,195.88	9,726.87	7,089	2,638	1,978.68	659.56

The total number of acres constructed on either stable or unstable land are shown in Figure 32, the values of which are significantly smaller than those shown in Figure 33. Adding the acres of uncontrolled and stabilized in Figure 33 gives 10,196 acres, corresponding to the total acre constructed in 2006 shown in the second column from the left of Figure 32.

Figure 33 Spreadsheet #8 from Proportional Rollback Model

Type of Construction	Un Ac Cons ion 19	ns r e ctio	Acres Uncontrolled	Acres Stabilized	Land Emission Rate (ton/acre/year)	Land Emission Rate (ton/acre/year)	PM10 Emissions for 2006 (tons)	Emissions from Unstable Land (tons)	Emissions from Stabilized Land (tons)	Controlled Unstable Land Emissions (tons)	Controlled PM10 Emisssions for 2006 (tons)
Airport		12	26.5	17.7	2.59	0.10	70.51	68.76	1.75	19.94	21.69
Commercial	3	3	1268.7	422.9	2.59	0.10	831.96	821.50	10.47	238.23	248.70
Flood Detention		12	59.4	32.0	2.59	0.10	157.00	153.83	3.17	44.61	47.78
Highway		12	248.0	165.3	2.59	0.10	658.66	642.29	16.37	186.26	202.63
Public Parks		6	60.0	40.0	2.59	0.10	79.66	77.68	1.98	22.53	24.51
Public Bridges		12	195.9	105.5	2.59	0.10	517.74	507.30	10.44	147.12	157.56
Public Works	1	3	386.0	207.9	2.59	0.10	255.09	249.94	5.14	72.48	77.63
Residential Homes	10	6	4150.2	1383.4	2.59	0.10	5442.93	5374.45	68.48	1558.59	1627.07
Underground Utilities		1	347.6	38.6	2.59	0.10	75.35	75.03	0.32	21.76	22.08
Miscellaneous	1	6	624.3	416.2	2.59	0.10	829.04	808.44	20.60	234.45	255.05
Total	1		7366.58	2829.42			8917.93	8779.22	138.71	2545.97	2684.69
					Without Highways		8259.28	8136.93		2359.71	2482.06

This demonstrates just one example of difficulties with naming conventions throughout this translation process. Some examples of naming changes are listed in the Appendix, for the complete listing see the Technical Documentation.

Inconsistencies

Where formulas or names differed in the spreadsheets, we interpreted them as best as possible. In some cases, spreadsheets were modified to remove the error so that validation could be preformed. One example of this is for the calculation of construction activity emissions for airports. In the specific row for this calculation, the value listed was notably out of scale with the other values. The problem was an extra calculation multiplying the percent of constructed acres going to each construction. Figure 34 shows the changed cells and the new values. Such changes made to the spreadsheets are noted in comments in the specific cells and all changed files were saved as separate files so that DAQEM can track any modifications.

Figure 34 Error in Airport Construction Activity Emissions

Type of Construction	Acres Under Active Construction in 2006	% Sites Implementing Controls	Overall Control Efficiency	Months Active Construction	PM10 Emission Rate (tons/acre/month)	PM10 Emissions for 2006 (tons)
Airport	44.25	80%	40%	12	0.42	0.6
Commercial	1,691.63	50%	25%	3	0.265	1,008.6
Flood Detention	91.38	70%	35%	12	0.42	299.3
Highway	413.31	80%	40%	12	0.42	1,249.9
Public Parks	99.94	80%	40%	6	0.265	95.3
Public Bridges	301.33	70%	35%	12	0.265	622.9
Public Works	593.86	70%	35%	3	0.42	486.4
Residential Homes	5,533.54	50%	25%	6	0.265	6,598.7
Underground Utilities	386.26	20%	10%	1	0.42	146.0
Miscellaneous	1,040.46	80%	40%	6	0.265	992.6
Total	10,196					11,500.3

Type of Construction	Acres Under Active Construction in 2006	% Sites Implementing Controls	Overall Control Efficiency	Months Active Construction	PM10 Emission Rate (tons/acre/month)	PM10 Emissions for 2006 (tons)
Airport	44.25	80%	40%	12	0.42	133.8
Commercial	1,691.63	50%	25%	3	0.265	1,008.6
Flood Detention	91.38	70%	35%	12	0.42	299.3
Highway	413.31	80%	40%	12	0.42	1,249.9
Public Parks	99.94	80%	40%	6	0.265	95.3
Public Bridges	301.33	70%	35%	12	0.265	622.9
Public Works	593.86	70%	35%	3	0.42	486.4
Residential Homes	5,533.54	50%	25%	6	0.265	6,598.7
Underground Utilities	386.26	20%	10%	1	0.42	146.0
Miscellaneous	1,040.46	80%	40%	6	0.265	992.6
Total	10,196					11,633.6

Controls

Control reductions to emissions may be applied twice in the current calculation method. Intermediate spreadsheets (Proportional Rollback Model spreadsheets #2-4 and #6-8) use the percent control efficiency for water and the percent of sites implementing controls to separate construction into acres uncontrolled or stabilized (termed "controlled" in the MAR and Updated MAR models). Stabilized/controlled acres have a significantly reduced emissions factor than uncontrolled acres. Yet, in the final calculations for PM_{10} mass emissions and concentration (spreadsheets #5 and #9), the control reductions are used again to further reduce total emissions. It seems that these reductions in emissions would occur once, either by reducing the emissions factor or by using the same emissions factor and reducing all emissions in the end.

In the spreadsheets therefore, control reduction values were brought in as stated in the Proportional Rollback Model, or expanded by numbers shown in the Appendix L or Chapter 4 of the SIP. Tables 3 and 4 compare these control reduction values within the new models, in the Proportional Rollback Model spreadsheets and the original sources listed in the SIP. DAQEM may want to revisit the calculations for reductions to determine where each of these reductions takes place so that the model can be modified to better reflect the process. The names of these individual pieces were carried through as individual variables within the model, but some original spreadsheets switch between “overall control efficiency” and the individual components of “rule penetration” and “control efficiency.”

Table 8 Comparison of control reduction values for 24-hour emissions.

24 hr Control Variables Parameter Values					
Variable	**Value used in model**	**spreadsheet value (rollback)**	**SIP Chapter 4**	**SIP Appendix L (for 2006)**	**Notes**
overall control reduction for disturbed VL	0.72	0.72	0.72 (2002+)	0.72	*In model and Appendix L: emission reduction (.91)*rule effectiveness (.8)* rule penetration (.99);*Ch. 4:Table 4-14
overall control reduction for SL dust	0.96	0.96	-	-	not shown in either Ch. 4 or Appendix L
overall control reduction for const actvty dust	0.68	0.68	0.68 (2003+)	0.68	*In model and Appendix L: emission reduction (.87) *rule effectiveness (.8) * rule penetration (.98)*;Ch. 4:Table 4-14
overall control reduction in paved road dust	0.29	0.29	N/A	trackout=0.22	Name in Rollback-"Paved Road Dust (Includes Const. Trackout)" ;Ch. 4:Table 4-14
overall control reduction in wind erosion dust	0.57	0.57	0.71 (2002+)	0.71	Name in Rollback-"Windblown Construction Dust"; Ch. 4:Table 4-14
overall control reduction in unpaved road dust	0.65	0.65	0.65 (2003+)	0.65	*In model and Appendix L: emission reduction (.99) *rule effectiveness (.99) * rule penetration (.66);Ch. 4:Table 4-14*
overall control reduction in hwy const actvty	0.54	0.54	0.68 (2003)	-	Name in Rollback-"Highway Construction Projects Activities"
overall control reduction in hwy WE	0.56	0.56	0.71 (2002+)	-	Name in Rollback-"Highway Construction Projects - Wind Erosion"

Where values differed within these references, the values used in the original spreadsheets were maintained. Additionally, Chapter 4 in the SIP indicates that some of the reductions would not take place until a later date. In the model, these reductions were set from the beginning of the simulation, however, this step-change in reductions could be incorporated into variables by changing the equation from a fixed constant to a conditional statement that looks at the current year of the simulation to determine which value is used.

Table 9 Comparison of control reduction values for Annual emissions.

Annual Control Variables Parameter Values					
Variable	**Value used in model**	**spreadsheet value (rollback)**	**SIP Chapter 4**	**SIP Appendix L (for 2006)**	**Notes**
overall control reduction for disturbed VL	same as 24hr 0.72	0.72	0.72 (2002+)	0.72	*In model and Appendix L: emission reduction (.91)*rule effectiveness (.8)* rule penetration (.99);*Ch. 4:Table 4-15
overall control reduction for const actvty dust	0.68	0.68	0.68 (2003+)	0.68	*In model and Appendix L: emission reduction (.98)*rule effectiveness (.8)* rule penetration (.98);*Ch. 4:Table 4-15
ann overall control reduction for const wind erosion	0.71	0.71	0.71	0.71	*In model and Appendix L: emission reduction (.91) *rule effectiveness (.8) * rule penetration (.98);Ch. 4:Table 4-15*
ann overall control reduction paved dust	0.13	0.13	NA	NA	Appx. L lists the number of improved shoulders and Table 4-15 lists improvements but no percentages
ann overall control reduction unpaved road dust	0.71	0.71	0.65 (2003+)	0.65	*In model and Appendix L: emission reduction (.99) *rule effectiveness (.99) * rule penetration (.66);Ch. 4:Table 4-15*
ann overall control reduction hwy const WE	0.71	0.71	0.71 (2002+)	0.71	*In model and Appendix L: emission reduction (.98) *rule effectiveness (.8) * rule penetration (.98);Ch. 4:Table 4-15*
ann overall control reduction hwy const actvy	0.63	0.63	0.63 (2003+)	0.68	*In model and Appendix L: emission reduction (.87) *rule effectiveness (.8) * rule penetration (.98);Ch. 4:Table 4-15*

Trackout Calculation

The equation for Trackout in the spreadsheet does not contain the final exponential power as listed in the DAQEM report on vehicle fleet weight and EPA sources for equation AP-42. A list of the equation as it appears in this source plus the two models follows.

ROLLBACK MODEL	0.016 [Silt Loading/2]^0.65)*(ADT*Miles per Track Out Point)*# of Access Points
MAR Models:	particle size multiplier k*((Silt loading rate/2)^0.65)* [((average daily traffic* avg vehicle weight) /3)]*(miles of trackout per point* # access points by type)
DAQEM PAPER	$E=k(sL/2)^{0.65}(W/3)^{1.5}$

The MAR Model equation was updated to represent the components of the equation represented in the DAQEM paper. However, as the Rollback Model does not include the last power (1.5). This was therefore excluded from the model so that the results would more closely replicate what the Rollback spreadsheets demonstrate. This calculation should be updated to maintain consistency with references, but will undoubtedly lead to a significant increase in emissions. The change to the vehicle fleet weight may offset this increase somewhat but the exponential factor would increase the emissions farm more than the linear multiplier of vehicle weight.

Appendices

1. Naming Conventions

File Names

The reference list for file names of spreadsheets used is shown in Figure 35. The first part of the name before the underscore ("_") is the number of the spreadsheet, while the second half is the original file name.

Figure 35 Reference for numbering of named spreadsheets

#1_Step 1c NativDesrtAcrs thru2006 using rtc popltion data & actual & projcted constrctin acres
#2_Step 1c 2006 24HourVLemissions calculation using rtc population estimates
#3_Step 2c - 24hourconstwinderosion2006
#4_Step 3c - 24 hr ConstActivity2006 RTC pop figures
#5_Step 4c - Controlled 24valleywide 6-18-03
#6_Step 1c NAAAnnualVacantLandEmissions
#7_Step 2c - 24 hr and Annual ConstActivity2006 RTC pop figures
#8_Step 3c Controlled2006VWAnnualConstructionWindErosion
#9_Step 4cjk 2006VWAnnual Emissions9-17-03

Variable Names

In general, new names were selected that allowed better clarification from one view to another. Most spreadsheets calculated a variable called PM_{10} emissions but, within the system dynamics representation, variable names must be unique. Table 10 lists a few of the major variables that were changed in the MAR Models, a full list is included in the Technical Documentation. One example is the distinction made between stable and unstable and controlled acres.

Table 10 Reference of names used for selected variables

In MAR Models	In Proprotional Rollback spreadsheets
24hr contrld Wind emissions	Stable Land Emissions (tons)
24hr Controlled Wind Emissions Rate	Stabilized land emission rate
Construction activity wind erosion (WE)	Stabilized land emissions
contrd -type- emissions	Stable Land Emissions (tons)
PM10 Emissions - type -	construction activities dust, Fugitive dust
Stable land	Stabilized Land
UNcontrld -type- emissions	Unstable Land Emissions (tons)
demand for new development	acres constructed
duration	months under active construction
density	bodies per acre

2. Conversion to Concentration

Figure 36 24-hour concentration conversion determination

SOURCE	PM10 (TPY)	Controlled PM10	Percent Reduction	Impact on Design	concent divid by mass controld	Uncontrolled Annual Values	Annual Values NOx	Annual Values SOx	Uncontrolled Percent	Design Concentration Impact	Controlled Annual	QA Check Uncontrolled	concentration divided by massPM10
Stationary Point Sources (1)													
Sand & Gravel Operations	1.72	1.72	0.00	1.18	0.69	627.00	294.00	22.00	0.004352	1.18	627.00	1.18	0.0018775
Utilities - Natural Gas	0.55	0.55	0.00	0.37	0.69	199.00	5,319.00	2.00	0.001381	0.37	199.00	0.37	0.0018775
Asphalt Concrete Manufacture	0.47	0.47	0.00	0.32	0.69	171.00	60.00	26.00	0.001187	0.32	171.00	0.32	0.0018775
Industrial Processes	0.22	0.22	0.00	0.15	0.69	80.00	437.00	124.00	0.000555	0.15	80.00	0.15	0.0018775
Other Sources	0.34	0.34	0.00	0.23	0.69	124.00	126.00	5.00	0.000861	0.23	124.00	0.23	0.0018775
Total	**3.29**	**3.29**	**0.00**	**2.25**	0.69	**1,201.00**	**6,236.00**	**179.00**	**0.01**	**2.25**	**1,201.00**	**2.25**	0.001878
Stationary Area Sources													
Small Point Sources	0.50	0.50	0.00	0.35	0.69	184.00	1,825.00	25.00	0.00	0.35	184.00	0.35	0.0018775
Residential Firewood	1.12	1.12	0.00	0.77	0.69	104.05	7.87	1.24	0.00	0.77	104.05	0.77	0.0073688
Residential Natural Gas	0.25	0.25	0.00	0.17	0.69	92.05	1,137.95	7.31	0.00	0.17	92.05	0.17	0.0018775
Commercial Natural Gas	0.09	0.09	0.00	0.06	0.69	33.20	536.70	2.60	0.00	0.06	33.20	0.06	0.0018775
Industrial Natural Gas	0.04	0.04	0.00	0.03	0.69	13.80	182.20	1.10	0.00	0.03	13.80	0.03	0.0018775
NG - Purchased at the source - Carried by SWG	0.58	0.58	0.00	0.39	0.69	210.30	2,767.30	16.60	0.00	0.39	210.30	0.39	0.0018775
Structural / Vehicle Fires / Wild Fires	0.07	0.07	0.00	0.04	0.69	23.74	3.07		0.00	0.04	23.74	0.04	0.0018775
Charbroiling / Meat cooking	2.84	2.84	0.00	1.94	0.69	1,035.06			0.01	1.94	1,035.06	1.94	0.0018775
Soil Microbial Activity / Biological Sources	0.00	0.00	0.00	0.00		0.00	1,142.77		0.00	0.00		0.00	
Disturbed Vacant Lands / Unpaved Parking Lots	274.00	76.72	0.72	3.70	0.05	2,530.00			0.05	13.23	708.00	13.23	0.0052278
Native Desert Fugitive Dust	0.00	0.00	0.00	0.00		2,830.00	0.00	0.00	0.00	0.00	2,830.00	0.00	
Stablized Vacant Lands Dust	30.30	1.09	0.96	0.03	0.02	142.00	0.00	0.00	0.00	0.75	142.00	0.75	0.0052604
Construction Activity Fugitive Dust	28.10	8.99	0.68	6.16	0.69	14,856.00	0.00	0.00	0.10	19.26	4,753.80	27.89	0.0012962
Windblown Construction Dust	63.14	27.20	0.57	12.98	0.48	11,816.00	0.00	0.00	0.23	43.27	3,551.00	61.91	0.003662
Total	**401.02**	**119.48**	**2.93**	**26.63**	0.22	**33,870.19**	**7,602.85**	**53.86**	**0.40**	**80.25**	**13,680.99**	**107.53**	
Nonroad Mobile Sources													
Airport Support Equipment	0.14	0.14	0.00	0.10	0.69	51.20	864.71	111.09	0.00	0.10	51.20	0.10	0.0018775
Commercial Equipment	0.00	0.00	0.00	0.00	0.69	0.41	3.31	0.55	0.00	0.00	0.41	0.00	0.0018775
Construction & Mining Equipment	1.36	1.36	0.00	0.94	0.69	498.18	8,640.18	1,136.84	0.00	0.94	498.18	0.94	0.0018775
Lawn & Garden Equipment	0.05	0.05	0.00	0.03	0.69	17.11	57.41	12.83	0.00	0.03	17.11	0.03	0.0018775
Railroad Equipment	0.05	0.05	0.00	0.04	0.69	20.01	905.28	10.63	0.00	0.04	20.01	0.04	0.0018775
Recreational Equipment	0.00	0.00	0.00	0.00	0.69	1.38	6.90	1.52	0.00	0.00	1.38	0.00	0.0018775
McCarran International Airport	0.57	0.57	0.00	0.39	0.69	208.20	2,870.40	128.62	0.00	0.39	208.20	0.39	0.0018775
Henderson Executive Airport	0.02	0.02	0.00	0.01	0.69	7.90	7.87	0.69	0.00	0.01	7.90	0.01	0.0018775
North Las Vegas Municipal Airport	0.07	0.07	0.00	0.05	0.69	24.00	26.36	2.07	0.00	0.05	24.00	0.05	0.0018775
Nellis Airforce Base	0.09	0.09	0.00	0.06	0.69	31.87	268.64	396.45	0.00	0.06	31.87	0.06	0.0018775
Total	**2.36**	**2.36**	**0.00**	**1.62**	0.69	**860.27**	**13,651.05**	**1,801.29**	**0.01**	**1.62**	**860.27**	**1.62**	0.001878
Onroad Mobile Sources													
Paved Road Dust (Includes Const. Trackout)	161.70	114.86	0.29	78.71	0.69	59,019.00			0.41	110.81	41,842.26	110.81	0.0018775
Unpaved Road Dust	55.11	19.50	0.65	13.36	0.69	20,115.12			0.14	37.77	7,118.27	37.77	0.0018775
Highway Construction Projects Activities	3.42	1.57	0.54	1.54	0.98	1,788.00			0.01	3.36	572.20	3.36	0.0018775
Highway Construction Projects - Wind Erosion	5.04	2.22	0.56	2.18	0.98	942.00			0.02	4.93	290.00	4.93	0.005238
Vehicular Sulfate PM	1.52	1.52	0.00	1.04	0.69	402.00			0.00	1.04	553.00	1.04	0.0025828
Vehicular Tire Wear	0.32	0.32	0.00	0.22	0.69	129.00			0.00	0.22	115.00	0.22	0.0016738
Vehicular Brake Wear	0.51	0.51	0.00	0.35	0.69	187.00			0.00	0.35	187.00	0.35	0.0018775
Vehicular Exhaust	0.91	0.91	0.00	0.62	0.69	546.00	24,206.00	417.00	0.00	0.62	332.00	0.62	0.0011417
Total	**228.51**	**141.40**	**2.04**	**98.02**	0.69	**83,128.12**	**24,206.00**	**417.00**	**1.41**	**159.10**	**51,009.73**	**159.10**	0.001914
TOTALS	**631.89**	**266.53**	**4.97**	**128.52**	0.48	**119,059.58**	**51,695.90**	**2,451.15**	**1.82**	**243.22**	**66,751.99**	**270.50**	
				139.02									

PM_{10} concentrations were previously determined in the PM_{10} Proportional Rollback Model by using the total mass emissions and determining the relative contribution of each source to the total emissions. This was then multiplied by the design concentration to determine the uncontrolled concentration. Mass emissions were then reduced by controls and multiplied by the final design concentration (a value close to the standard minus background levels) to achieve the final concentration. This process was difficult to follow and assumed that changes in mass concentrations would not change the overall concentration total. A conversion factor was therefore determined based on the current values in the spreadsheet, which were most likely checked against real-world monitored values. Figure 36 shows the conversion factor determined for each row of the spreadsheet for either controlled (diagonally shaded) or uncontrolled emissions (solidly shaded). As can be seen in the conversion factor column of these two calculations, values in many rows differ significantly. Therefore an average was calculated for both the controlled and the uncontrolled emissions. The value used in the models is the average of the controlled conversion factors, 0.48 $\mu g/m^3$/ton. The units for the conversion factor are derived through unit analysis.

Unit Analysis Controlled 24hr CF = Impact on Design (concentration)/ Controlled PM10 (mass)

	?	($\mu g/m^3$/day)	(tons/day)	
		($\mu g/m^3$~~/day~~)	*(tons~~/day~~)*	= *$\mu g/m^3$/tons*

Check:

Controlled 24hr CF	*Controlled PM10 (mass)	=	*concentration*
($\mu g/m^3$/ton)	(tons/day)		($\mu g/m^3$/day)

A similar process was followed for determining an annual concentration conversion factor. The final value used in the model, outlined and bold in Figure 37, is 0.000179 $\mu g/m^3$/ton.

Figure 37 Annual concentration conversion determination

SOURCE	PM10	NOX	SOX	Percent	Relative Mass	Overall	2006	Relative Mass	concentratio	concentrati
Stationary Point Sources (1)									controlled	uncontrolled
Sand & Gravel Operations	627	294	22	0.44%	0.16		943	0.17	0.000180	0.000253549
Utilities - Natural Gas	199	5,319	2	0.14%	0.05		5,520	0.05	0.000009	0.000253549
Asphalt Concrete Manufacture	171	60	26	0.12%	0.04		257	0.05	0.000195	0.000253549
Industrial Processes	80	437	124	0.06%	0.02		641	0.02	0.000031	0.000253549
Other Sources	124	126	5	0.09%	0.03		255	0.03	0.000118	0.000253549
Total	1,201	6,236	179	0.83%	0.30		7,616	0.32	0.000042	0.000253549
Stationary Area Sources										
Small Point Sources	184	1,825	25	0.13%	0.05		2,034	0.05	0.000025	0.000253549
Residential Firewood	101	0	0	0.07%	0.03		101	0.03	0.000297	0.000253549
Residential Natural Gas	89	0	0	0.06%	0.02		89	0.02	0.000225	0.000253549
Commercial Natural Gas	33	537	3	0.02%	0.01		573	0.01	0.000017	0.000253549
Industrial Natural Gas	14	182	1	0.01%	0.00		197	0.00	0.000000	0.000253549
NG - Purchased at the source - Carried by SWG	210	2767	17	0.15%	0.05		2,994	0.06	0.000020	0.000253549
Structural / Vehicle Fires / Wild Fires	23	0		0.02%	0.01		23	0.01	0.000435	0.000253549
Charbroiling / Meat cooking	1,005			0.70%	0.25		1,005	0.27	0.000269	0.000253549
Soil Microbial Activity / Biological Sources	0	0		0.00%	0.00		0	0.00		
Disturbed Vacant Lands / Unpaved Parking Lots	35,866			24.91%	9.09	72	10,042	2.55	0.000254	0.000253549
Native Desert Fugitive Dust	3,999			2.78%	1.01		3,999	1.01	0.000254	0.000253549
Stablized Vacant Lands Dust	3,948			2.74%	1.00		3,948	1.00	0.000254	0.000253549
Construction Activity Fugitive Dust	10,250			7.12%	2.60	68	3,280	0.83	0.000254	0.000253549
Windblown Construction Dust	8,259			5.74%	2.09	71	2,395	0.61	0.000254	0.000253549
Total	63,981	5311	45	44.44%	16.22		30,680	6.45	0.000210	0.000253549
Nonroad Mobile Sources										
Airport Support Equipment	50	0	0	0.03%	0.01		50	0.01	0.000200	0.000253549
Commercial Equipment	0	0	0	0.00%	0.00		0	0.00		
Construction & Mining Equipment	484	0	0	0.34%	0.12		484	0.13	0.000269	0.000253549
Lawn & Garden Equipment	17	0	0	0.01%	0.00		17	0.00	0.000000	0.000253549
Railroad Equipment	19	0	0	0.01%	0.00		19	0.00	0.000000	0.000253549
Recreational Equipment	1	0	0	0.00%	0.00		1	0.00	0.000000	0.000253549
McCarran International Airport	335	0	0	0.23%	0.08		335	0.09	0.000269	0.000253549
Henderson Executive Airport	7	0	0	0.00%	0.00		7	0.00	0.000000	0.000253549
North Las Vegas Municipal Airport	31	0	0	0.02%	0.01		31	0.01	0.000323	0.000253549
Nellis Airforce Base	32	268.6	396.5	0.02%	0.01		697	0.01	0.000014	0.000253549
Total2	976	269	396	0.68%	0.25		1,641	0.25	0.000151	0.000253549
Onroad Mobile Sources										
Paved Road Dust (Includes Const. Trackout)	55,717	-	-	38.70%	14.13	13	48,474	12.29	0.000254	0.000253549
Unpaved Road Dust	19,082	-	-	13.26%	4.84	71	5,534	1.40	0.000254	0.000253549
Highway Construction Projects Activities	1,250	-	-	0.87%	0.32	63	463	0.12	0.000254	0.000253549
Highway Construction Projects - Wind Erosion	659	-	-	0.46%	0.17	71	191	0.05	0.000254	0.000253549
Vehicular Sulfate PM	496	-	-	0.34%	0.13		496	0.12	0.000242	0.000253549
Vehicular Tire Wear	102	-	-	0.07%	0.03		102	0.02	0.000196	0.000253549
Vehicular Brake Wear	166	-	-	0.12%	0.04		166	0.04	0.000241	0.000253549
Vehicular Exhaust3	326	22,035	491	0.23%	0.08		22,852	0.08	0.000004	0.000253549
Total	77,798	22,035	491	54.04%	19.73		78,277	14.12	0.000180	0.000253549
TOTALS	143,956	33,851	1,112		36.5		118,215	21	0.000179	0.000253549
				Backgrou	16.5			15.75		
				Total	53.00			37		

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