Application of User Interface Tool for Air Quality Post Process (AQPP)

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Introduction

- AQPP (Air Quality Post Processor) has been developed to estimate the emissions in transportation planning model by utilizing the emission rates from MOVES.
- The original process developed by Florida DOT was implemented by the Cube application manager, and has been improved recently along with the user interface tool. The AQPP tool has also been enhanced as follows:
  - Addition of alternative process for VMT computation
  - Addition of flexible application to any counties in US
  - Addition of flexible analysis to any types of pollutants
  - Conversion process of input file formats

Transportation Conformity

- Transportation conformity establishes the framework for improving air quality to protect public health and the environment.
- A provision to ensure that transportation investments conform to a State's air quality implementation plan (SIP) for meeting the Federal air quality standards.
- Primarily concerned air pollutants:
  - OZONE (O_3)
  - Carbone Monoxide (CO)
  - Particulate Matter (PM_{10} and $PM_{2.5}$)
  - Nitrogen Dioxide (NO_2)

MOVES (Motor Vehicle Emission Simulator)

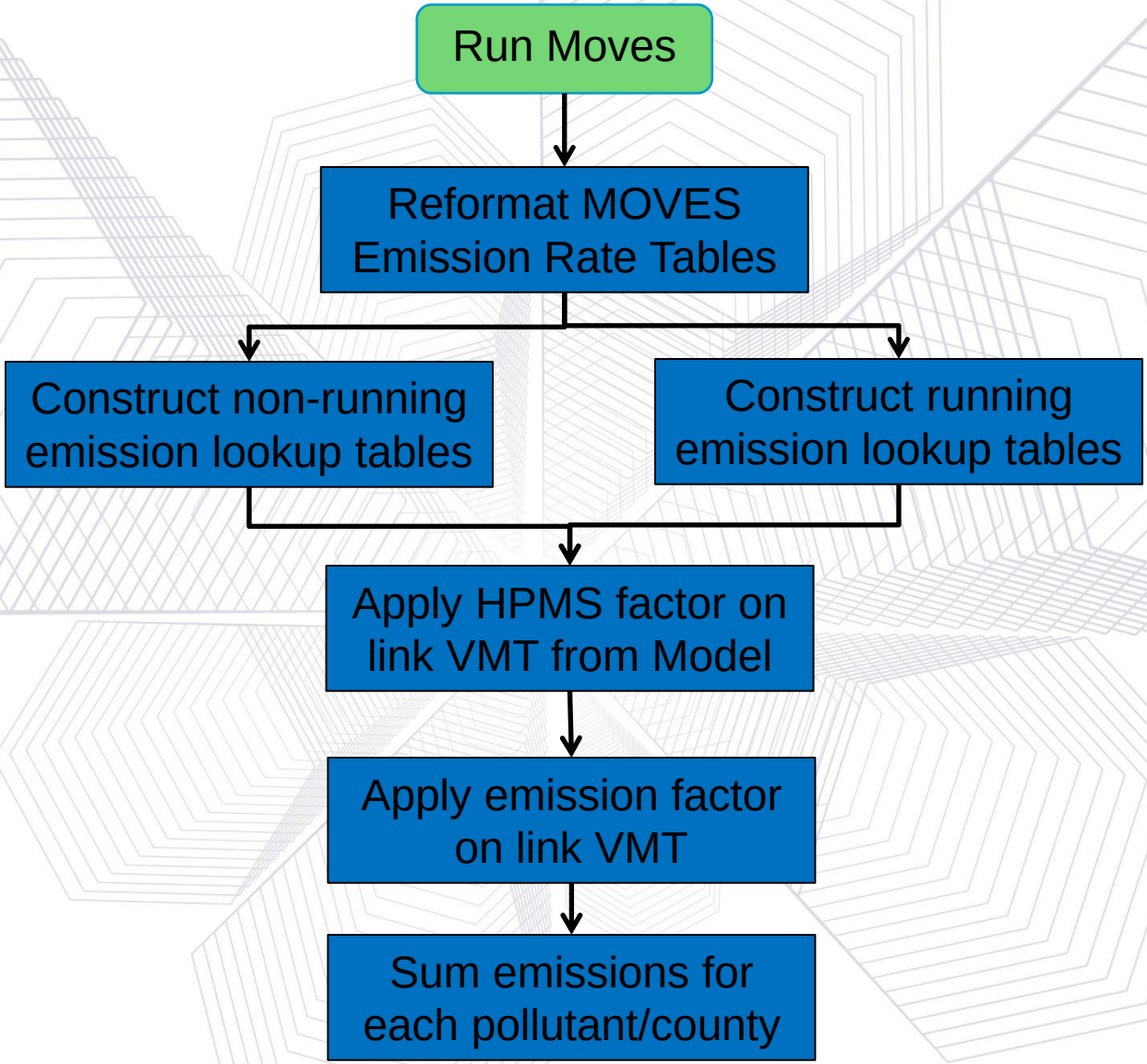
- EPA (US Environmental Protection Agency) has developed the MOVES that is a new emission modeling system to estimate emissions for highway vehicles.
- The latest version of MOVES: 'MOVES2010b' (June 2012)
- Input specifications :
  - Vehicle types
  - Time periods
  - Geographical area
  - Vehicle operating characteristics
  - Road types
- Output estimates :
  - Bulk emissions
  - Emission rates

Running vs. Non-Running Emissions

- Running – produced while vehicle in motion
  - Tailpipe exhaust
  - Crankcase (engine)
  - Evaporative

- Non-running – produced while vehicle is stationary
  - Start exhaust
  - Refueling
  - Evaporative

Overview of FSUTMS AQPP



Overview of FSUTMS AQPP (cont'd)

Step 1: Develop Emissions Factors in MOVES

- By speed bin, pollutant, model year, and County
  - Grams/mile (running emissions)
  - Grams/vehicle (non-running emissions)
- AQPP reformats MOVES output emissions factors for input into FSUTMS

Step 2: Prepare FSUTMS network within FSUTMS AQPP

- Congested speeds (already included)
- VMT
  - Calculate intrazonal VMT and append to centroid connectors
  - Calculate link-level VMT (AADT * link distance)
- Append MOVES road types
- Append HPMS functional classification codes **(outside AQPP within GIS)**

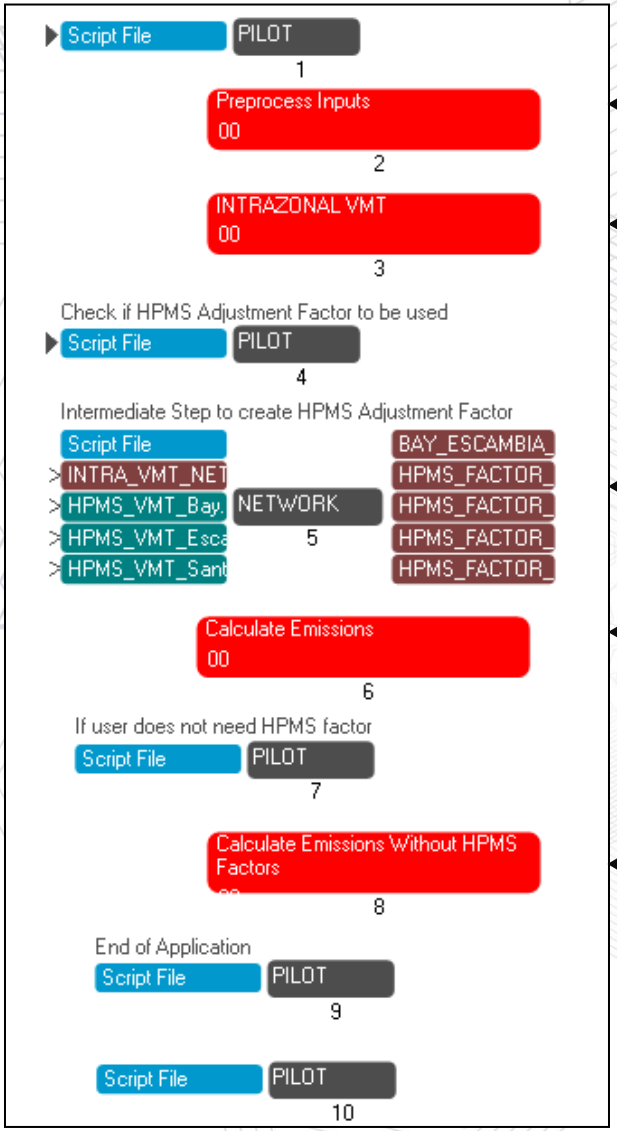
Step 3: Reconcile with Count Data within FSUTMS AQPP

- Aggregate link-level model VMT by HPMS functional class by County
- Calculate HPMS adjustment factor using ratio of HPMS VMT to model VMT
- Apply HPMS adjustment factor to VMT estimates at link-level by HPMS functional class

Step 4: Estimate Emissions within FSUTMS AQPP

- Running emissions
  - Apply emissions factors/mile to model VMT for each link
  - Aggregate link-level emissions by HPMS functional class by county and pollutant
- Non-running emissions
  - Apply emissions factors/vehicle to vehicle population
- Sum running and non-running emissions by HPMS functional class by county and pollutant

Cube-based AQPP



Preparing input data files

Computing intrazonal VMT

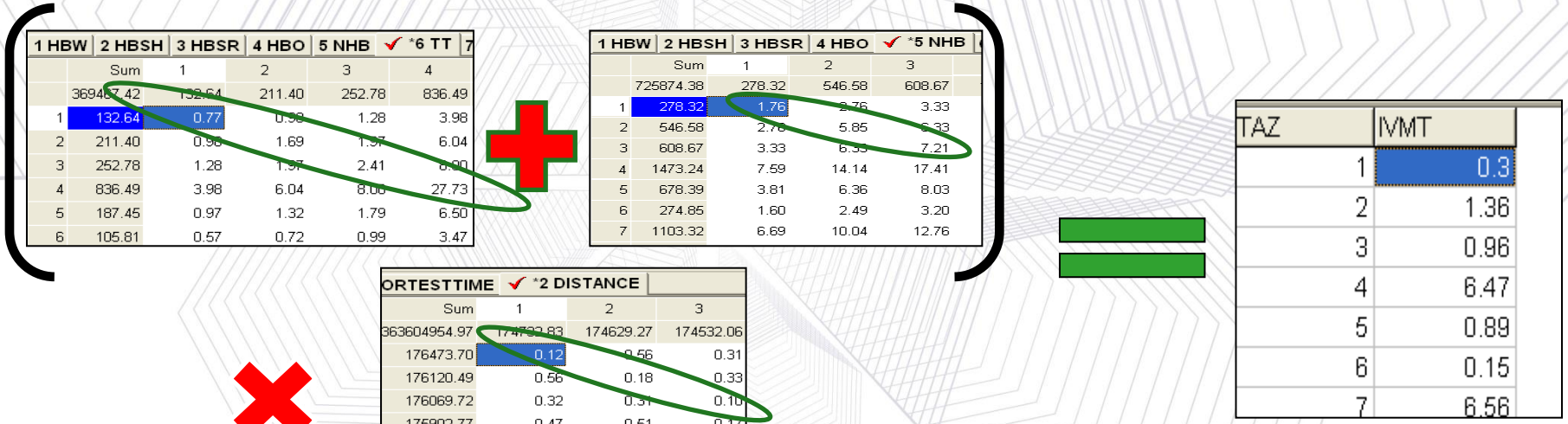
Creating VMT adjustment factor

Estimating both non-running & running emissions

Estimating both non-running & running emissions without VMT adjustment factor

Calculation of Intrazonal VMT per TAZ

- Calculate intrazonal VMT by multiplying intrazonal time matrix by vehicle trip matrix
  - Take the result on the diagonal (zone 3 to 3 which represents the intrazonal value for example)



1 HBW	2 HBSH	3 HBSR	4 HBO	5 NHB	*6 TT	7
	Sum	1	2	3	4	
	369467.42	132.64	211.40	252.78	836.49	
1	132.64	0.77	0.98	1.28	3.98	
2	211.40	0.98	1.69	1.97	6.04	
3	252.78	1.28	1.97	2.41	8.00	
4	836.49	3.98	6.04	8.06	27.73	
5	187.45	0.97	1.32	1.79	6.50	
6	105.81	0.57	0.72	0.99	3.47	

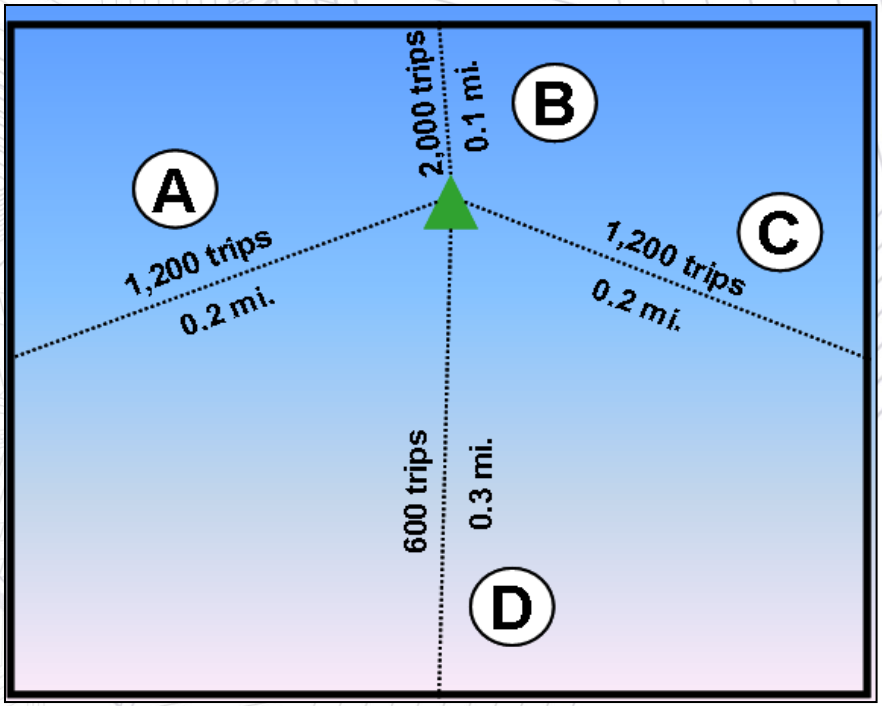
1 HBW	2 HBSH	3 HBSR	4 HBO	*5 NHB	
	Sum	1	2	3	
	725874.38	278.32	546.58	608.67	
1	278.32	1.76	2.76	3.33	
2	546.58	2.76	5.85	6.33	
3	608.67	3.33	6.33	7.21	
4	1473.24	7.59	14.14	17.41	
5	678.39	3.81	6.36	8.03	
6	274.85	1.60	2.49	3.20	
7	1103.32	6.69	10.04	12.76	

ORTESTTIME	*2 DISTANCE		
Sum	1	2	3
363604954.97	174732.83	174629.27	174532.06
176473.70	0.12	0.56	0.31
176120.49	0.56	0.18	0.33
176069.72	0.32	0.31	0.10
175902.77	0.47	0.51	0.17
176026.45	0.31	0.58	0.35
176183.47	0.29	0.62	0.36
176531.02	0.33	0.77	0.52

TAZ	IVMT
1	0.3
2	1.36
3	0.96
4	6.47
5	0.89
6	0.15
7	6.56

Adding Intrazonal VMT to Network

- Once the intrazonal VMT per zone is calculated, the VMT must be appended to the network
  - Pro-rate the intrazonal VMT by the total VMT distribution between centroid connectors within the zone
  - Add pro-rated intrazonal VMT to each centroid connector link

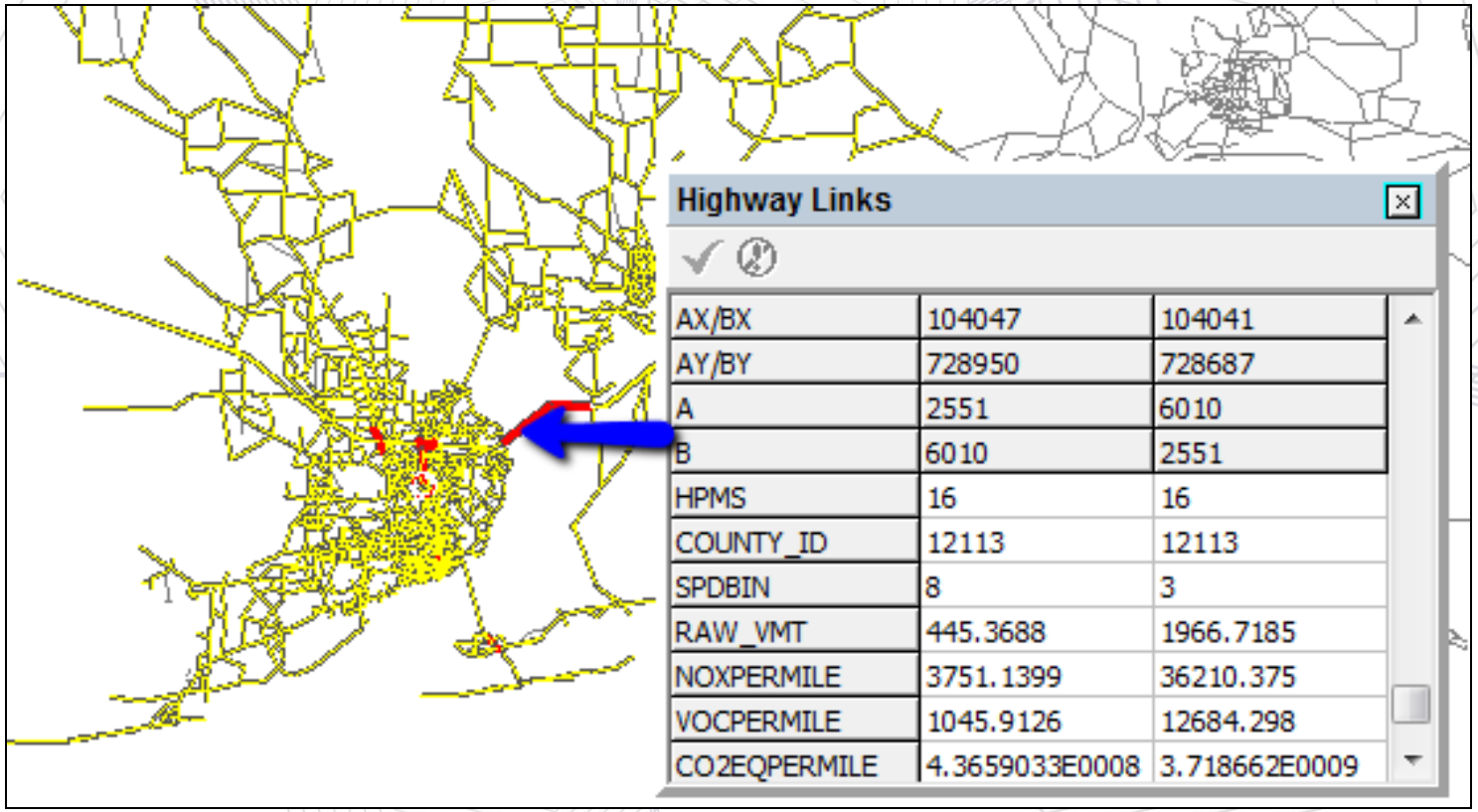


AQPP Input Data

- Emission rates per distance (for running)
- Emission rates per vehicle profile (for non-running)
- Emission rates per vehicle (for non-running)
- VMT hourly fractions
- Vehicle populations
- VMT (Vehicle Miles Travelled)
- Skimming data (e.g. distance)
- O-D trips

AQPP Outputs

- Highway network including emission estimations (NOx, VOC and CO_2EQ)



AQPP Outputs (cont'd)

- Emission summary by county and region

SUMMARY OF AIR QUALITY FOR BAY COUNTY

DESCRIPTION, NAME,	HPMS FUNCTIONAL CLASSES,	Daily Model, UNADJ. VMT,	Daily HPMS, ADJ. FACTOR,	Daily Model, ADJUSTED VMT,	Daily Model, NOX (grams),	Daily Model, VOC (grams),	Daily Model CO2EQ (grams)
Rural Interstate,	1,	0,	0,	0,	0,	0,	0
Rural Principal Arterial,	2,	676105.3,	0.6097,	412221.4,	571099.1,	132218.1,	183634957.7
Rural Minor Arterial,	6,	249549.7,	0.6829,	170417.5,	436891.2,	79290.4,	107903303.7
Rural Major Collector,	7,	9935.9,	0.5146,	5113.0,	7249.3,	1953.3,	2434412.0
Rural Minor Collector,	8,	0,	0,	0,	0,	0,	0
Rural Local,	9,	99594.6,	0.8202,	81687.5,	158725.5,	48511.0,	51382473.4
Urban Interstate,	11,	0,	0,	0,	0,	0,	0
Urban Freeway,	12,	0,	0,	0,	0,	0,	0
Urban Other Arterial,	14,	2007755.9,	0.8663,	1739318.9,	2843414.8,	859074.0,	957936776.1
Urban Minor Arterial,	16,	779261.0,	1.0434,	813080.9,	1343099.0,	385094.0,	439156642.9
Urban Collector,	17,	727947.2,	0.9584,	697664.6,	1206791.5,	340499.8,	382465234.0
Urban Local,	19,	590519.5,	1.7744,	1047817.7,	1949312.4,	683945.6,	677066293.6
Total Running Emissions				,	8516582.8,	2530586.1,	2801980093.3
Total Non-Running Emissions				,	12332233.3,	20869887.0,	753781857.2
Total Emissions including Non-Running				,	20848816.1,	23400473.1,	3555761950.3

Total NOx Emissions = 20,848,816 grams/day
Total VOC Emissions = 23,400,473 grams/day
Total CO2eq (GHG) Emissions = 3,555,761,950 grams/day

Enhanced AQPP Tool

- Addition of alternative VMT computation process
- Applicable to any counties in US
- Applicable to any types of pollutants
- Conversion of input file formats
- Development of AQPP user interface tool

Additional Option of VMT Computation

- In the Cube-based AQPP, the user can directly input the VMT data by HPMS functional class and vehicle type.
- In the AQPP user interface tool, the user can alternatively input the VMT data by HPMS functional class and the VMT proportions.
  - The VMT proportions by HPMS functional class and vehicle type are obtained from any valid source.
  - The observed VMT data by HPMS functional class are classified into the HPMS vehicle type using the VMT proportions.

Additional Option of VMT Computation (cont'd)

CO_NO	CO_NAME	COUNTY_ID	YEAR	HPMS_FC	HPMS_VT10	HPMS_VT20	HPMS_VT30	HPMS_VT40	HPMS_VT50	HPMS_VT60	HPMS_VT_T
48	ESCAMBIA	12033	2009	1	0	0	0	0	0	0	0
48	ESCAMBIA	12033	2009	2	8253	1292374	748573	6149	106156	236096	2397601
48	ESCAMBIA	12033	2009	6	7664	847746	617634	2903	95106	56616	1627669
48	ESCAMBIA	12033	2009	7	16	1762	1106	3	195	166	3248
48	ESCAMBIA	12033	2009	8	17	1869	956	54	174	29	3099
48	ESCAMBIA	12033	2009	9	0	0	0	0	0	0	0
48	ESCAMBIA	12033	2009	11	18950	4124502	1745670	29820	273966	822062	7014970
48	ESCAMBIA	12033	2009	12	0	0	0	0	0	0	0
48	ESCAMBIA	12033	2009	14	58579	8210351	3125631	7107	356972	293589	12052229
48	ESCAMBIA	12033	2009	16	17283	5039219	1350269	3866	92162	34036	6536835
48	ESCAMBIA	12033	2009	17	509	96532	32672	652	4805	1440	136610
48	ESCAMBIA	12033	2009	19	0	0	0	0	0	0	0

CO_NAME	CO_NO	CO_FIPS	YEAR	R_INT	R_PRI_ART	R_MIN_ART	R_MAJ_COL	R_MIN_COL	R_LOCAL	U_INT	U_PRI_ART	U_ART_OTH	U_MIN_ART	U_COL	U_LOCAL
ESCAMBIA	48	12033	2008	68533	261542	168862	21261	131279	149920	958646	0	2073672	1956770	1162102	2695248

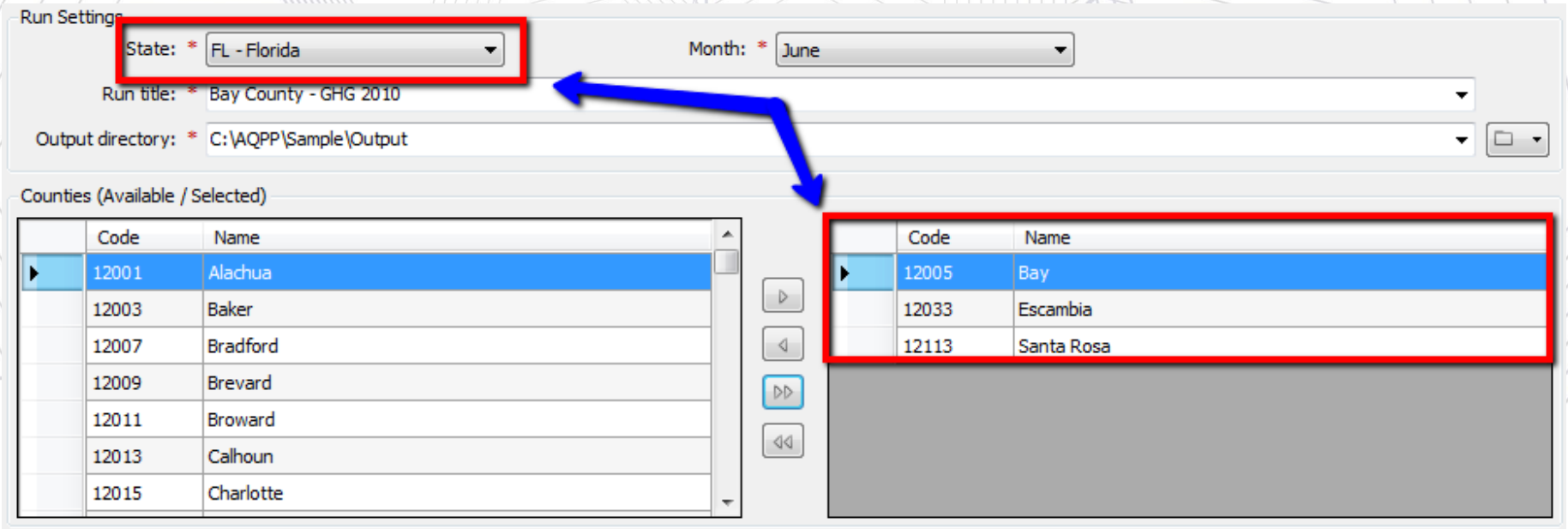
VT	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
1	235.9	900.28	795.1	104.73	720.15	822.41	2589.65	0	10078.93	5173.58	4329.92	10042.32
2	36941.2	140978.45	87949.14	11533.83	79174.07	90416.42	563642.8	0	1412649.48	1508465.88	821169.97	1904528.8
3	21397.2	81657.99	64076.24	7239.74	40497.81	46248.31	238558.33	0	537787.12	404196.51	277931.31	644602.46
4	175.76	670.76	301.17	19.64	2287.53	2612.35	4075.12	0	1222.81	1157.27	5546.38	12863.64
5	3034.36	11580.01	9866.74	1276.45	7370.94	8417.58	37439.42	0	61419.58	27588.25	40874.75	94800.28
6	6748.57	25754.5	5873.61	1086.62	1228.49	1402.93	112340.67	0	50514.08	10188.51	12249.67	28410.49

Applicable to any Counties in US

- The Cube-based AQPP is originally processed for only 3 counties such as Bay, Escambia, and Santa Rosa.
- The AQPP tool is applicable to select any counties in US.
- The county FIPS codes with the state code are used to indicate the designated county. For examples,
  - Bay County = 12005
  - Escambia County = 12033
  - Santa Rosa County = 12113

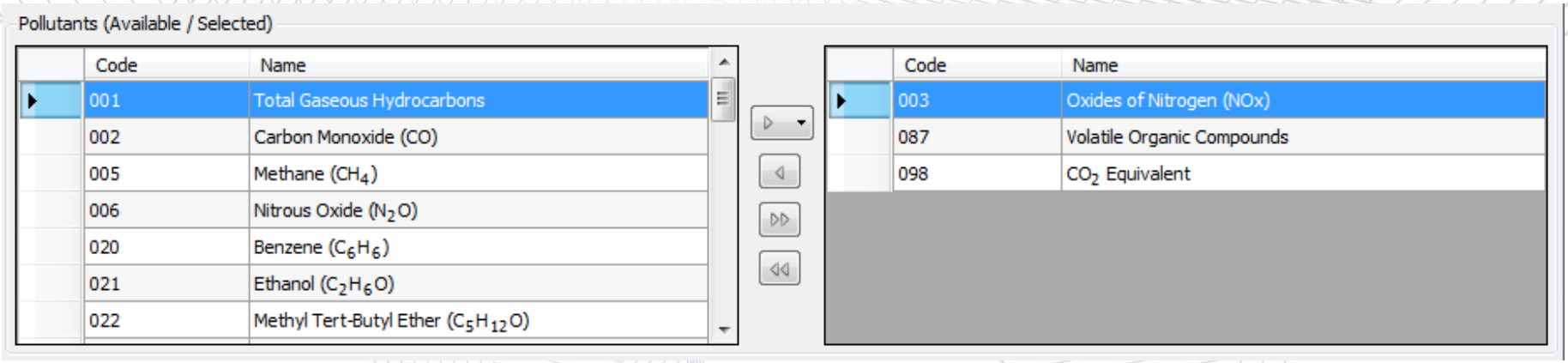
Applicable to any Counties in US (cont'd)

- The user can select any designated counties from the list.



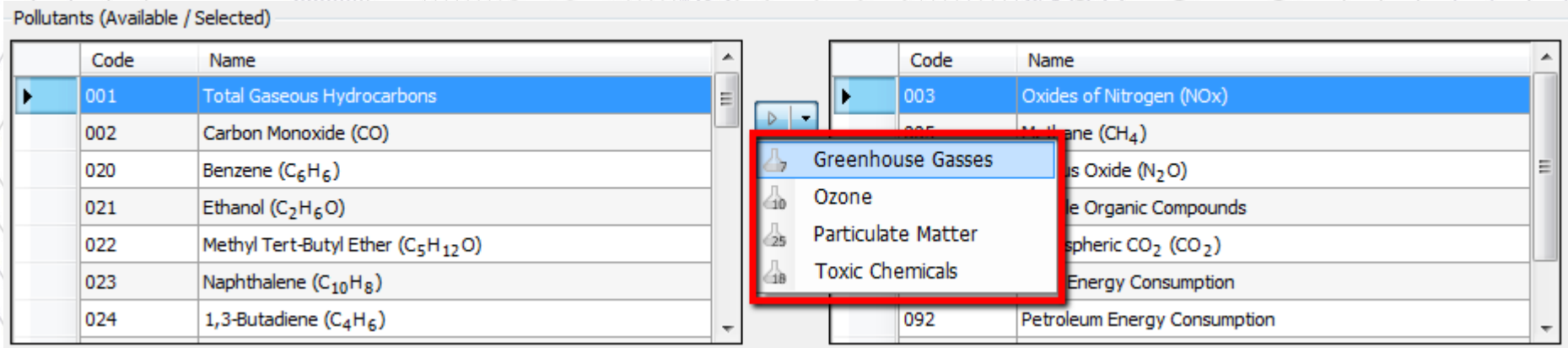
Applicable to Any Pollutant Types

- The Cube-based AQPP was originally processed for only 3 pollutants such as Oxides of Nitrogen (NOx), Volatile Organic Compounds (VOC) and CO_2 Equivalent (CO_2EQ) to estimate the emissions.
- The AQPP user interface tool can estimate any types of pollutants by the user's selection.



Applicable to Any Pollutant Types (cont'd)

- As an additional option, the user can also select the type of pollutant group (e.g. GHG - Greenhouse Gasses).

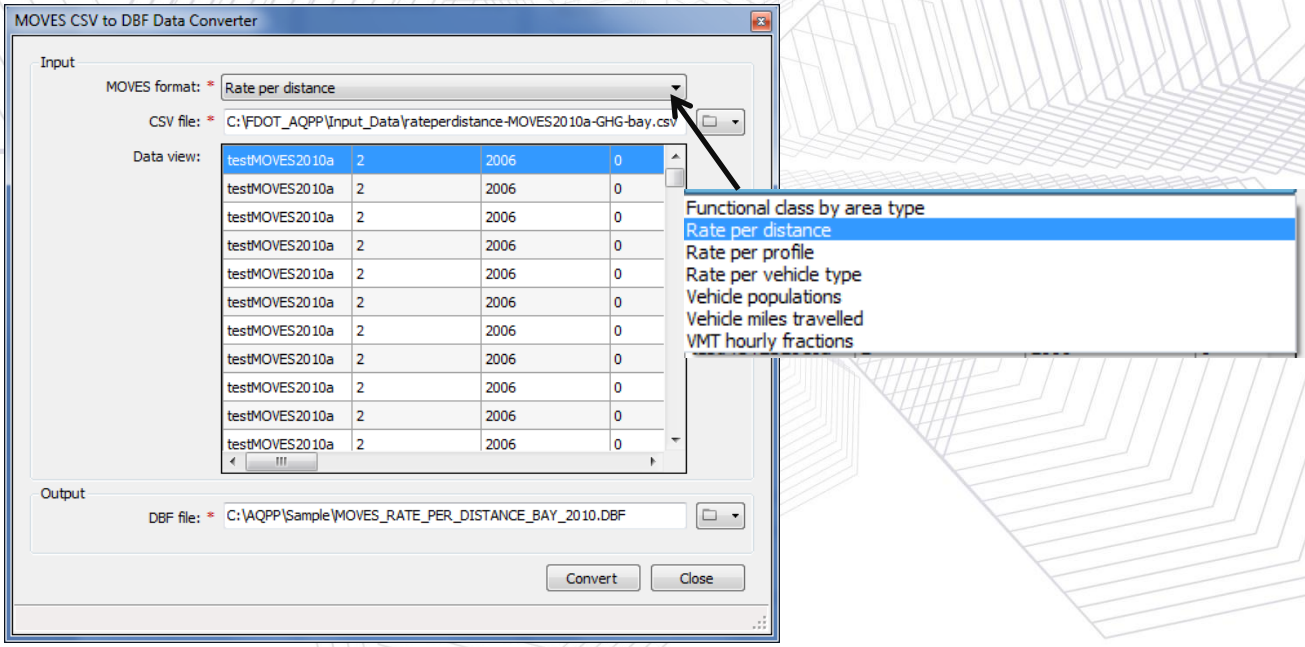


Pollutant ID	Pollutant Name	Pollutant Group			
		Ozone	Toxics	PM	GHG
1	Total Gaseous Hydrocarbons	d	d	d	
2	Carbon Monoxide (CO)	X			
3	Oxides of Nitrogen	X		X	
5	Methane (CH4)	d	d	d	X
6	Nitrous Oxide (N2O)				X
20	Benzene		X	X	
21	Ethanol				
22	MTBE		X		
23	Naphthalene		X		
24	1,3-Butadiene		X		
25	Formaldehyde		X		
26	Acetaldehyde		X		
27	Acrolein		X		
30	Ammonia (NH3)			X	
31	Sulfur Dioxide (SO2)			X	
32	Nitrogen Oxide	X		X	
33	Nitrogen Dioxide	X		X	
79	Non-Methane Hydrocarbons	d	d	d	
80	Non-Methane Organic Gases	d	d	d	

Pollutant ID	Pollutant Name	Pollutant Group			
		Ozone	Toxics	PM	GHG
86	Total Organic Gases	X	X	X	
87	Volatile Organic Compounds	X	X	X	
90	Atmospheric CO2				X
91	Total Energy Consumption		d	d	X
92	Petroleum Energy Consumption				X
93	Fossil Fuel Energy Consumption				X
98	CO2 Equivalent				X
100	Primary Exhaust PM10 - Total		d	X	
101	Primary PM10 - Organic Carbon		d	X	
102	Primary PM10 - Elemental Carbon		d	X	
105	Primary PM10 - Sulfate Particulate		d	X	
106	Primary PM10 - Brakewear Particulate			X	
107	Primary PM10 - Tirewear Particulate			X	
110	Primary Exhaust PM2.5 - Total			X	
111	Primary Exhaust PM2.5 - Organic Carbon			X	
112	Primary Exhaust PM2.5 - Elemental Carbon			X	
115	Primary Exhaust PM2.5 - Sulfate Particulate			X	
116	Primary Exhaust PM2.5 - Brakewear Particulate			X	
117	Primary Exhaust PM2.5 - Tirewear Particulate			X	

Conversion of Input File Formats

- The AQPP user interface tool changes all the original input files into the dBase format from CSV format because the dBase files are more compatible with Cube Voyager program.
- The AQPP user interface tool includes a tool to convert the CSV format to the dBase format.

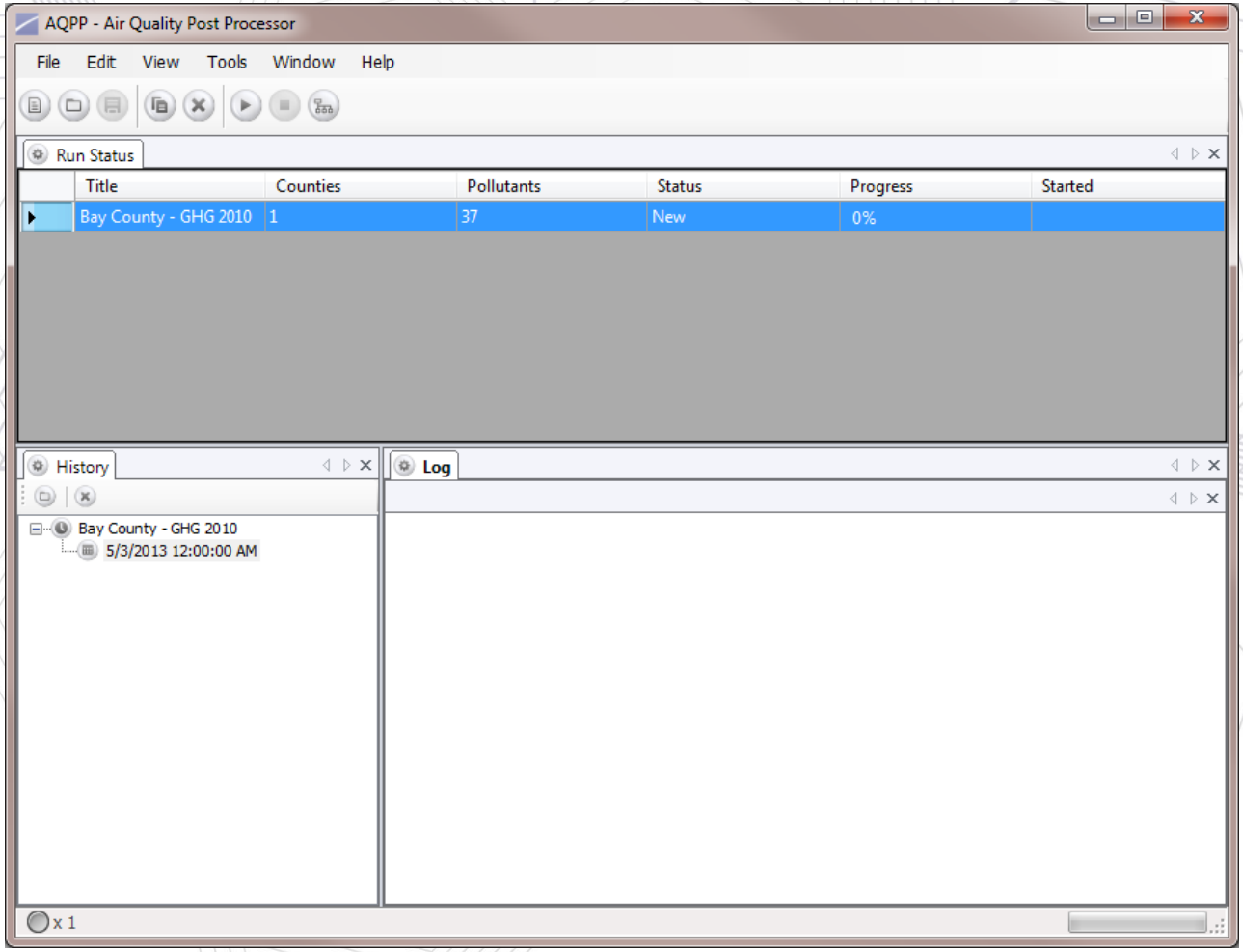


Development of AQPP User Interface Tool

- The AQPP user interface tool has been developed to implement the process with setting the input/output data interactively.
  - Scenario management settings
  - General input data settings
  - County input data settings

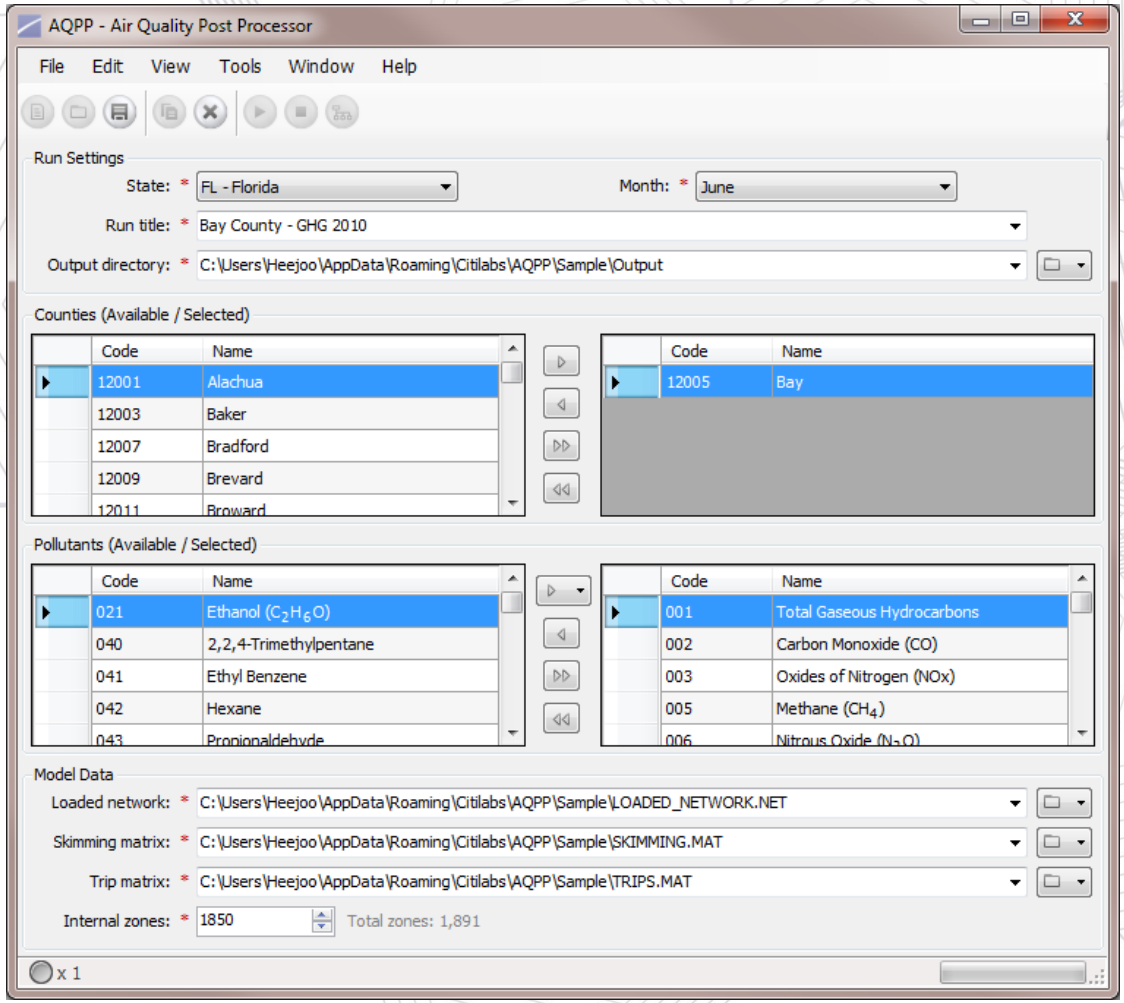
Scenario Management Settings

- The user can create/update any scenarios through the scenario management interface.



General Input Data Settings

- Setting general input data and output folder



Run settings

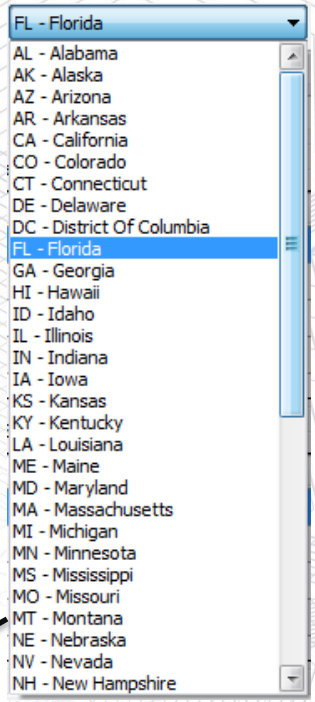
County settings

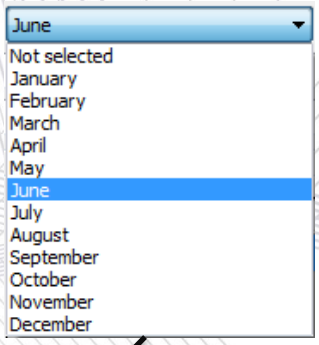
Pollutant settings

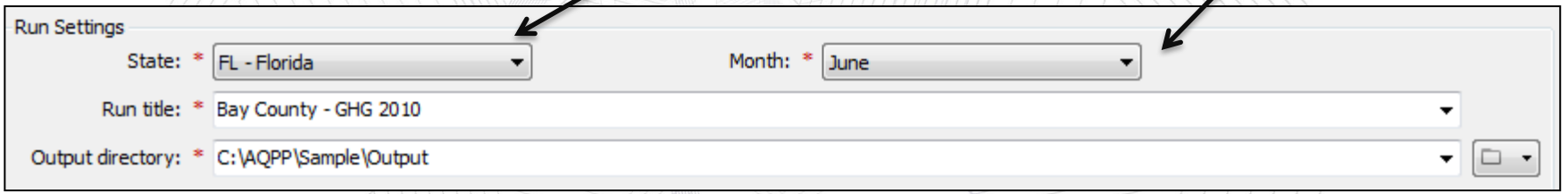
Model data settings

Run Settings

- Selecting applicable state
- Selecting applicable month
- Run title
- Setting output folder

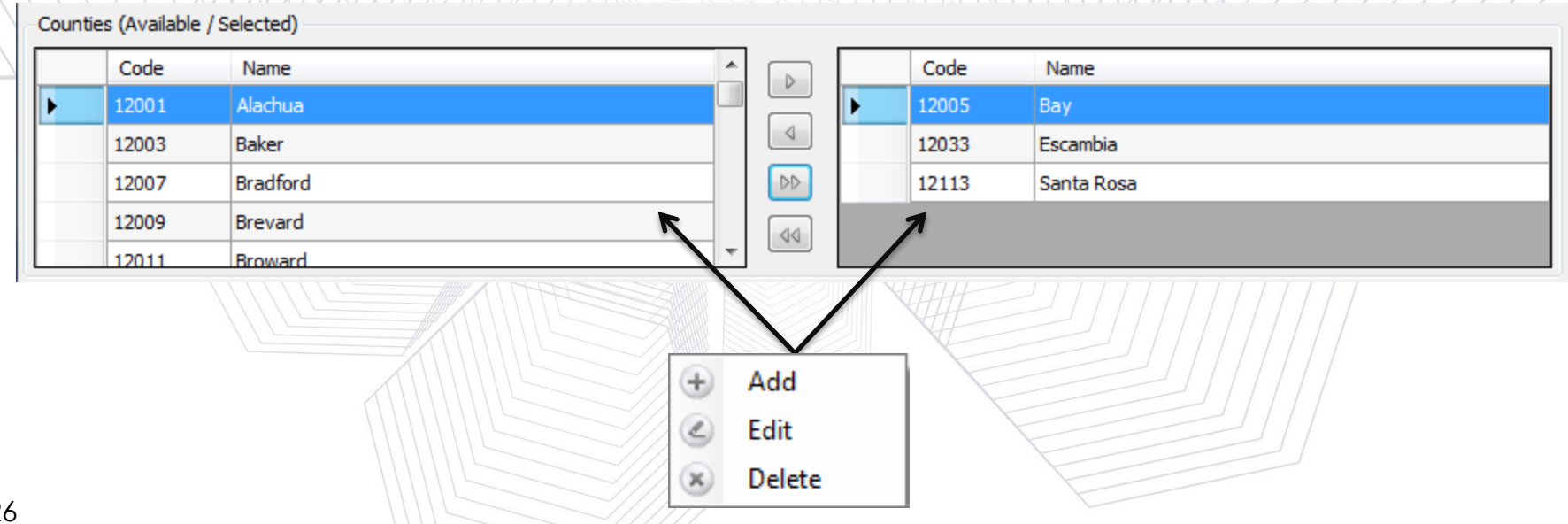






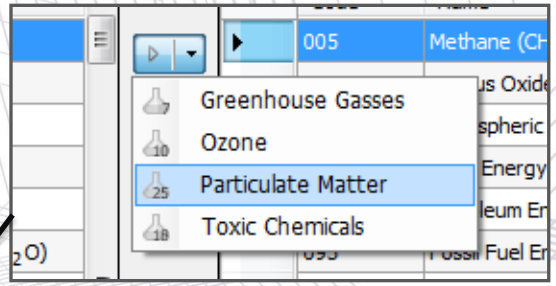
County Settings

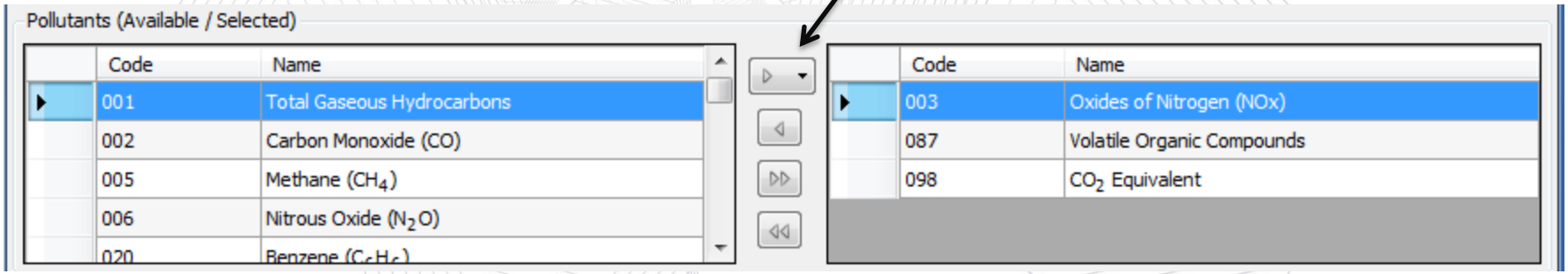
- The state selection filters which counties are available for selection.
- Counties can be added/removed/edited from the model by dragging the selected county, using the arrow buttons, or by options.
- All counties are preloaded (without input data).



Pollutant Settings

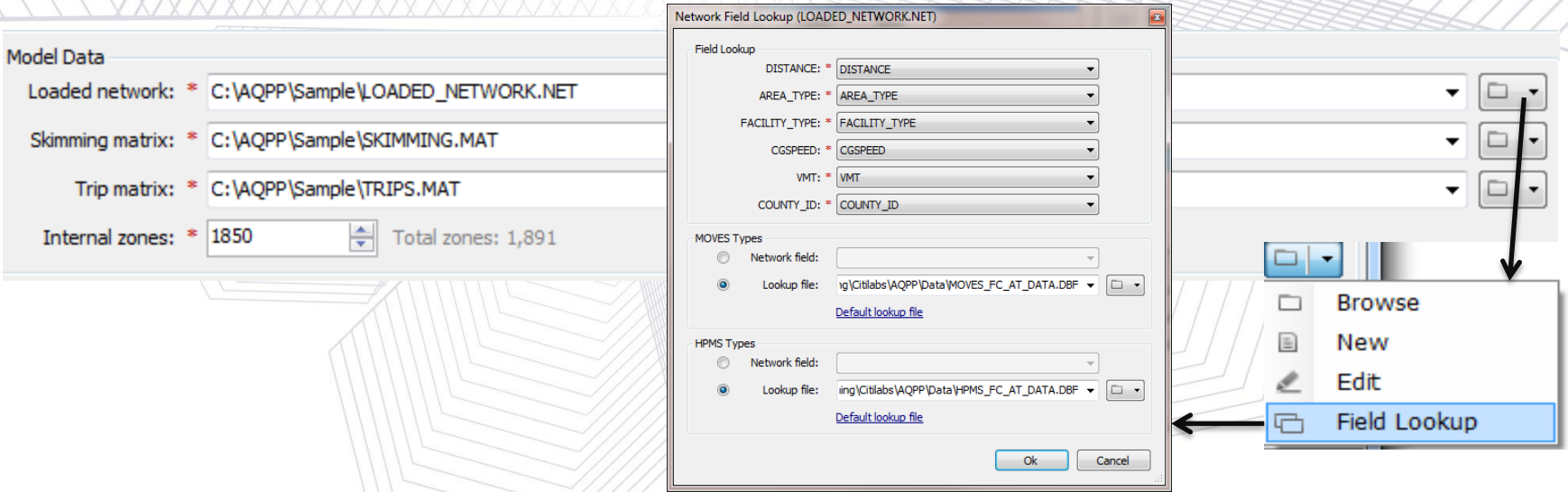
- Pollutants can be added or removed from the model by dragging the selected pollutants or using the arrow buttons
- The user has the flexibility to select a group of predefined pollutants:
  - Greenhouse gasses
  - Ozone
  - Particulate Matter
  - Toxic Chemicals





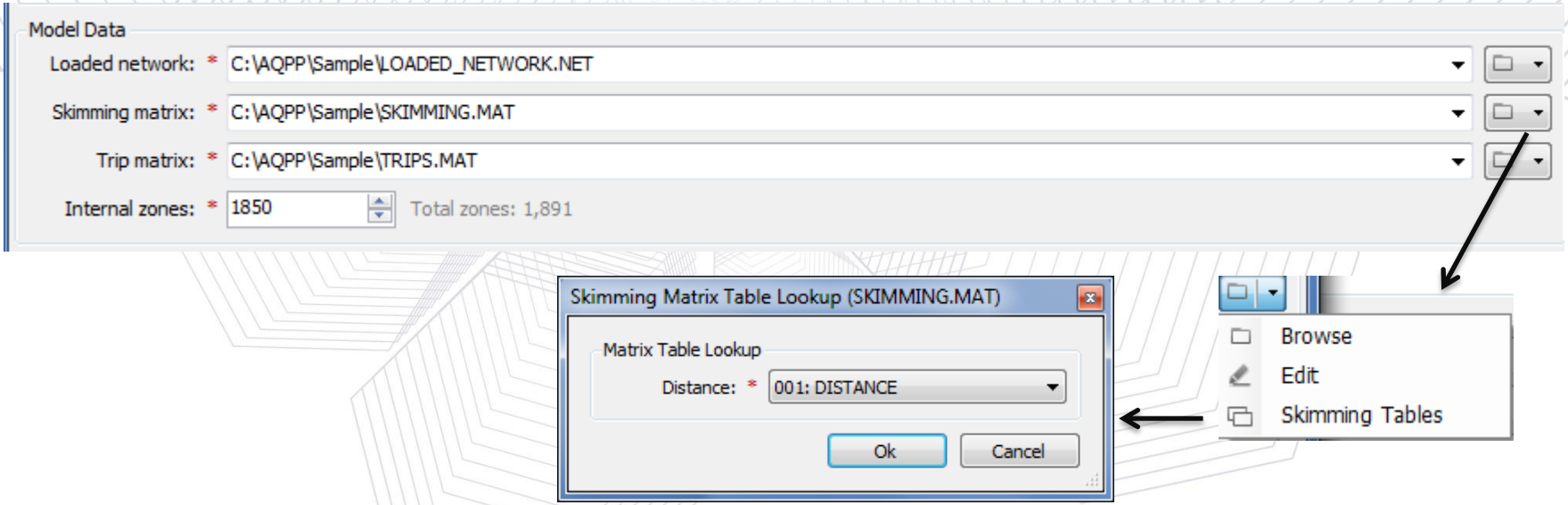
Loaded Highway Network Settings

- The loaded network (.net) is a required input file for AQPP. The additional options should be set along with setting the highway network.
  - Browse for a “loaded” highway network file
  - Create a new highway network (based on a template with the required fields)
  - Edit the currently specified network (in Cube)
  - Setting applicable link attributes using ‘Field Lookup’ option



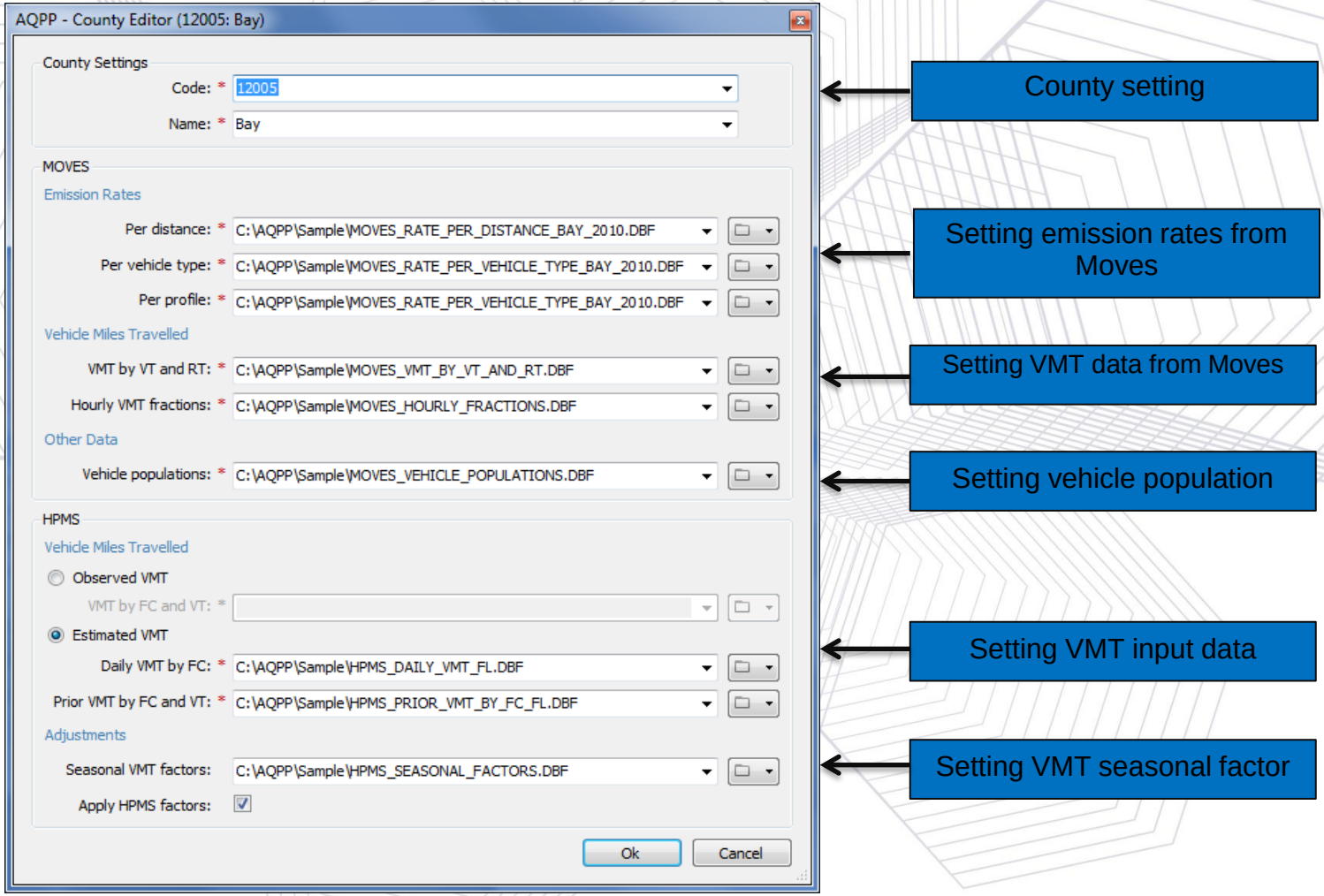
Skimming Matrix Setting

- The skim impedance (e.g. distance) is used to compute the intrazonal VMT value. The additional options should be set.
  - Browse for a trip matrix file
  - Open the currently specified file (in Cube)
  - Setting applicable skimming tables using ‘Skimming Tables’ option



County Input Data Settings

- Setting county-related input data



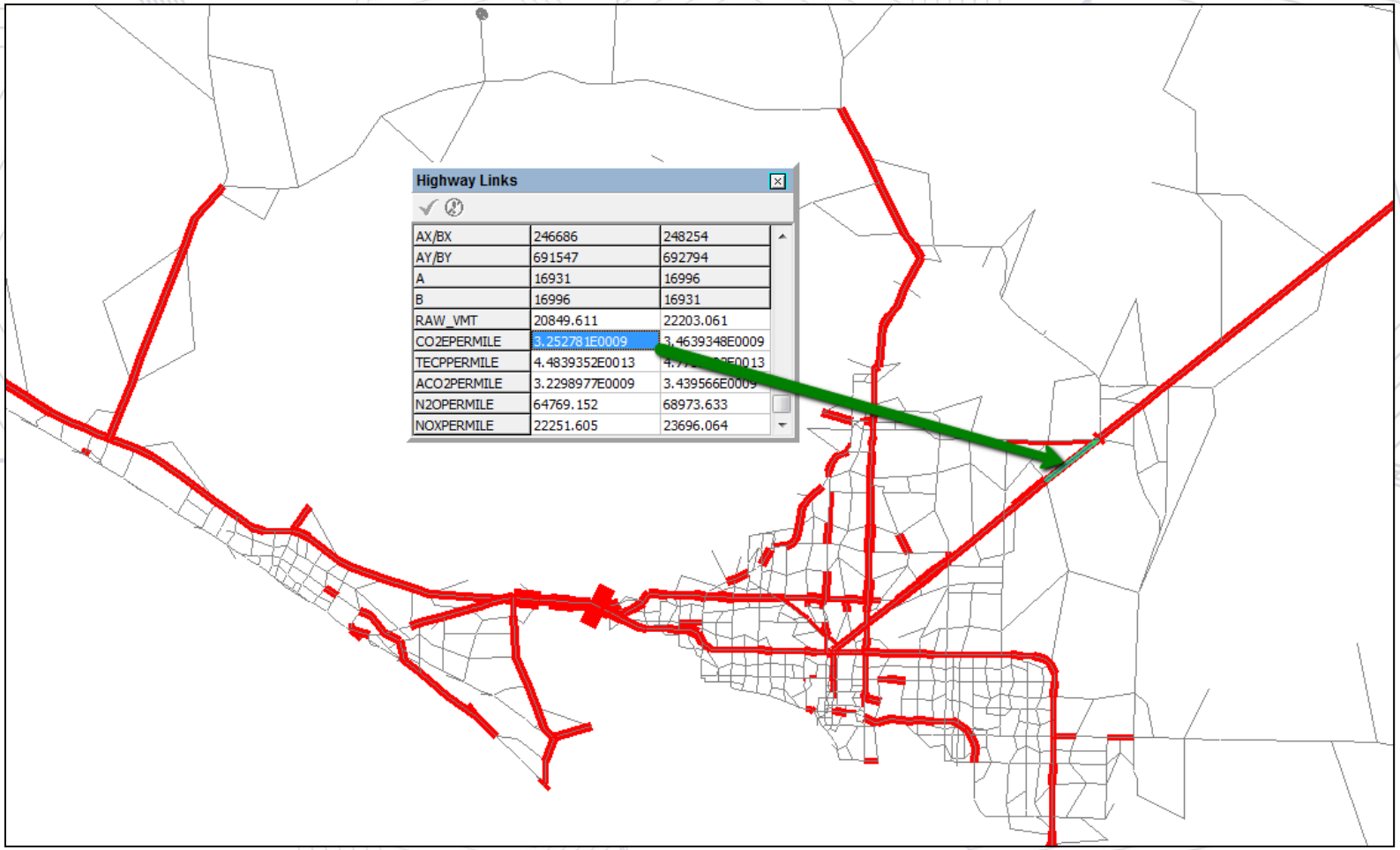
Output Summary of Emission Estimations

- Database format (*.DBF)

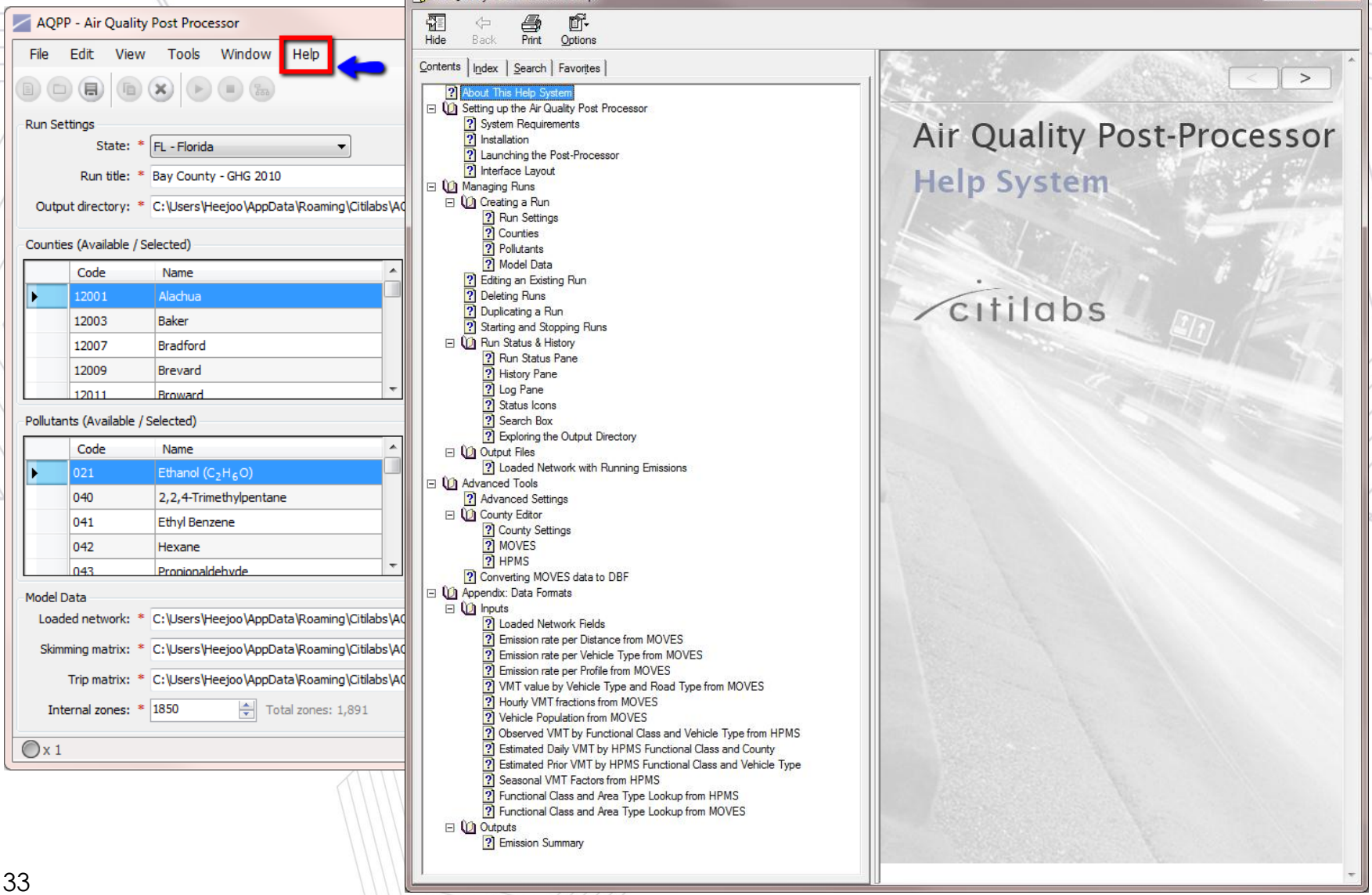
DESC	CLASS	UNADJVMT	ADJFAC	ADJVMT	NOX	N2O	ACO2	TECP	CO2E
Rural Interstate	1	0	0	0	0	0	0	0	0
Rural Principal Arterial	2	801737.5	0.6097	488819.4	1030420	1731252.2	156839750301.5	2.1679697E15	157481643425.9
Rural Minor Arterial	6	249549.7	0.6829	170417.5	430147.9	938633.7	57784464022.7	798333120000000	58070037042.7
Rural Major Collector	7	11782.2	0.5146	6063.1	14631.8	43512	2616089425.5	36141584644972	2628509524
Rural Minor Collector	8	0	0	0	0	0	0	0	0
Rural Local	9	117995	0.8202	96779.5	285421.6	585975.3	32189932358.6	444978370000000	32390241136.8
Urban Interstate	11	0	0	0	0	0	0	0	0
Urban Freeway	12	0	0	0	0	0	0	0	0
Urban Other Arterial	14	2007735.8	0.8663	1739301.5	2548315.8	9145200.8	381496616692.9	5.2964184E15	384264236541.1
Urban Minor Arterial	16	779261	1.0434	813080.9	1053982.2	3167271.4	137584111184.9	1.9112021E15	138554795779.9
Urban Collector	17	727940	0.9584	697657.7	995234.4	2903121	131987974942.7	1.8317122E15	132862981165.5
Urban Local	19	681062.5	1.7744	1208477.4	2374882	3314752.4	159358969215.1	2.2118376E15	160687575174.3
	0	0	0	0	0	0	0	0	0
Total Running Emissions	0	0	0	0	8733035.8	21829718.8	1059857908144	1.4698593E16	1066940019790
Total Non-Running Emissions	0	0	0	0	12328330.9	26533070	18172680085.1	252669210000000	26974821875.2
Total Emissions including Non-Running	0	0	0	0	21061366.7	48362788.7	1078030588229.1	1.49512626E16	1093914841665.4
	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0
HPMS VEHICLE DESCRIPTION	0	0	0	0	0	0	0	0	0
Motorcycles	10	34349.6	0	35084.8	22484.2	17149.4	4781287601.2	66529948380718	4807302088.4
Private Auto	20	3645341	0	3595987.2	3614975.4	13474619.5	568228380781.5	7.9063083E15	572354297879.8
Light Trucks	30	1410641.1	0	1342861.4	2304623.9	7477704.1	306078828048	4.2542008E15	308705865492.9
Buses	40	5653.4	0	4693.9	62850.4	5027.1	2893865825.9	39489307067742	2897170976.8
Single Unit Trucks	50	163625	0	146067.2	1067120.7	822802.8	74254871386.3	1.0190361E15	74512482454.3
Combination Unit Trucks	60	117453.7	0	95902.5	1660981.1	32415.9	103620674501.2	1.4130288E15	103662900898

Output Network

- CO_2EQ distribution for Bay county in Florida



AQPP Help


AQPP - Air Quality Post Processor
File Edit View Tools Window Help
Run Settings
State: * FL - Florida
Run title: * Bay County - GHG 2010
Output directory: * C:\Users\Heejoo\AppData\Roaming\Citilabs\AC
Counties (Available / Selected)
Code Name
12001 Alachua
12003 Baker
12007 Bradford
12009 Brevard
12011 Broward
Pollutants (Available / Selected)
Code Name
021 Ethanol (C2H6O)
040 2,2,4-Trimethylpentane
041 Ethyl Benzene
042 Hexane
043 Propionaldehyde
Model Data
Loaded network: * C:\Users\Heejoo\AppData\Roaming\Citilabs\AC
Skimming matrix: * C:\Users\Heejoo\AppData\Roaming\Citilabs\AC
Trip matrix: * C:\Users\Heejoo\AppData\Roaming\Citilabs\AC
Internal zones: * 1850 Total zones: 1,891
x 1
Air Quality Post Processor Help
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citilabs

Next Step

- AQPP user interface tool will be available as an option in Cube program.