APPENDIX F

Treatment of Vessel Emissions as Elevated Point Sources in the HGA Nonattainment Area

Houston/Galveston Attainment Demonstration and
Post-1999 Rate-of-Progress SIP

December 2000

Introduction

Ships are typically modeled as line or area sources, that is, their emissions are assumed to occur either along a series of straight lines (e.g. channels, canals, shipping lanes) or across large expanses of navigable water. In the past, the Commission treated emissions from commercial vessels in the Galveston Bay system (except for some fishing vessels) as line sources, primarily occurring along the Houston Ship Channel and the Intracoastal Waterway. The emissions were then input into EPS-2 and processed into gridded, model-ready emissions data files. The drawback to this approach is that it places all ship emissions within the first vertical layer of the model, which is only 20 meters deep. However, many ships have stacks which are more than 20 meters (about 60 feet) above the water line, and many more emit exhaust gases which rise above 20 meters through momentum or thermal buoyancy. In fact, some ships may even emit gases which rise above the second model layer (top at 80 meters).

It is important to place emissions into the correct vertical layers since ozone production depends largely on the concentrations of precursor pollutants in each 3-dimensional grid cell. For example, emissions in the lowest layer mix immediately precursor emissions from other ground-level sources, while elevated emissions may travel some distance before being mixed with significant amounts of precursors from other sources. In some cases, large emissions of NO_X at ground level can cause local ozone titration (i.e. reduce ozone concentration by reacting with it), but in other circumstances can lead to higher peak ozone concentrations. Elevated NO_X emissions are more often associated with increased ozone concentrations downwind from the source. In any case, it is important to assign emissions to the correct vertical layer to ensure that they are modeled appropriately.

Unfortunately, present-day emission processing software does not readily accommodate line sources which are not contained within the lowest layer of the modeling domain. Only point sources are afforded the opportunity to inject emissions into the upper layers. If the ships remained stationary throughout the modeled episode, then it would be relatively easy to just treat each vessel as a stationary point source and process it along with the conventional point sources. But the ships do move along the various corridors, and it is clearly not practical to treat them as non-stationary points. So the Commission modeling staff devised a methodology that uses a large number of pseudo-stacks placed along the shipping lanes which approximate a line source, but still allow CAMx to loft the emissions to the appropriate elevation.

Emissions Data

Appendix C of this SIP contains a detailed description of the development of the marine vessel emissions inventory in the Galveston Bay system. The contractor, Starcrest, Inc., provided Commission staff with emissions for several classes of commercial vessels, divided into segments, where each segment is a portion of one of the major shipping lanes. Emissions by segment for various classes of vessels are provided in Table 1 (1993) and Table 2 (2007) at the end of this document (descriptions of the segments themselves are provided in Table 3). The contractor provided emissions for both transit segments and “dwelling” zones, where ships are moored but typically operate their engines at or near idle speeds. Because some of the segments were not straight lines, Commission staff used a GIS to break some of the segments into sub-segments, each consisting of straight lines. Table 3 lists the segments and sub-segments, along with the starting and ending points (in UTM zone 15) coordinates of each.

Next, a SAS program was developed to identify locations along the sub-segments to place the pseudo-stacks. Since the area covered lies within the 4 km × 4 km fine-grid, it was necessary to ensure that the

distance between pseudo-stacks was much smaller than 4 km to ensure that emissions would be allocated smoothly along the shipping lanes. The SAS program was coded to space the pseudo-stacks evenly along each sub-segment so that the maximum distance between points was no more than one kilometer. Also, to avoid concentrating emissions at the points where two sub-segments join, the first and last pseudo-stacks were placed up to one-half kilometer from the respective endpoints. Emissions for each segment were divided among its sub-segments in proportion to their lengths, then apportioned equally among the pseudo-stacks on the sub-segment.

Because the various classes of vessels have differing physical stack parameters, it was decided that a pseudo-stack would be constructed for each vessel class at each location. The Commission modeling staff received typical stack parameters from Starcrest for each of the 13 vessel classes, as shown in Table 4. The SAS program then wrote the output as AFS recoeds, which were processed through SMOKE to provide CAMx-ready input data files. Figure 1 shows NO_X emissions for September 9, 1993 (all vertical layers have been collapsed for the figure).

Table 1: 1993 commercial vessel emissions by segment

			Emissions (tons/day)		
Segment	Vessel Type	Category	NO_X	VOC	CO
FT01	Ocean-Going Vessels	2280003010	0.056667998	0.001630596	0.005708983
FD01	Ocean-Going Vessels	2280003010	0.558940885	0.014264397	0.097901701
GT01	Ocean-Going Vessels	2280003010	0.273466021	0.007868861	0.027550166
GD01	Ocean-Going Vessels	2280003010	0.829942526	0.021180468	0.145369192
TT01	Ocean-Going Vessels	2280003010	0.71882497	0.020683863	0.072417578
TD01	Ocean-Going Vessels	2280003010	1.350491511	0.034465088	0.236546332
BT01	Bulk Cargo Vessels	2280003011	0.004731674	0.000132029	0.000452351
BT01	General Cargo Vessels	2280003012	0	0	0
BT01	Container Ships	2280003013	0	0	0
BT01	Liquefied Gas Carriers	2280003014	0.051331059	0.001427329	0.005019319
BT01	Oil/Chemical Tankers	2280003015	0.472493722	0.013586049	0.047111078
BT01	Other Ocean-Going-Vessels	2280003016	0	0	0
BT01	Cruise Ships	2280003017	0	0	0
BD01	Bulk Cargo Vessels	2280003011	0.000908794	2.34055E-05	0.000142259
BD01	General Cargo Vessels	2280003012	0	0	0
BD01	Container Ships	2280003013	0	0	0
BD01	Liquefied Gas Carriers	2280003014	0.076077635	0.001757338	0.013795387
BD01	Oil/Chemical Tankers	2280003015	0.363228356	0.009672773	0.070535927
BD01	Other Ocean-Going-Vessels	2280003016	0	0	0
HT01	Bulk Cargo Vessels	2280003011	0.809908059	0.02295873	0.078648294
HT01	General Cargo Vessels	2280003012	1.106863981	0.032823955	0.11397974

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
HT01	Container Ships	2280003013	0.53011214	0.014733727	0.051336345
HT01	Liquefied Gas Carriers	2280003014	0.308130183	0.00855633	0.030159279
HT01	Oil/Chemical Tankers	2280003015	2.804173994	0.080514041	0.280413097
HT01	Other Ocean-Going-Vessels	2280003016	0.166377034	0.005358688	0.018801326
HD01	Bulk Cargo Vessels	2280003011	0.014717107	0.000379093	0.002306359
HD01	General Cargo Vessels	2280003012	0.045812693	0.00115657	0.007196583
HD01	Container Ships	2280003013	0.269421424	0.006814245	0.041134217
HD01	Liquefied Gas Carriers	2280003014	0.011481228	0.000265208	0.002081926
HD01	Oil/Chemical Tankers	2280003015	0.062220703	0.001657031	0.012083381
HD01	Other Ocean-Going-Vessels	2280003016	0.07509934	0.001929047	0.011540053
HT02	Bulk Cargo Vessels	2280003011	0.113833392	0.003221033	0.011227631
HT02	General Cargo Vessels	2280003012	0.156990924	0.00462159	0.016469952
HT02	Container Ships	2280003013	0.01070628	0.000296553	0.00105731
HT02	Liquefied Gas Carriers	2280003014	0.049695391	0.001374393	0.005017106
HT02	Oil/Chemical Tankers	2280003015	0.42243435	0.012105247	0.043316843
HT02	Other Ocean-Going-Vessels	2280003016	0.02158833	0.000696302	0.002489237
HD02	Bulk Cargo Vessels	2280003011	0.007228437	0.000186194	0.001132745
HD02	General Cargo Vessels	2280003012	0	0	0
HD02	Container Ships	2280003013	0	0	0
HD02	Liquefied Gas Carriers	2280003014	0	0	0
HD02	Oil/Chemical Tankers	2280003015	0.299645069	0.007979607	0.058187226
HD02	Other Ocean-Going-Vessels	2280003016	0	0	0
HT03	Bulk Cargo Vessels	2280003011	0.031610989	0.000890358	0.003245385
HT03	General Cargo Vessels	2280003012	0.052288418	0.001515653	0.005697065
HT03	Container Ships	2280003013	0.004587178	0.000126471	0.000464916
HT03	Liquefied Gas Carriers	2280003014	0.015503448	0.000424431	0.001685743
HT03	Oil/Chemical Tankers	2280003015	0.120481927	0.003439302	0.013015428
HT03	Other Ocean-Going-Vessels	2280003016	0.007193084	0.000228101	0.000864205
HD03	Bulk Cargo Vessels	2280003011	0.15139567	0.003899694	0.02372322
HD03	General Cargo Vessels	2280003012	0.243804706	0.006155413	0.038302154
HD03	Container Ships	2280003013	0	0	0
HD03	Liquefied Gas Carriers	2280003014	0.18964322	0.00438062	0.034388578
HD03	Oil/Chemical Tankers	2280003015	1.460827045	0.038901663	0.283677572

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
HD03	Other Ocean-Going-Vessels	2280003016	0.096945955	0.002490265	0.014899329
HT04	Bulk Cargo Vessels	2280003011	0.043731098	0.001230682	0.004519017
HT04	General Cargo Vessels	2280003012	0.072400882	0.00209353	0.007980938
HT04	Container Ships	2280003013	0.009174356	0.000252942	0.000929832
HT04	Liquefied Gas Carriers	2280003014	0.012062004	0.000329011	0.001346354
HT04	Oil/Chemical Tankers	2280003015	0.082694541	0.002377343	0.008657137
HT04	Other Ocean-Going-Vessels	2280003016	0.009868203	0.000315479	0.001201545
HD04	Bulk Cargo Vessels	2280003011	0.123589674	0.003183461	0.019366178
HD04	General Cargo Vessels	2280003012	0.373148778	0.009420801	0.058620589
HD04	Container Ships	2280003013	0	0	0
HD04	Liquefied Gas Carriers	2280003014	0.363137339	0.008388208	0.06584879
HD04	Oil/Chemical Tankers	2280003015	0.325019213	0.008655569	0.0631187
HD04	Other Ocean-Going-Vessels	2280003016	0.097275284	0.00249869	0.014948466
HT05	Bulk Cargo Vessels	2280003011	0.00467673	0.00013117	0.000496684
HT05	General Cargo Vessels	2280003012	0.014044319	0.000406189	0.001485125
HT05	Container Ships	2280003013	0.001823789	5.01141E-05	0.000188255
HT05	Liquefied Gas Carriers	2280003014	0.001677032	4.86734E-05	0.000162714
HT05	Oil/Chemical Tankers	2280003015	0.04074249	0.001194195	0.003906562
HT05	Other Ocean-Going-Vessels	2280003016	0.00111494	3.55138E-05	0.000140183
HD05	Bulk Cargo Vessels	2280003011	0.267674634	0.006894817	0.04194274
HD05	General Cargo Vessels	2280003012	0.560678789	0.014155261	0.088080429
HD05	Container Ships	2280003013	0.049818094	0.001260021	0.007606153
HD05	Liquefied Gas Carriers	2280003014	0.040909125	0.000944971	0.007418175
HD05	Oil/Chemical Tankers	2280003015	0.222305366	0.00592	0.043171726
HD05	Other Ocean-Going-Vessels	2280003016	0.126139085	0.003241231	0.01943151
BF01	Ferries	2280002022	1.207	0.025	0.226
IT01	Towboats	2280002023	2.444	0.063	0.367
IT02	Towboats	2280002023	1.223	0.031	0.183
GT01	Assist Tugboats	2280002021	0.275	0.003	0.051
GT01	Towboats	2280002023	0.010	0.000	0.002
GT02	Assist Tugboats	2280002021	0.275	0.003	0.051
GT02	Towboats	2280002023	0.010	0.000	0.002
GD01	Barge Pumps	2280002026	0.033	0.001	0.005

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
TT01	Assist Tugboats	2280002021	0.044	0.000	0.008
TT01	Towboats	2280002023	0.236	0.002	0.044
TT02	Assist Tugboats	2280002021	0.044	0.000	0.008
TT02	Towboats	2280002023	0.239	0.002	0.044
TD01	Barge Pumps	2280002026	0.345	0.009	0.052
FT01	Assist Tugboats	2280002021	0.121	0.001	0.023
FT01	Towboats	2280002023	0.046	0.000	0.009
FD01	Barge Pumps	2280002026	0.060	0.002	0.009
BT01	Assist Tugboats	2280002021	0.085	0.001	0.016
BT01	Towboats	2280002023	0.131	0.001	0.024
BT02	Assist Tugboats	2280002021	0.046	0.000	0.008
BT02	Towboats	2280002023	0.131	0.001	0.024
BD01	Barge Pumps	2280002026	0.080	0.002	0.012
HT01	Excursions	2280002024	0.000	0.000	0.000
HT01	Assist Tugboats	2280002021	0.125	0.001	0.023
HT01	Towboats	2280002023	2.243	0.021	0.416
HD01	Barge Pumps	2280002026	0.000	0.000	0.000
HT02	Assist Tugboats	2280002021	0.057	0.001	0.011
HT02	Towboats	2280002023	0.978	0.009	0.182
HD02	Barge Pumps	2280002026	0.216	0.006	0.032
HT03	Assist Tugboats	2280002021	0.444	0.005	0.082
HT03	Ferries	2280002022	0.022	0.001	0.004
HT03	Towboats	2280002023	0.978	0.009	0.182
HD03	Barge Pumps	2280002026	0.224	0.006	0.034
HT04	Assist Tugboats	2280002021	0.194	0.002	0.036
HT04	Towboats	2280002023	0.978	0.009	0.182
HD04	Barge Pumps	2280002026	0.224	0.006	0.034
HT05	Assist Tugboats	2280002021	0.194	0.002	0.036
HT05	Excursions	2280002024	0.000	0.000	0.000
HT05	Towboats	2280002023	0.575	0.005	0.107
HD05	Barge Pumps	2280002026	0.056	0.002	0.008
GT01	Dredging Emissions	2280002025	0.1623	0.0020	0.0291
BT01	Dredging Emissions	2280002025	0.0901	0.0011	0.0161

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
GT02	Dredging Emissions	2280002025	0.0011	0.0000	0.0002
IT02	Dredging Emissions	2280002025	0.0606	0.0008	0.0108
FT01	Dredging Emissions	2280002025	0.0601	0.0008	0.0107
BF01	Dredging Emissions	2280002025	0.2762	0.0035	0.0494

Table 2: 2007 commercial vessel emissions by segment

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
FT01	Ocean-Going Vessels	2280003010	0.095708793	0.002753977	0.009642123
FD01	Ocean-Going Vessels	2280003010	0.94401707	0.024091696	0.165350003
GT01	Ocean-Going Vessels	2280003010	0.216859267	0.006240027	0.021847353
GD01	Ocean-Going Vessels	2280003010	0.658146584	0.016796166	0.115278148
TT01	Ocean-Going Vessels	2280003010	0.990354116	0.028496992	0.099772615
TD01	Ocean-Going Vessels	2280003010	1.860626556	0.04748394	0.32589941
BT01	Bulk Cargo Vessels	2280003011	0.007587114	0.000211705	0.000725332
BT01	General Cargo Vessels	2280003012	0	0	0
BT01	Container Ships	2280003013	0.204505196	0.005683937	0.019804393
BT01	Liquefied Gas Carriers	2280003014	0.082308002	0.002288684	0.008048345
BT01	Oil/Chemical Tankers	2280003015	0.757631245	0.021784873	0.075541374
BT01	Other Ocean-Going-Vessels	2280003016	0	0	0
BT01	Cruise Ships	2280003017	0.518082192	0.022794521	0.069041096
BD01	Bulk Cargo Vessels	2280003011	0.001457228	3.75302E-05	0.000228108
BD01	General Cargo Vessels	2280003012	0	0	0
BD01	Container Ships	2280003013	0.103936652	0.002628781	0.015868644
BD01	Liquefied Gas Carriers	2280003014	0.121988485	0.002817845	0.02212054
BD01	Oil/Chemical Tankers	2280003015	0.582427106	0.015510037	0.113102502
BD01	Other Ocean-Going-Vessels	2280003016	0	0	0
BD01	Cruise Ships	2280003017	0.626849315	0.013561644	0.120821918
HT01	Bulk Cargo Vessels	2280003011	1.298666252	0.03681372	0.126110468
HT01	General Cargo Vessels	2280003012	1.774827256	0.052632348	0.182763513
HT01	Container Ships	2280003013	0.645515665	0.017941207	0.062512084
HT01	Liquefied Gas Carriers	2280003014	0.494078638	0.01371985	0.04835961
HT01	Oil/Chemical Tankers	2280003015	4.49641918	0.129102145	0.449635019
HT01	Other Ocean-Going-Vessels	2280003016	0.266781195	0.008592515	0.030147432
HD01	Bulk Cargo Vessels	2280003011	0.023598494	0.000607866	0.003698185
HD01	General Cargo Vessels	2280003012	0.073459448	0.001854529	0.011539532
HD01	Container Ships	2280003013	0.328073509	0.008297682	0.050088989
HD01	Liquefied Gas Carriers	2280003014	0.018409848	0.000425254	0.003338313
HD01	Oil/Chemical Tankers	2280003015	0.09976926	0.002657006	0.019375384
HD01	Other Ocean-Going-Vessels	2280003016	0.120419815	0.003093176	0.018504171

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
HT02	Bulk Cargo Vessels	2280003011	0.182528847	0.005164841	0.018003211
HT02	General Cargo Vessels	2280003012	0.251730814	0.007410598	0.026409134
HT02	Container Ships	2280003013	0.017167238	0.000475514	0.001695368
HT02	Liquefied Gas Carriers	2280003014	0.079685251	0.002203803	0.008044798
HT02	Oil/Chemical Tankers	2280003015	0.677362359	0.019410445	0.069457418
HT02	Other Ocean-Going-Vessels	2280003016	0.034616319	0.001116503	0.003991426
HD02	Bulk Cargo Vessels	2280003011	0.011590609	0.000298557	0.001816326
HD02	General Cargo Vessels	2280003012	0	0	0
HD02	Container Ships	2280003013	0	0	0
HD02	Liquefied Gas Carriers	2280003014	0	0	0
HD02	Oil/Chemical Tankers	2280003015	0.480472979	0.012795089	0.093301686
HD02	Other Ocean-Going-Vessels	2280003016	0	0	0
HT03	Bulk Cargo Vessels	2280003011	0.050687389	0.001427666	0.00520389
HT03	General Cargo Vessels	2280003012	0.083843102	0.00243031	0.009135094
HT03	Container Ships	2280003013	0.007355419	0.000202793	0.000745481
HT03	Liquefied Gas Carriers	2280003014	0.024859371	0.000680564	0.002703045
HT03	Oil/Chemical Tankers	2280003015	0.193189598	0.005514831	0.020869897
HT03	Other Ocean-Going-Vessels	2280003016	0.01153392	0.000365754	0.00138573
HD03	Bulk Cargo Vessels	2280003011	0.242758972	0.006253057	0.038039559
HD03	General Cargo Vessels	2280003012	0.390934427	0.009870043	0.061416496
HD03	Container Ships	2280003013	0	0	0
HD03	Liquefied Gas Carriers	2280003014	0.304087911	0.00702421	0.055141179
HD03	Oil/Chemical Tankers	2280003015	2.342397711	0.062377793	0.454869519
HD03	Other Ocean-Going-Vessels	2280003016	0.155450287	0.003993075	0.023890681
HT04	Bulk Cargo Vessels	2280003011	0.070121664	0.001973366	0.007246126
HT04	General Cargo Vessels	2280003012	0.116092909	0.003356921	0.012797225
HT04	Container Ships	2280003013	0.014710838	0.000405586	0.001490961
HT04	Liquefied Gas Carriers	2280003014	0.019341105	0.000527561	0.002158843
HT04	Oil/Chemical Tankers	2280003015	0.13259852	0.003812007	0.013881491
HT04	Other Ocean-Going-Vessels	2280003016	0.015823404	0.000505862	0.001926646
HD04	Bulk Cargo Vessels	2280003011	0.198172789	0.005104595	0.031053157
HD04	General Cargo Vessels	2280003012	0.598334242	0.015106007	0.093996571
HD04	Container Ships	2280003013	0	0	0

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
HD04	Liquefied Gas Carriers	2280003014	0.582281163	0.013450271	0.105586802
HD04	Oil/Chemical Tankers	2280003015	0.521159752	0.013878977	0.101209174
HD04	Other Ocean-Going-Vessels	2280003016	0.155978358	0.004006583	0.023969472
HT05	Bulk Cargo Vessels	2280003011	0.007499014	0.000210328	0.00079642
HT05	General Cargo Vessels	2280003012	0.022519696	0.000651314	0.002381359
HT05	Container Ships	2280003013	0.002924398	8.03567E-05	0.000301863
HT05	Liquefied Gas Carriers	2280003014	0.002689076	7.80465E-05	0.000260908
HT05	Oil/Chemical Tankers	2280003015	0.06532951	0.00191486	0.006264069
HT05	Other Ocean-Going-Vessels	2280003016	0.001787778	5.69454E-05	0.00022478
HD05	Bulk Cargo Vessels	2280003011	0.429209229	0.011055658	0.06725408
HD05	General Cargo Vessels	2280003012	0.899033678	0.022697589	0.141234649
HD05	Container Ships	2280003013	0.079882003	0.002020411	0.012196266
HD05	Liquefied Gas Carriers	2280003014	0.065596704	0.001515236	0.011894848
HD05	Oil/Chemical Tankers	2280003015	0.356460803	0.009492565	0.069224726
HD05	Other Ocean-Going-Vessels	2280003016	0.202260703	0.005197228	0.031157915
BF01	Ferries	2280002022	1.136	0.025	0.226
IT01	Towboats	2280002023	2.069	0.06	0.353
IT02	Towboats	2280002023	1.036	0.03	0.176
GT01	Assist Tugboats	2280002021	0.192	0.002	0.04
GT01	Towboats	2280002023	0.009	0	0.002
GT02	Assist Tugboats	2280002021	0.192	0.002	0.04
GT02	Towboats	2280002023	0.009	0	0.002
GD01	Barge Pumps	2280002026	0.032	0.001	0.005
TT01	Assist Tugboats	2280002021	0.053	0.001	0.011
TT01	Towboats	2280002023	0.2	0.002	0.042
TT02	Assist Tugboats	2280002021	0.053	0.001	0.011
TT02	Towboats	2280002023	0.202	0.002	0.043
TD01	Barge Pumps	2280002026	0.334	0.01	0.053
FT01	Assist Tugboats	2280002021	0.174	0.002	0.037
FT01	Towboats	2280002023	0.039	0	0.008
FD01	Barge Pumps	2280002026	0.058	0.002	0.009
BT01	Assist Tugboats	2280002021	0.12	0.001	0.025
BT01	Towboats	2280002023	0.111	0.001	0.023

Segment	Vessel Type	Category	Emissions (tons/day)		
			NO_X	VOC	CO
BT02	Assist Tugboats	2280002021	0.064	0.001	0.014
BT02	Towboats	2280002023	0.111	0.001	0.023
BD01	Barge Pumps	2280002026	0.077	0.002	0.012
HT01	Excursions	2280002024	0	0	0
HT01	Assist Tugboats	2280002021	0.177	0.002	0.037
HT01	Towboats	2280002023	1.899	0.021	0.4
HD01	Barge Pumps	2280002026	0	0	0
HT02	Assist Tugboats	2280002021	0.08	0.001	0.017
HT02	Towboats	2280002023	0.828	0.009	0.175
HD02	Barge Pumps	2280002026	0.209	0.006	0.033
HT03	Assist Tugboats	2280002021	0.627	0.008	0.132
HT03	Ferries	2280002022	0.021	0.001	0.004
HT03	Towboats	2280002023	0.828	0.009	0.175
HD03	Barge Pumps	2280002026	0.217	0.006	0.035
HT04	Assist Tugboats	2280002021	0.273	0.003	0.058
HT04	Towboats	2280002023	0.828	0.009	0.175
HD04	Barge Pumps	2280002026	0.217	0.006	0.035
HT05	Assist Tugboats	2280002021	0.273	0.003	0.058
HT05	Excursions	2280002024	0	0	0
HT05	Towboats	2280002023	0.487	0.005	0.103
HD05	Barge Pumps	2280002026	0.054	0.002	0.009
BT01	Dredging Emissions	2280002025	0.0465	0.0006	0.008
BT02	Dredging Emissions	2280002025	0.0465	0.0006	0.008
IT01	Dredging Emissions	2280002025	0.0465	0.0006	0.008
IT02	Dredging Emissions	2280002025	0.0465	0.0006	0.008
FP01	Dredging Emissions	2280002025	0.0465	0.0006	0.008

Table 3: Segments and Sub-Segments used to spatially allocate commercial vessel emissions

Segment Name	Segment	Sub-Segment	Segment Description	Start Easting	Start Northing	End Easting	End Northing
HT05	1	1	Transit - Sims Bayou to Turning Basin	278376.42	3293117.88	280446.99	3290357.11
HT05	1	2	Transit - Sims Bayou to Turning Basin	280446.99	3290357.11	283054.38	3289787.43
HD05	1	1	Dwelling - Zone 1	278376.42	3293117.88	280446.99	3290357.11
HD05	1	2	Dwelling - Zone 1	280446.99	3290357.11	283054.38	3289787.43
HT04	2	1	Transit - Greens Bayou to Sims Bayou	283054.38	3289787.43	285092.09	3290313.29
HT04	2	2	Transit - Greens Bayou to Sims Bayou	285092.09	3290313.29	287206.48	3292044.25
HT04	2	3	Transit - Greens Bayou to Sims Bayou	287206.48	3292044.25	290646.48	3292394.82
HD04	2	1	Dwelling - Zone 2	283054.38	3289787.43	285092.09	3290313.29
HD04	2	2	Dwelling - Zone 2	285092.09	3290313.29	287206.48	3292044.25
HD04	2	3	Dwelling - Zone 2	287206.48	3292044.25	290646.48	3292394.82
HT03	3	1	Transit - Lynchburg to Greens Bayou	290646.48	3292394.82	292837.56	3291430.74
HT03	3	2	Transit - Lynchburg to Greens Bayou	292837.56	3291430.74	294568.51	3291014.44
HT03	3	3	Transit - Lynchburg to Greens Bayou	294568.51	3291014.44	296934.88	3292657.75
HT03	3	4	Transit - Lynchburg to Greens Bayou	296934.88	3292657.75	298819.21	3294344.88
HD03	3	1	Dwelling - Zone 3	290646.48	3292394.82	292837.56	3291430.74
HD03	3	2	Dwelling - Zone 3	292837.56	3291430.74	294568.51	3291014.44
HD03	3	3	Dwelling - Zone 3	294568.51	3291014.44	296934.88	3292657.75
HD03	3	4	Dwelling - Zone 3	296934.88	3292657.75	298819.21	3294344.88
HT02	4	1	Transit - Barbours Cut to Lynchburg	298819.21	3294344.88	304285.96	3290105.14
HT02	4	2	Transit - Barbours Cut to Lynchburg	304285.96	3290105.14	305348.63	3287333.42
HT02	4	3	Transit - Barbours Cut to Lynchburg	305348.63	3287333.42	308169.65	3285432.66
HT02	4	4	Transit - Barbours Cut to Lynchburg	298819.21	3294344.88	301842.90	3290718.64
HD02	4	1	Dwelling - Zone 4	298819.21	3294344.88	304285.96	3290105.14

Segment Name	Segment	Sub-Segment	Segment Description	Start Easting	Start Northing	End Easting	End Northing
HD02	4	2	Dwelling - Zone 4	304285.96	3290105.14	305348.63	3287333.42
HD02	4	3	Dwelling - Zone 4	305348.63	3287333.42	308169.65	3285432.66
HD02	4	4	Dwelling - Zone 4	298819.21	3294344.88	301842.90	3290718.64
HD01	4	1	Dwelling - Barbours Cut	305644.43	3285109.47	307747.87	3285405.27
BT01	5	1	Transit - Sea Buoy to Bayport Docks	304001.12	3277626.93	310612.71	3277665.28
BT01	5	2	Transit - Sea Buoy to Bayport Docks	310612.71	3277665.28	311193.34	3275638.53
BT01	5	3	Transit - Sea Buoy to Bayport Docks	311193.34	3275638.53	318451.30	3266036.11
BT01	5	4	Transit - Sea Buoy to Bayport Docks	318451.30	3266036.11	325051.93	3250550.64
BT01	5	5	Transit - Sea Buoy to Bayport Docks	325051.93	3250550.64	326667.85	3247959.69
BT01	5	6	Transit - Sea Buoy to Bayport Docks	326667.85	3247959.69	327944.16	3247494.09
BT01	5	7	Transit - Sea Buoy to Bayport Docks	327944.16	3247494.09	330255.75	3247658.42
BT01	5	8	Transit - Sea Buoy to Bayport Docks	330255.75	3247658.42	342098.54	3245697.40
BD01	5	1	Dwelling - Bayport	304012.07	3277155.85	305962.14	3277495.47
HT01	5	1	Sea Buoy to Barbours Cut	301842.90	3290718.64	311193.34	3275638.53
HT01	5	2	Transit - Sea Buoy to Barbours Cut	311193.34	3275638.53	318451.30	3266036.11
HT01	5	3	Transit - Sea Buoy to Barbours Cut	318451.30	3266036.11	325051.93	3250550.64
HT01	5	4	Transit - Sea Buoy to Barbours Cut	325051.93	3250550.64	326667.85	3247959.69
HT01	5	5	Transit - Sea Buoy to Barbours Cut	326667.85	3247959.69	327944.16	3247494.09
HT01	5	6	Transit - Sea Buoy to Barbours Cut	327944.16	3247494.09	330255.75	3247658.42
HT01	5	7	Transit - Sea Buoy to Barbours Cut	330255.75	3247658.42	342098.54	3245697.40
TT01	5	1	Transit - Sea Buoy to Texas City Jetty	327944.16	3247494.09	330255.75	3247658.42
TT01	5	2	Transit - Sea Buoy to Texas City Jetty	330255.75	3247658.42	342098.54	3245697.40
TD01	5	1	Dwelling - Port of Texas City	313708.79	3249763.90	316381.87	3249676.26
TD01	5	2	Dwelling - Port of Texas City	316381.87	3249676.26	316622.89	3251330.50

Segment Name	Segment	Sub-Segment	Segment Description	Start Easting	Start Northing	End Easting	End Northing
GT01	5	1	Transit - Sea Buoy to Galveston Channel Entrance	327944.16	3247494.09	330255.75	3247658.42
GT01	5	2	Transit - Sea Buoy to Galveston Channel Entrance	330255.75	3247658.42	342098.54	3245697.40
GD01	5	1	Dwelling - Port of Galveston	323315.50	3243643.26	325879.06	3243610.40
GD01	5	2	Dwelling - Port of Galveston	325879.06	3243610.40	327062.25	3244421.10
GT02	5	1	Transit - Galveston Channel	323359.32	3244004.79	325703.78	3243960.97
GT02	5	2	Transit - Galveston Channel	325703.78	3243960.97	327270.40	3245001.73
GT02	5	3	Transit - Galveston Channel	327270.40	3245001.73	327900.34	3247384.53
TT02	5	1	Transit - Texas City Jetty to Port of Texas City	313680.22	3249608.48	316457.41	3249548.23
TT02	5	2	Transit - Texas City Jetty to Port of Texas City	316457.41	3249548.23	317103.78	3251925.55
TT02	5	3	Transit - Texas City Jetty to Port of Texas City	317103.78	3251925.55	326667.85	3247959.69
TT02	5	4	Transit - Texas City Jetty to Port of Texas City	326667.85	3247959.69	327944.16	3247494.09
TT02	5	5	Transit - Texas City Jetty to Port of Texas City	327944.16	3247494.09	330255.75	3247658.42
TT02	5	6	Transit - Texas City Jetty to Port of Texas City	330255.75	3247658.42	342098.54	3245697.40
BF01	5	1	Bolivar Ferry	327221.10	3249586.57	327741.48	3245889.12
FT01	0	1	Transit - From Sea into Freeport Docks	272993.69	3203809.48	273201.97	3202824.87
FT01	0	2	Transit - From Sea into Freeport Docks	273201.97	3202824.87	273997.23	3203752.67
FT01	0	3	Transit - From Sea into Freeport Docks	273997.23	3203752.67	275322.67	3203752.67
FT01	0	4	Transit - From Sea into Freeport Docks	275322.67	3203752.67	280018.50	3198450.93
FD01	0	1	Dwelling - Freeport Channel	273069.43	3203089.96	274186.58	3204074.57
IT02	5	1	Transit - Intercoastal Waterway Seg #1	252733.45	3191833.22	258016.26	3195146.81
IT02	5	2	Transit - Intercoastal Waterway Seg #1	258016.26	3195146.81	260932.22	3195733.79
IT02	5	3	Transit - Intercoastal Waterway Seg #1	260932.22	3195733.79	266082.49	3199208.32

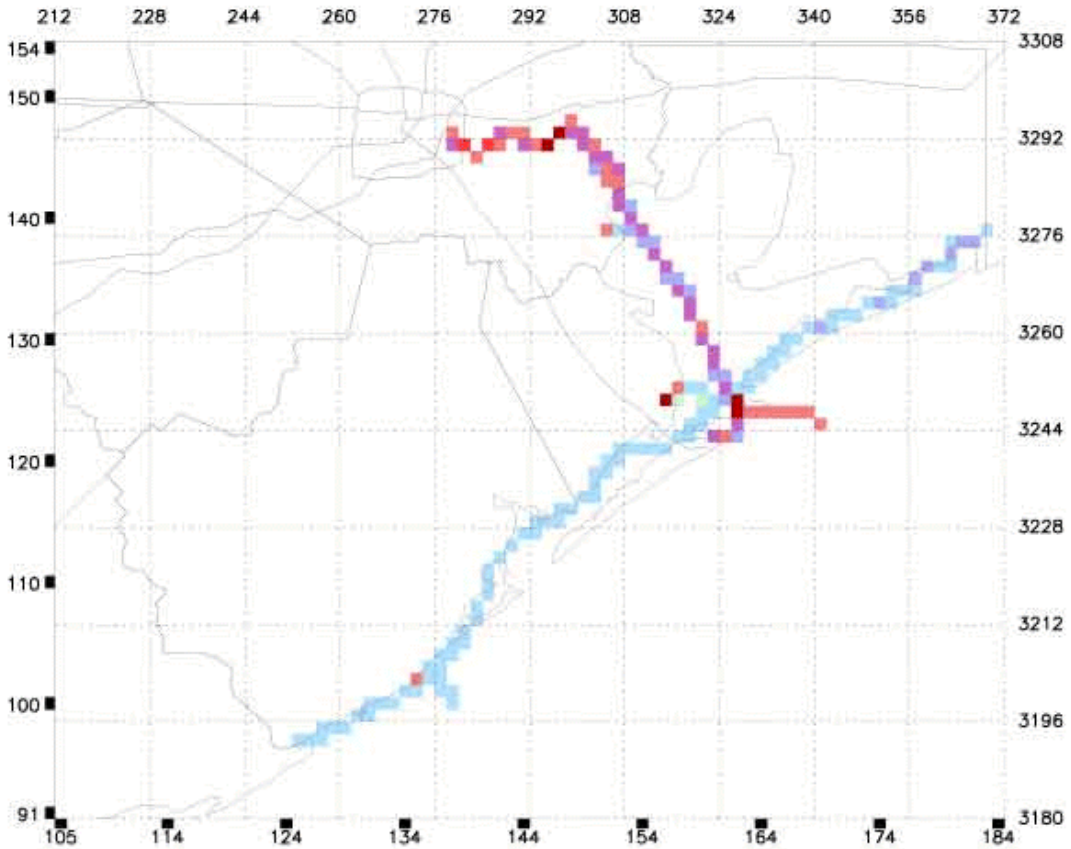
Segment Name	Segment	Sub-Segment	Segment Description	Start Easting	Start Northing	End Easting	End Northing
IT02	5	4	Transit - Intercoastal Waterway Seg #1	266082.49	3199208.32	267407.92	3198734.95
IT02	5	5	Transit - Intercoastal Waterway Seg #1	267407.92	3198734.95	273656.41	3202550.31
IT02	5	6	Transit - Intercoastal Waterway Seg #1	273656.41	3202550.31	279601.93	3208457.97
IT02	5	7	Transit - Intercoastal Waterway Seg #1	279601.93	3208457.97	282461.09	3212614.16
IT02	5	8	Transit - Intercoastal Waterway Seg #1	282461.09	3212614.16	285452.79	3219591.64
IT02	5	9	Transit - Intercoastal Waterway Seg #1	285452.79	3219591.64	285926.16	3221930.09
IT02	5	10	Transit - Intercoastal Waterway Seg #1	285926.16	3221930.09	294049.19	3228850.76
IT02	5	11	Transit - Intercoastal Waterway Seg #1	294049.19	3228850.76	302115.42	3233243.63
IT02	5	12	Transit - Intercoastal Waterway Seg #1	302115.42	3233243.63	303024.29	3235383.26
IT02	5	13	Transit - Intercoastal Waterway Seg #1	303024.29	3235383.26	308212.42	3240637.67
IT02	5	14	Transit - Intercoastal Waterway Seg #1	308212.42	3240637.67	313457.36	3241698.02
IT02	5	15	Transit - Intercoastal Waterway Seg #1	313457.36	3241698.02	315975.69	3241698.02
IT02	5	16	Transit - Intercoastal Waterway Seg #1	315975.69	3241698.02	325802.85	3249593.83
IT01	5	1	Transit -Intercoastal Waterway Seg #2	325802.85	3249593.83	336822.91	3259638.75
IT01	5	2	Transit -Intercoastal Waterway Seg #2	336822.91	3259638.75	355966.00	3267117.99
IT01	5	3	Transit -Intercoastal Waterway Seg #2	355966.00	3267117.99	359033.43	3271084.83
IT01	5	4	Transit -Intercoastal Waterway Seg #2	359033.43	3271084.83	362744.66	3271804.36
IT01	5	5	Transit -Intercoastal Waterway Seg #2	362744.66	3271804.36	363634.59	3274843.39
IT01	5	6	Transit -Intercoastal Waterway Seg #2	363634.59	3274843.39	366020.38	3274578.31
IT01	5	7	Transit -Intercoastal Waterway Seg #2	366020.38	3274578.31	368993.14	3276433.92

Table 4: Stack parameters used for modeling various vessel types

Vessel Class	Category	Stack Height	Stack Diameter	Exit Velocity
Assist Tugboats	2280002021	7 meters	0.3 meters	20.0 meters/second
Ferries	2280002022	9 meters	0.4 meters	20.0 meters/second
Towboats	2280002023	7 meters	0.3 meters	20.0 meters/second
Excursions	2280002024	5 meters	0.3 meters	20.0 meters/second
Dredging Emissions	2280002025	5 meters	0.3 meters	20.0 meters/second
Barge Pumps	2280002026	5 meters	0.3 meters	20.0 meters/second
Ocean-Going Vessels	2280003010	25 meters	1.0 meters	20.0 meters/second
Bulk Cargo Vessels	2280003011	25 meters	1.0 meters	20.0 meters/second
General Cargo Vessels	2280003012	25 meters	1.0 meters	20.0 meters/second
Container Ships	2280003013	25 meters	1.0 meters	20.0 meters/second
Liquefied Gas Carriers	2280003014	25 meters	1.0 meters	20.0 meters/second
Oil/Chemical Tankers	2280003015	25 meters	1.0 meters	20.0 meters/second
Other Ocean-Going-Vessels	2280003016	25 meters	1.0 meters	20.0 meters/second
Cruise Ships	2280003017	25 meters	1.0 meters	20.0 meters/second

HG–BPA Elevated Point Source NO_x Emissions, 09/07/93

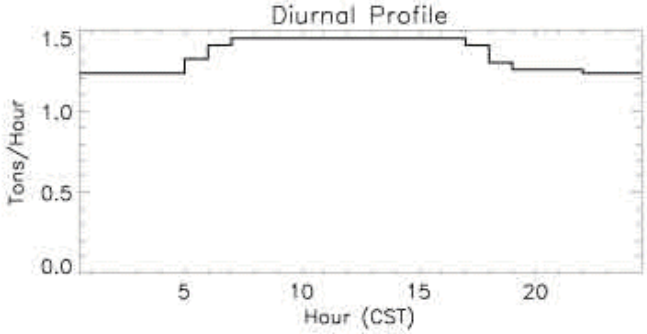
2 km x 2 km Fine Grid



Emissions Plotted

County	Tons/Day
Brazoria	1.75
Chambers	3.27
Fort Bend	0.00
Galveston	13.77
Harris	13.55
Liberty	0.00
Montgomery	0.00
Waller	0.00
HG SUBTOTAL:	32.34
Hardin	0.00
Jefferson	0.02
Orange	0.00
BPA SUBTOTAL:	0.02
MAP TOTAL:	32.39

Legend (Tons/Day)

< 0.00 | 0.00 – 0.01 | 0.01 – 0.10 | 0.10 – 0.20 | 0.20 – 0.40 | 0.40 – 0.80 | 0.80 – 1.00 | >= 1.00

Max Cell: 1.2 tons/day at (295, 3291)