MOVES ODBC Transportation Inventory System (OTIS)

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Introduction

MOVES is the EPA emission factor model for calculation of vehicle emissions and emission factors.

MOVES stores input and output files in a database – MySQL.

This use of MySQL databases makes MOVES more flexible but
It can be daunting to get data out of these databases.

Software Query Language (SQL) programming is often required to get the data in the needed format.

The System presented here is a method to utilize Microsoft Access with its Graphical User Interface (GUI).

The MySQL OBDC Driver is Installed With MOVES: (Slide from MOVES installation)

If the ODBC Connector is not installed, you will see the screen at left. Click Continue to proceed to the MySQL ODBC Connector installation.

NOTE: If prompted, click Run on the "Open File – Security Warning." This will open the MySQL Connector/ODBC 5.1 – Setup Wizard

We can use this driver to link to the MOVES output data tables in MySQL from Microsoft Access.

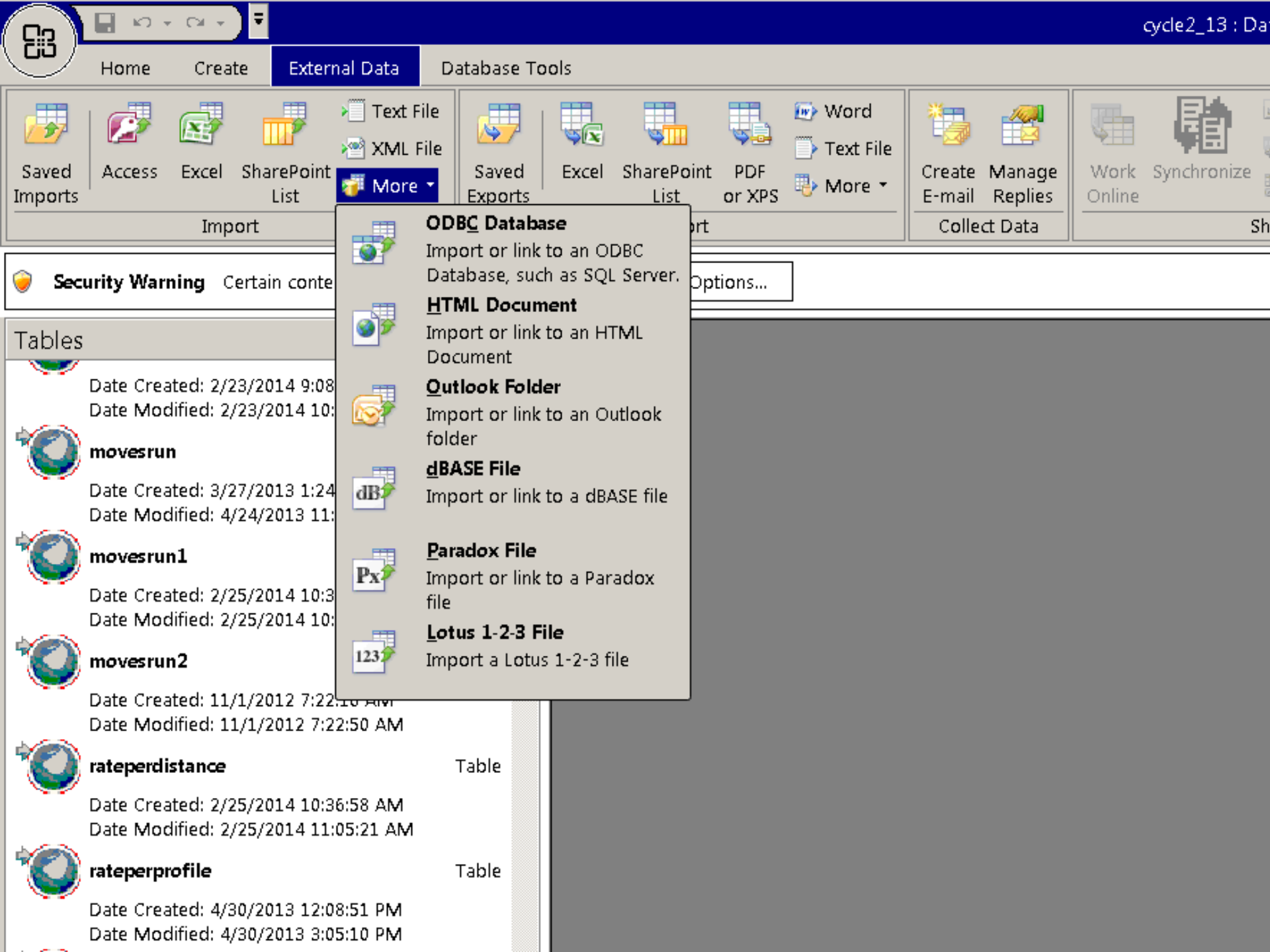
I use this process to calculate Highway Vehicle emissions for SIP Inventories, Conformity Budgets, Conformity Analyses, and Environmental Impact Analyses.

The process is fast and flexible to perform.

I use MOVES in the Emission Factor Mode to calculate emissions using link data From Metropolitan Transportation Planning Agencies (MPOs) such as the Denver Regional Council of Governments (DRCOG) .

Using MOVES in Emission Factor Mode separates the MOVES data from the Transportation Data and greatly improves transparency and accuracy. There is no pre-aggregation or averaging.

The linking process is shown on the next slide: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Home
Create
External Data
Database Tools
Saved Imports
Access
Excel
SharePoint List
Text File
XML File
More
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Saved Exports
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SharePoint List
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Word
Text File
More
Create E-mail
Manage Replies
Collect Data
Work Online
Synchronize
ODBC Database
Import or link to an ODBC Database, such as SQL Server.
HTML Document
Import or link to an HTML Document
Outlook Folder
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Tables
Date Created: 2/23/2014 9:08
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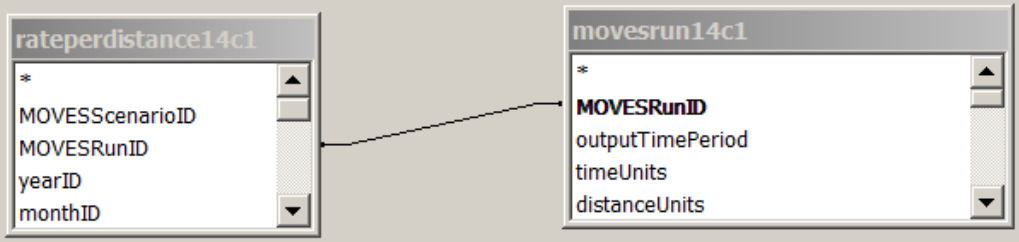
Date Modified: 4/24/2013 11:
movesrun1
Date Created: 2/25/2014 10:3
Date Modified: 2/25/2014 10:
movesrun2
Date Created: 11/1/2012 7:22:16 AM
Date Modified: 11/1/2012 7:22:50 AM
rateperdistance
Table
Date Created: 2/25/2014 10:36:58 AM
Date Modified: 2/25/2014 11:05:21 AM
rateperprofile
Table
Date Created: 4/30/2013 12:08:51 PM
Date Modified: 4/30/2013 3:05:10 PM

A simple query to examine the movesrun and ratesperdistance tables. Note that emission factors are listed with each in a separate row by speed bin ID. The two tables are linked to each other by the MOVESrunID.

Query4 : Select Query



Field:	MOVESRunID	runSpecFileName	hourID	roadTypeID	sourceTypeID	avgSpeedBinID	ratePerDistance
Table:	rateperdistance14c1	movesrun14c1	rateperdistance14c1	rateperdistance14c1	rateperdistance14c1	rateperdistance14c1	rateperdistance14c1
Sort:							
Show:	☑	☑	☑	☑	☑	☑	☑
Criteria:	223		7	5			
or:							

Query4 : Select Query

MOVESRunID	runSpecFileName	hourID	roadTypeI	sourceTypeID	avgSpeedBinI	ratePerDistanc
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	12	0.00212129
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	12	0.014142
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	8	0.00285786
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	8	0.0190525
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	15	0.00169647
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	15	0.0113099
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	16	0.00157443
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	16	0.0104963
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	11	0.00228547
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	11	0.0152365
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	2	0.00446878
223	C:\Users\Public\MOVES2014\NFR\PMmrs\nfrog30r50.mrs	7	5	0	2	0.029792

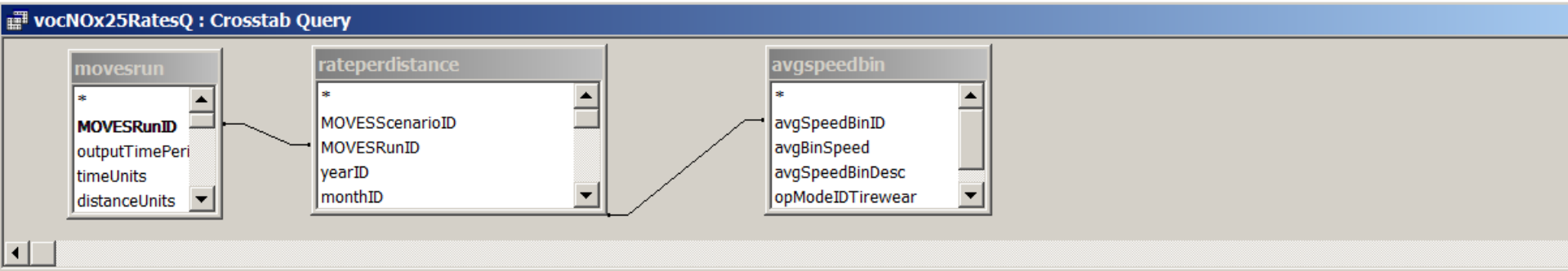
Having the each factor by speed bin on a separate row is not practical for calculating emissions for a particular link VMT and speed.

MOVES guidance says we are to linearly interpolate between speed bins by the speed.

We don't even know what speed each bin represents – we only have the ID.

Fortunately, Access has a query type called a crosstab query that allows us to put all the emission factors for all bins on a single row.

We can also link a new table into our query to decode the speed bin IDs into average speed.



Field:	yearID	monthID	hourID	HPMSVtypeID: Val(IIf(Righ	sourceTypeID	pollutantID	roadTypeID	avgBinSpeed	ratePerDistance
Table:	rateperdistance	rateperdistan	rateperdistan		rateperdistanc	rateperdistance	rateperdistance	avgspeedbin	rateperdistance
Total:	Group By	Group By	Group By	Group By	Group By	Group By	Group By	Group By	Sum
Crosstab:	Row Heading	Row Heading	Row Heading	Row Heading	Row Heading	Row Heading	Row Heading	Column Heading	Value
Sort:									
Criteria:									
or:									

vocNOxCORatesQ : Crosstab Query

yearID	monthID	HPMSVtypeID	sourceType	pollut	roadType	hourID	2_5	5	10	15	20	25	30	35	40	45	50	5
2040	1	10	11	87	5	20	10.451	5.3887	2.8577	2.0140	1.591	1.3347	1.1651	1.0602	0.9851	0.9263	0.8784	0.8
2040	1	10	11	87	5	21	10.451	5.3886	2.8577	2.0140	1.591	1.3347	1.1651	1.0602	0.9851	0.9263	0.8784	0.8
2040	1	10	11	87	5	22	10.451	5.3886	2.8577	2.0140	1.591	1.3347	1.1651	1.0602	0.9851	0.9263	0.8784	0.8
2040	1	10	11	87	5	23	10.450	5.3886	2.8577	2.0140	1.591	1.3347	1.1651	1.0602	0.9851	0.9263	0.8784	0.8
2040	1	10	11	87	5	24	10.450	5.3886	2.8577	2.0140	1.591	1.3347	1.1651	1.0602	0.9851	0.9263	0.8784	0.8
2040	1	20	21	2	2	1	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	2	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	3	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	4	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	5	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	6	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0
2040	1	20	21	2	2	7	2.3105	1.3871	0.898	0.7351	0.6903	0.6613	0.7034	0.8817	1.0156	1.1043	1.1114	1.0

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We now have our emission factors in a usable form, Now let's look at the Transportation Model output.

A typical sample of the link data from a transportation model is shown in the Next slide.

Transportation Model Output

Query1 : Select Query

ID	DIST	FT	AT_	AM1_ABFLOW	AM1_BAFLOW	AM1_ABSPD	AM1_BASPD	AM2_ABFLOW	AM2_BAFLOW	AM
2701	0.5	8	5	11.47	4.24	28	28	31.02	11.46	
2929	0.52	8	4	93.09	30.07	20	20	251.83	81.34	
3088	0.64	4	5	264.93	375.31	42.92	31.32	747.49	899.24	
3991	0.21	3	3	1110.03	949.14	31.85	33.94	2859.61	2778.8	
8841	0.13	6	3	263.24	0	38.58	0	609.11	0	
8842	1.86	1	3	2915.51	0	39.7	0	6736.6	0	
8843	0.11	6	3	506.29	0	33.65	0	1134.9	0	
8844	0.29	3	3	907.56	1489.74	34.36	21.25	2201.25	3928.36	
8845	0.34	3	3	868.47	1433.83	34.7	23.13	1940.42	3674.73	
8846	0.53	4	3	504.53	183.16	25.92	30.97	1407.68	983.68	
8849	1.23	1	3	2031.51	0	61.5	0	4824.01	0	
8855	0.52	5	2	92.65	82.39	19.84	19.89	439.35	490.5	
8857	0.62	3	3	312.16	861.03	35.94	27.8	723.56	2326.12	

Record: 1 of 300

Again, this is not a good format for calculating emissions. We need each speed/VMT combination in a separate row.

We now have 20 speed/VMT combinations on each row (10 periods X 2 directions = 20).

I developed what I call a “reverse crosstab” to format this properly.

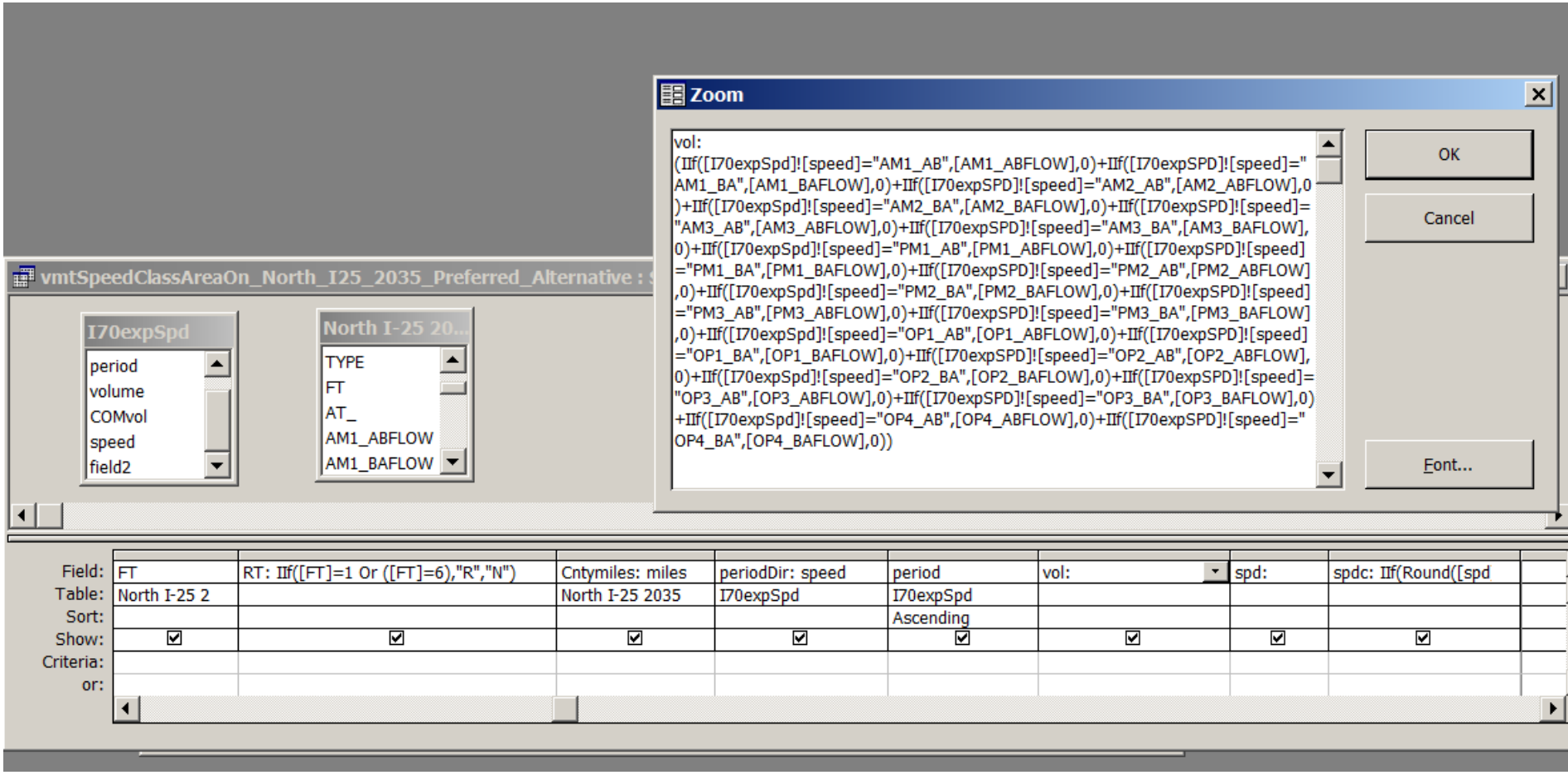
The following table has one row for each period and direction to facilitate this.

ExpandSpd Table

I70expSpd : Table

period	volume	COMvol	speed	field2
1	AM1_ABFLOW	AM1_ABCOMF	AM1_AB	AM1_AB
1	AM1_BAFLOW	AM1_BACOMF	AM1_BA	AM1_BA
2	AM2_ABFLOW	AM2_ABCOMF	AM2_AB	AM2_AB
2	AM2_BAFLOW	AM2_BACOMF	AM2_BA	AM2_BA
3	AM3_ABFLOW	AM3_ABCOMF	AM3_AB	AM3_AB
3	AM3_BAFLOW	AM3_BACOMF	AM3_BA	AM3_BA
4	PM1_ABFLOW	PM1_ABCOMF	PM1_AB	PM1_AB
4	PM1_BAFLOW	PM1_BACOMF	PM1_BA	PM1_BA
5	PM2_ABFLOW	PM2_ABCOMF	PM2_AB	PM2_AB
5	PM2_BAFLOW	PM2_BACOMF	PM2_BA	PM2_BA
6	PM3_ABFLOW	PM3_ABCOMF	PM3_AB	PM3_AB
6	PM3_BAFLOW	PM3_BACOMF	PM3_BA	PM3_BA
7	OP1_ABFLOW	OP1_ABCOMF	OP1_AB	OP1_AB
7	OP1_BAFLOW	OP1_BACOMF	OP1_BA	OP1_BA
8	OP2_ABFLOW	OP2_ABCOMF	OP2_AB	OP2_AB
8	OP2_BAFLOW	OP2_BACOMF	OP2_BA	OP2_BA
9	OP3_ABFLOW	OP3_ABCOMF	OP3_AB	OP3_AB
9	OP3_BAFLOW	OP3_BACOMF	OP3_BA	OP3_BA
10	OP4_ABFLOW	OP4_ABCOMF	OP4_AB	OP4_AB
10	OP4_BAFLOW	OP4_BACOMF	OP4_BA	OP4_BA

Reverse Crosstab Query



Each row of the “ExpandSpd” table is inserted into the output of this query, so we now have 20 times as many rows as we did originally.

The zoomed code uses “if” statements to parse out the speed and volume data.

Output of “reverse crosstab query:

vmtSpeedClassAreaOn_North_I25_2035_Preferred_Alternative : Select Query

ID	Rural?	AT_	FT	RT	Cntymiles	periodDir	period	vol	spd	spdc
16923	U	3	1	R	0.254630141	AM1_BA	1	0	0	2.5
16923	U	3	1	R	0.254630141	AM1_AB	1	2350.55	57.09	57
16923	U	3	1	R	0.254630141	AM2_AB	2	5373.62	46.78	47
16923	U	3	1	R	0.254630141	AM2_BA	2	0	0	2.5
16923	U	3	1	R	0.254630141	AM3_AB	3	4745.49	56.54	57
16923	U	3	1	R	0.254630141	AM3_BA	3	0	0	2.5
16923	U	3	1	R	0.254630141	PM1_AB	4	8618.44	58.36	58
16923	U	3	1	R	0.254630141	PM1_BA	4	0	0	2.5
16923	U	3	1	R	0.254630141	PM2_BA	5	0	0	2.5
16923	U	3	1	R	0.254630141	PM2_AB	5	4552.78	55.11	55
16923	U	3	1	R	0.254630141	PM3_BA	6	0	0	2.5
16923	U	3	1	R	0.254630141	PM3_AB	6	4080.01	60.42	60
16923	U	3	1	R	0.254630141	OP1_AB	7	6899.35	64	64
16923	U	3	1	R	0.254630141	OP1_BA	7	0	0	2.5
16923	U	3	1	R	0.254630141	OP2_AB	8	10546.32	60.71	61
16923	U	3	1	R	0.254630141	OP2_BA	8	0	0	2.5
16923	U	3	1	R	0.254630141	OP3_AB	9	15713.33	58.21	58
16923	U	3	1	R	0.254630141	OP3_BA	9	0	0	2.5
16923	U	3	1	R	0.254630141	OP4_BA	10	0	0	2.5
16923	U	3	1	R	0.254630141	OP4_AB	10	11381.42	63.84	64

Record: 1 of 20 (Filtered)

“AT_” is the area type field – all area types except 5 are urban, and 5 is rural.
“FT” is the facility type field – a facility type of 1 is a freeway thus the “RT”
Field is equal to R for restricted. Note that this link does not really exist in the “BA” direction.

The previous table now is in the proper format to calculate emissions – one row For each speed, volume and distance (VMT equals volume times distance).

There is still one problem – we do not have the VMT by vehicle type.

MOVES has 14 vehicle types (Source Types), but has a super class of 6 HPMS classes. For example, HPMS Class 50 is broken down into 4 types as follows:

51 Refuse Truck Trucks primarily used to haul refuse to a central location.

52 Single Unit Short-haul Truck Single unit trucks with more than four tires with a range of operation of up to 200 miles.

53 Single Unit Long-haul Truck Single unit trucks with more than four tires with a range of operation of over 200 miles.

54 Motor Home Trucks whose primary functional design is to provide sleeping quarters.

Traffic Counts

The Federal Highway Administration (FHWA) has 13 vehicle classes, and requires states to maintain a system of traffic counters to count vehicles by these 13 classes.

The Colorado Department of Transportation (CDOT) has such a system which they permanently maintain on selected principle arterials and freeways. They also supplement these Permanent counters with temporary counters on lower level facilities.

This is important because freeways and principal arterials have a higher percentage of heavy trucks than the lower level roads such as minor arterials, collectors and local streets.

I have modified a crosswalk between the FHWA vehicle classes and the 6 HPMS Mobile6 vehicle classes for MOVES. ENVIRON developed the original crosswalk for The Lake Michigan Air Directors Consortium (LADCO) . (The counters can not differentiate all 14 of the MOVES Source Types, nor can they differentiate fuel type).

I used this crosswalk with the CDOT traffic count data to develop the following table of the fraction of VMT by HPMS vehicle class.

Vehicle Mix Fractions From CDOT Traffic Counters

Query3 : Select Query

Weld?	Rural?	FUNCCLA	RT	Hour	f10	f20	f30	f40	f50	f60
0	0	3	N	17	0.00246737	0.50596828	0.469348	0.00167214	0.0062644	0.01428
0	0	4	N	17	0.01762288	0.49921786	0.463876	0.00315087	0.0068742	0.0092585
0	0	5	N	17	0.02108039	0.49650913	0.462755	0.00403975	0.0076663	0.0079496
0	0	6	N	17	0.02108039	0.49650913	0.462755	0.00403975	0.0076663	0.0079496
0	0	7	N	17	0.02108039	0.49650913	0.462755	0.00403975	0.0076663	0.0079496
-1	-1	1	R	17	0.00366469	0.45711724	0.497437	0.00146128	0.0130645	0.0272553
-1	-1	2	R	17	0.00050244	0.48397010	0.499660	0.00017733	0.0062587	0.0094313
-1	0	1	R	17	0.00366469	0.45711724	0.497437	0.00146128	0.0130645	0.0272553
-1	0	2	R	17	0.00058261	0.47642730	0.499594	0.00023014	0.0080221	0.0151442
0	-1	1	R	17	0.00258812	0.48744728	0.498584	0.00024439	0.0027036	0.0084328
0	-1	2	R	17	0.00052117	0.49707371	0.499650	0.00017878	0.0014965	0.0010798
0	0	1	R	17	0.00104869	0.48612981	0.499348	0.00025568	0.0048788	0.0083392
0	0	2	R	17	0.00052117	0.49707371	0.499650	0.00017878	0.0014965	0.0010798

Record: 1 of 28 (Filtered)

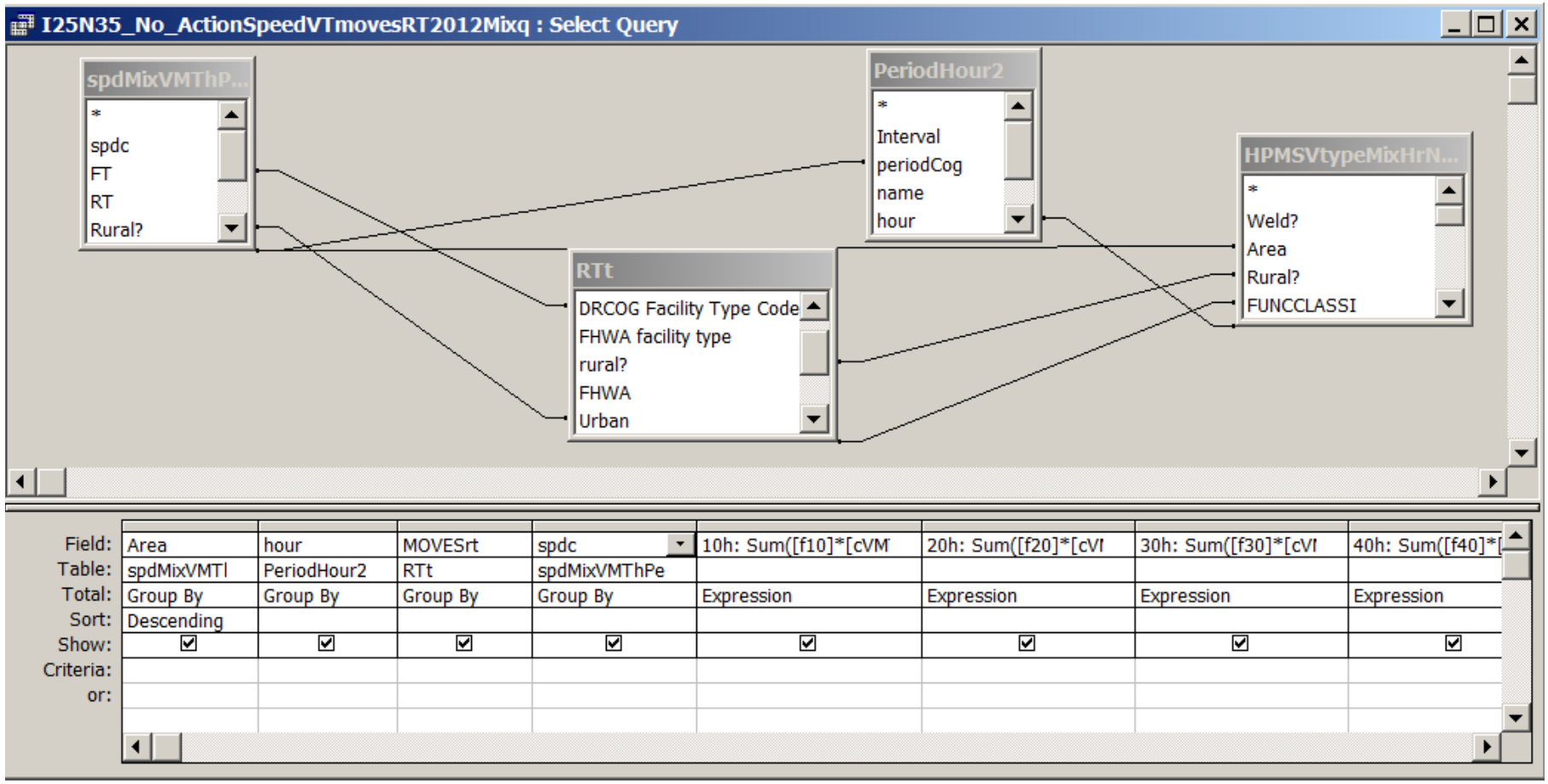
Weld County Colorado is broken out because of having a higher percentage of heavy trucks due to the intensive oil and gas development in that county.

Now we finally have all the information needed to calculate VMT
by vehicle type .

The following query performs this calculation using the reverse crosstab query and the vehicle mix fraction table. The query also uses two additional tables to translate The DRCOG road types to the CDOT road types, and to translate the DRCOG periods to hours.

The design of this query is shown in the following slide:

Calculation of VMT by HPMS Vehicle Type



Field:	Area	hour	MOVESrt	spdc	10h: Sum([f10]*[cVM	20h: Sum([f20]*[cVI	30h: Sum([f30]*[cVI	40h: Sum([f40]*[
Table:	spdMixVMTl	PeriodHour2	RTt	spdMixVMThPe				
Total:	Group By	Group By	Group By	Group By	Expression	Expression	Expression	Expression
Sort:	Descending							
Show:	☑	☑	☑	☑	☑	☑	☑	☑
Criteria:								
or:								

VMT by HPMS Vehicle Type

I25N35_No_ActionSpeedVTmovesRT2012Mixq : Select Query

Area	hour	MOVESrt	spdc	10h	20h	30h	40h	50h	60h
D	1	4	2.5	0	0	0	0	0	0
D	1	4	39	0.53540208	290.40552	319.4834	0.3148245	2.7426121	26.3352658
D	1	4	62	2.07408727	1124.9982	1237.6426	1.2195947	10.62457	102.019849
D	1	4	64	11.2267892	6089.4824	6699.2133	6.6015219	57.509541	552.221383
D	1	4	65	4.93970365	2679.3269	2947.604	2.9046205	25.303770	242.973297
D	1	5	13	4.96451516	132.66200	124.59648	1.3567360	3.3617913	8.65271517
D	1	5	16	12.9209285	345.27364	324.28187	3.531118	8.7495886	22.5200468
D	1	5	20	4.13223146	110.42168	103.70832	1.1292839	2.7981987	7.20211757
D	1	5	22	2.7604719	73.765456	69.280701	0.7544003	1.8692924	4.81126078
D	1	5	25	1.64842178	44.049202	41.371121	0.4504918	1.1162520	2.87305481
D	1	5	26	1.89382063	328.53469	304.10404	1.1848100	3.5722484	48.6954646
D	1	5	28	0.14610022	3.9040967	3.6667374	0.0399272	0.0989338	0.25463989
D	1	5	31	4.21807487	119.16323	110.23200	1.1994008	1.0701100	3.43561365
D	1	5	35	4.98559625	140.84619	130.28983	1.4176439	1.2648274	4.0607583
D	1	5	36	12.237682	2110.8764	1953.9363	7.627118	22.983971	312.691839
D	1	5	42	3.85979303	669.58607	619.79400	2.4147596	7.2805943	99.2461544
D	1	5	47	4.63521819	130.94779	121.13331	1.3180146	1.1759377	3.77537606
D	2	4	2.5	0	0	0	0	0	0
D	2	4	39	0.59941385	278.35831	319.29966	0.6182827	3.9045262	37.0368299
D	2	4	62	2.32206166	1078.3287	1236.9309	2.3951574	15.125694	143.476501

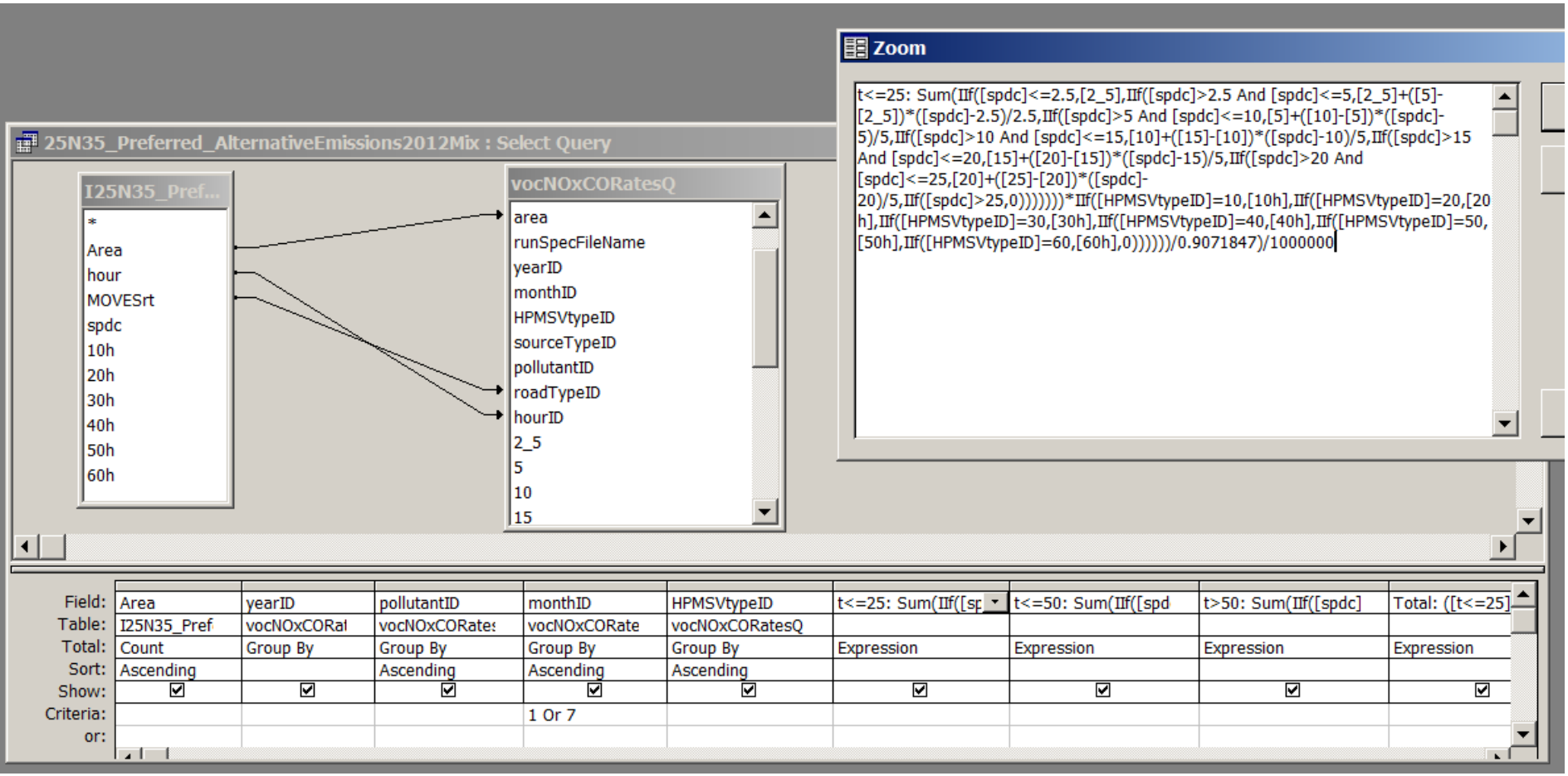
Record: 1 of 658

Now we are ready to calculate emissions (**Finally**!).

The following slide shows the design of the query to do this calculation with the VMT by HPMS Vehicle Type query and the emission rates crosstab query.

The emission rates table has factors for each average speed bin in a separate column in each row, and each row is for a different vehicle type.

The VMT table has the VMT for each vehicle type in a separate column in each row, and each row is for a different speed.



The two tables are related to each other by linking hour and road type. The Area fields are also linked because two of the counties have different emission factors .

The zoomed code shows the selection of the correct speed bins, VMT by vehicle class and the interpolation between speed bins by speed.

Emissions output in tons per day summed by vehicle type, month and pollutant code. VMT is also provided, and is an important QA check to see that the total is the same as we started with.

25N35_Preferred_AlternativeEmissions2012Mix : Select Query

pollutantID	yearID	monthID	HPMSVtypeID	VMT	t<=25	t<=50	t>50	Total
2	2040	1	10	11,217	0.0653600031	0.0503182378	0.0201100780	0.1357883189
2	2040	1	20	1,702,463	0.2451799628	0.6735281052	0.8524761565	1.7711842245
2	2040	1	30	1,708,842	0.2485145886	0.7454196447	1.0469107890	2.0408450223
2	2040	1	40	4,189	0.0011237751	0.0012003479	0.0003231578	0.0026472808
2	2040	1	50	24,025	0.0076562703	0.0159121639	0.0103934285	0.0339618627
2	2040	1	60	62,731	0.0042089741	0.0116989127	0.0085003983	0.0244082851
2	2040	7	10	11,217	0.0653600031	0.0503182378	0.0201100780	0.1357883189
2	2040	7	20	1,702,463	0.3534672267	1.0364017075	1.1478772095	2.5377461437
2	2040	7	30	1,708,842	0.3535443288	1.1369365745	1.3945811894	2.8850620927
2	2040	7	40	4,189	0.0011237751	0.0012003479	0.0003231577	0.0026472807
2	2040	7	50	24,025	0.0076562703	0.0159121666	0.0103934285	0.0339618654
2	2040	7	60	62,731	0.0042089741	0.0116989126	0.0085003983	0.0244082850
3	2040	1	10	11,217	0.0030911237	0.0033119186	0.0015032381	0.0079062805
3	2040	1	20	1,702,463	0.0061448720	0.0258342365	0.0404417486	0.0724208571
3	2040	1	30	1,708,842	0.0096567361	0.0391814933	0.0628879897	0.1117262192
3	2040	1	40	4,189	0.0028562589	0.0026376242	0.000763087	0.0062569702
3	2040	1	50	24,025	0.0050862187	0.0096305292	0.0069442963	0.0216610442
3	2040	1	60	62,731	0.0167143177	0.0477100846	0.0396705254	0.1040949278
3	2040	7	10	11,217	0.0026133118	0.0028015211	0.0012902821	0.0067051150
3	2040	7	20	1,702,463	0.0060479017	0.0252236201	0.0385550578	0.0698265796
3	2040	7	30	1,708,842	0.0097970656	0.0383476415	0.059940004	0.1080847110
3	2040	7	40	4,189	0.0025724573	0.0023705976	0.0006961399	0.0056391949
3	2040	7	50	24,025	0.0045605272	0.0084428492	0.0061851838	0.0191885602
3	2040	7	60	62,731	0.0151133000	0.0427625305	0.0362459489	0.0941217794
87	2040	1	10	11,217	0.0106398380	0.0052969063	0.0014153527	0.017352097
87	2040	1	20	1,702,463	0.0124045389	0.0222268897	0.018420038	0.0530514666

Record: 1 of 36

The example just presented is only for on-network emissions.
The on-network emissions are roughly 75% of the CO and NOx emissions, but only about 25% of the VOC emissions.

To calculate the off-network emissions we link to the rates per vehicle and rates per profile Tables from the MOVES MySQL output database (using the MySQL OBDC driver).

Emissions from these tables are in grams per vehicle by hour, and we would calculate emissions by multiplying by the vehicle population for the appropriate vehicle class.

Questions?