APPENDIX B

Methodology for the Quantification of the Benefits of a National Low Emission Vehicle Program on California Air Quality

Methodology for the Quantification of the Benefits of a National Low Emission Vehicle Program on California Air Quality

Introduction

California's Low Emission Vehicle standards call for progressively more stringent fleet average non-methane organic gas (NMOG) emission standards for on-road motor vehicles between 1998 and 2003. The Air Resources Board (ARB) staff has suggested a plausible implementation schedule whereby a combination of three specific low-emission vehicle categories referred to as transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), and ultra low-emission vehicles (ULEVs), might be produced in order to comply with these standards. In addition, vehicles having no tailpipe emissions, zero-emission vehicles (ZEVs), were required to be produced for sale beginning in 1998 as two percent of passenger cars and light-duty truck production, increasing to five percent in 2001, and ten percent in 2003.

For reasons set forth in the staff report, the staff is proposing to eliminate the ZEV production requirement for the 1998 through 2002 model years. The 10 percent production requirement in 2003 and subsequent model years would be retained.

In the Memoranda of Agreement (MOA) being developed with affected manufacturers, each manufacturer would agree to meet the fleet average NMOG tailpipe standard even in the absence of ZEV production. While this assumes no increase in tailpipe emissions of NMOG, reductions in exhaust emissions of oxides of nitrogen (NOx) and evaporative emission of hydrocarbons (HC) may be lost due to the delay of the introduction of ZEVs.

An analysis has been performed to quantify the emission benefits lost due to a delay in the introduction of ZEVs in California from 1998 through 2002, and to quantify the potential benefits of a proposal by vehicle manufacturers to voluntarily produce a National Low Emission Vehicle (NLEV) beginning in 2001, which for the years 2001 through 2003, has the objective of offsetting this potential loss of benefits.

ZEV Benefit Calculation

The benefits of ZEVs were calculated by establishing a baseline in which the ARB staff suggested a plausible implementation schedule for TLEVs, LEVs and ULEVs, and the required production of ZEVs. This calculation is used to establish a ton-per-day inventory for the South Coast Air Basin for the evaluation years of 2004 and 2010 (See Table 1).

This ton per day estimate was contrasted to an alternative implementation schedule in which the fleet average exhaust emission rate of NMOG is maintained without ZEVs (See Table 2). Because both LEVs and ULEVs have NOx and evaporative emissions, a disbenefit will be realized when more of these vehicles are produced in lieu of ZEVs in

order to comply with the NMOG fleet average tailpipe emission standard. ZEVs, which have no NOx or evaporative emissions, do have NOx emissions resulting from power generation to charge their batteries of one tenth the NOx emissions of a ULEV.

The category specific emission factors used in this analysis are from EMFAC7F modified for enhanced I/M and changes to OBDII, and are listed in Table 3. The ton per day estimates were derived through the use of EMFAC7F and are listed in Table 4.

TABLE 1
BASELINE IMPLEMENTATION ASSUMED PRODUCTION MIX (Fraction)
(To Comply with Average NMOG Tailpipe Standard)

Model Year	Tier I	TLEV	LEV	ULEV	ZEV
1998	0.48	0	0.48	0.02	0.02
1999	0.23	0	0.73	0.02	0.02
2000	0	0	0.96	0.02	0.02
2001	0	0	0.90	0.05	0.05
2002	0	0	0.85	0.10	0.05
2003+	0	0	0.75	0.15	0.10

TABLE 2
ALTERNATIVE IMPLEMENTATION
ASSUMED PRODUCTION MIX (Fraction)
(No ZEVs - But Maintain Same Average NMOG Tailpipe Standard)

Model Year	Tier I	TLEV	LEV	ULEV	ZEV
1998	0.48	0	0.46	0.06	0.00
1999	0.23	0	0.71	0.06	0.00
2000	0	0	0.94	0.06	0.00
2001	0	0	0.85	0.15	0.00
2002	0	0	0.80	0.20	0.00
2003+	0	0	0.75	0.15	0.10

TABLE 3
CATEGORY SPECIFIC BASIC EMISSION RATES
EMFAC7F (Adjusted to Reflect Enhanced I/M & OBDII)

Category	Pollutant	Zero Mile	Deterioration*
0.25	HC	0.1453	0.0152
TLEV	HC	0.0992	0.0093
LEV	HC	0.0351	0.0055
ULEV	HC	0.0219	0.0028
ZEV	HC	0	0
0.25	NOx	0.2846	0.0208
TLEV	NOx	0.3588	0.0167
LEV	NOx	0.1694	0.0089
ULEV	NOx	0.1694	0.0089
ZEV	NOx	0	0

*Grams/Mile/10,000 miles

TABLE 4
BENEFIT OF ZEV REQUIREMENT 1998 - 2002 (LIGHT-DUTY VEHICLES)
SCAB EMISSIONS IN TONS PER DAY

Scenario		A	B	(B-A)		A	B	(B-A)
Year			2004				2010	
TOG								
Diurnal Evaporation	15.18	15.25	0.07		12.26	12.33	0.07	
Hot Soak Evaporation		9.42	9.47	0.05		7.10	7.15	0.05
Running Losses		44.96	45.00	0.04		33.62	33.83	0.21
Resting Losses		6.78	6.80	0.02		4.00	4.01	0.01
Total Evap		76.34	76.52	0.18		56.98	57.32	0.34
NOx								
Running Exhaust		100.55	101.34	0.79		76.47	76.92	0.45
Cold Start		27.85	28.13	0.28		21.80	21.92	0.12
Hot Start		10.07	10.16	0.09		7.54	7.59	0.05
Total NOx Emissions		138.47	139.63	1.17		105.81	106.43	0.62

TABLE 5
BENEFIT OF ZEV REQUIREMENT 1998 - 2002 (LIGHT-DUTY TRUCKS)
SCAB EMISSIONS IN TONS PER DAY

Scenario		A	B	(B-A)		A	B	(B-A)
Year			2004				2010	
TOG								
Diurnal Evaporation	3.06	3.07	0.01		2.25	2.27	0.02	
Hot Soak Evaporation		1.65	1.66	0.01		1.11	1.13	0.02
Running Losses		9.65	9.66	0.01		6.34	6.40	0.06
Resting Losses		1.30	1.31	0.01		0.64	0.65	0.01
Total Evap		15.66	15.70	0.04		10.34	10.45	0.11
NOx								
Running Exhaust		35.06	35.39	0.33		29.39	29.69	0.30
Cold Start		8.38	8.47	0.09		7.00	7.06	0.06
Hot Start		2.94	2.97	0.03		2.40	2.42	0.02
Total NOx Emissions		46.38	46.83	0.45		38.79	39.17	0.38

Scenario A - With ZEVs

Scenario B - Without ZEVs

Calculation of the NLEV Benefit

To offset the loss of benefit attributable to the delay of the ZEV production requirement, a strategy has been suggested by which a national low emission vehicle, or NLEV, could be introduced nationally in the year 2001. It is assumed, based upon United States Environmental Protection Agency (U.S. EPA) existing authorities, that an NLEV program will be instituted by regulation in the year 2004, therefore, no benefit can be attributed to an NLEV strategy for purposes of offsets beyond the 2003 model year.

Through the early introduction of NLEVs, model year 2001 through 2003 vehicles migrating into California from other states would be certified to LEV rather than Tier I (0.25) levels. The lower emissions of the migrant fleet are evaluated to determine if they offset the emission shortfall of a delay in ZEV production.

The EMFAC model was again used to quantify the relative tons-per-day emissions in the years 2004 and 2010 for a Tier I and NLEV scenario. In carrying out this analysis the following assumptions were made:

1) 18 percent of all new registration transactions in California between the years 2001 and 2003 were assumed to be associated with vehicles which originate from outside of California. This is the average of the percentage migration for 1980 to 1994, which ranged from 14 percent to 22 percent.

2) In the baseline assumption, all 2001 to 2003 model year vehicles originating from outside of the state were assumed to be certified to Tier I levels.

3) In the alternative analysis, all 2001 to 2003 model year vehicles originating from outside of the state were assumed to be certified to a LEV standard.

4) Vehicles certified to similar standards were assumed to emit identically once in California regardless of their origin (EMFAC7F emission rates were used for both migrating and native fleets)

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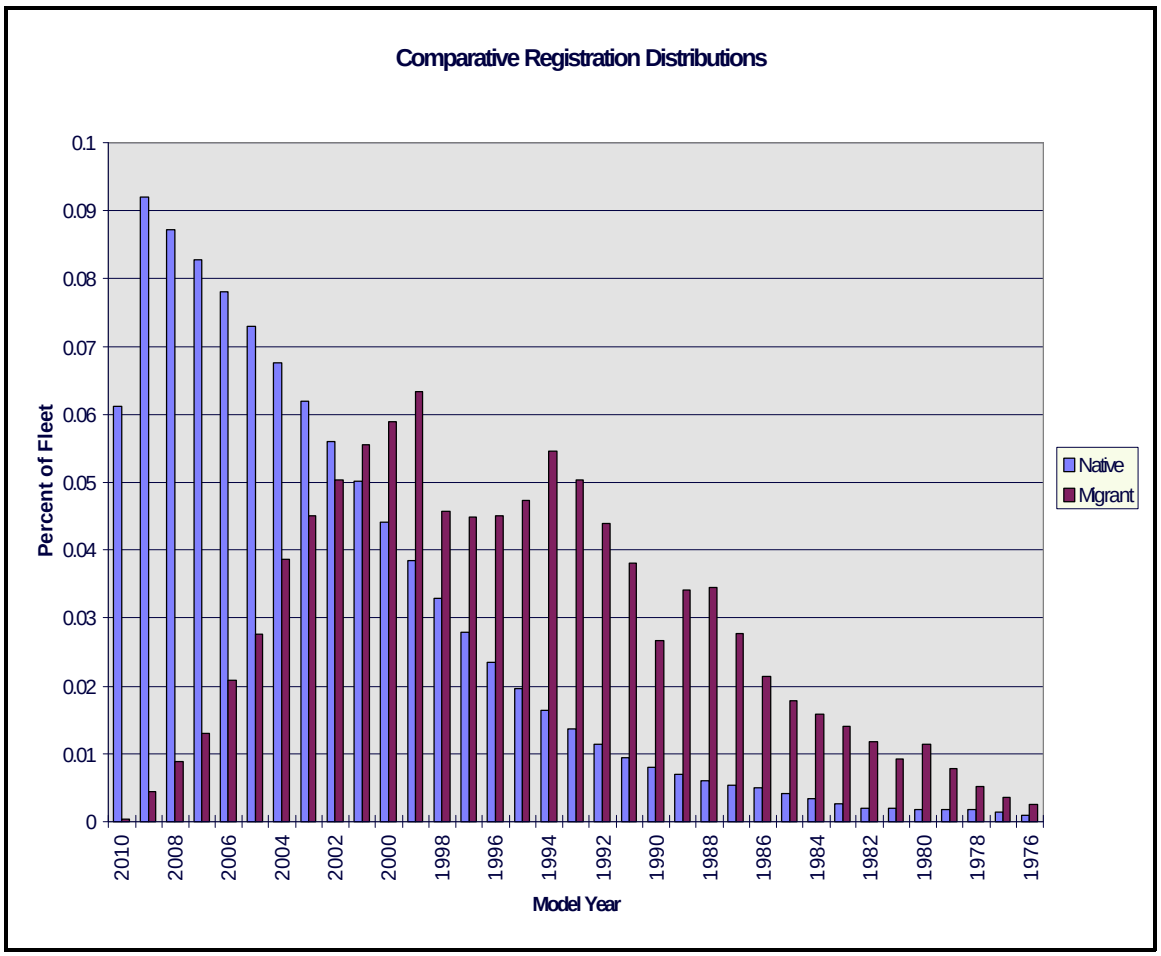
5) Vehicles of the same vintage display identical use patterns regardless of origin (BURDEN activity data was used for both migrating and native fleets).

Modification of Activity Assumptions

Concerned that the relatively small benefits associated with perturbing three model years within the migrant fleet may be lost in the analysis of all vehicles within the South Coast Air Basin, the activity assumptions used in the inventory model were modified to reflect only the activity and emissions of the migrant fleet.

Using data supplied by the California Department of Motor Vehicles, an analysis of 1,700,000 registration records was performed to determine the current age distribution of vehicles which were originally registered outside of California. Figure 1 contrasts the California native and migrant registration age distributions. As can be seen, the migrant fleet is considerably older on average than the California native fleet, and a marked delay is seen in the appearance of new vehicles in the migrant fleet. This model year distribution was used for the migrant fleet in the calculating the NLEV benefit.

Figure 1



In addition to adjusting the registration distribution to reflect the migrant fleet in California, it was also necessary to adjust the vehicle population, daily vehicle miles of travel (VMT) and total trips. These adjustments were derived outside of the models and were used to overwrite the default assumptions in BURDEN. For additional information, see Table 6 and the data provided at the end of this appendix.

TABLE 6
COMPARISON OF
SCAB NATIVE AND MIGRANT FLEETS
(Catalyst Equipped Passenger Cars in 2010)

Activity	Combined Fleet	Migrant Fleet Only
Average Age	7.31 years	14.68 years
Population	9,425,536	1,625,339
VMT	301,337,000	32,284,252
Total Trips	34,320,646	4,204,593
2001-2003 Population	1,583,584 (16.8%)	245,295 (15.09%)
2001-2003 VMT	46,418,714 (15.4%)	6,230,960 (19.3%)

Once the activity had been properly adjusted, the analysis was completed by substituting either the Tier I or LEV emission rates (listed earlier) for model years 2001 to 2003 and the EMFAC/BURDEN models were run to produce inventories for the SCAB for 2004 and 2010. The results of this analysis are shown in Tables 7 and 8.

TABLE 7
LIGHT DUTY AUTOMOBILE NLEV BENEFIT
SCAB EMISSIONS IN TONS PER DAY

Scenario		A	B	(A-B)		A	B	(A-B)
			2004				2010	
TOG								
Running Exhaust		0.10	0.03	0.07		0.96	0.29	0.67
Cold Start		0.21	0.06	0.15		1.13	0.35	0.78
Hot Start		0.02	0.01	0.01		0.10	0.03	0.07
Total TOG Emissions	0.33	0.10	0.23		2.19	0.67	1.52	
NOx								
Running Exhaust		0.40	0.23	0.17		2.69	1.41	1.28
Cold Start		0.17	0.10	0.07		0.87	0.46	0.41
Hot Start		0.05	0.03	0.02		0.30	0.16	0.14
Total NOx Emissions	0.62	0.36	0.26		3.87	2.03	1.83	

TABLE 8
LIGHT DUTY TRUCK NLEV BENEFIT
SCAB EMISSIONS IN TONS PER DAY

Scenario		A	B	(A-B)		A	B	(A-B)
TOG			2004				2010	
Running Exhaust		0.04	0.01	0.03		0.28	0.12	0.16
Cold Start		0.05	0.01	0.04		0.24	0.10	0.14
Hot Start		0.00	0.00	0.00		0.02	0.01	0.01
Total TOG Emissions	0.09	0.02	0.07		0.54	0.23	0.31	
NOx								
Running Exhaust		0.12	0.06	0.06		0.72	0.35	0.37
Cold Start		0.04	0.02	0.02		0.18	0.09	0.09
Hot Start		0.01	0.01	0.00		0.06	0.03	0.03
Total NOx Emissions	0.17	0.09	0.08		0.96	0.47	0.49	

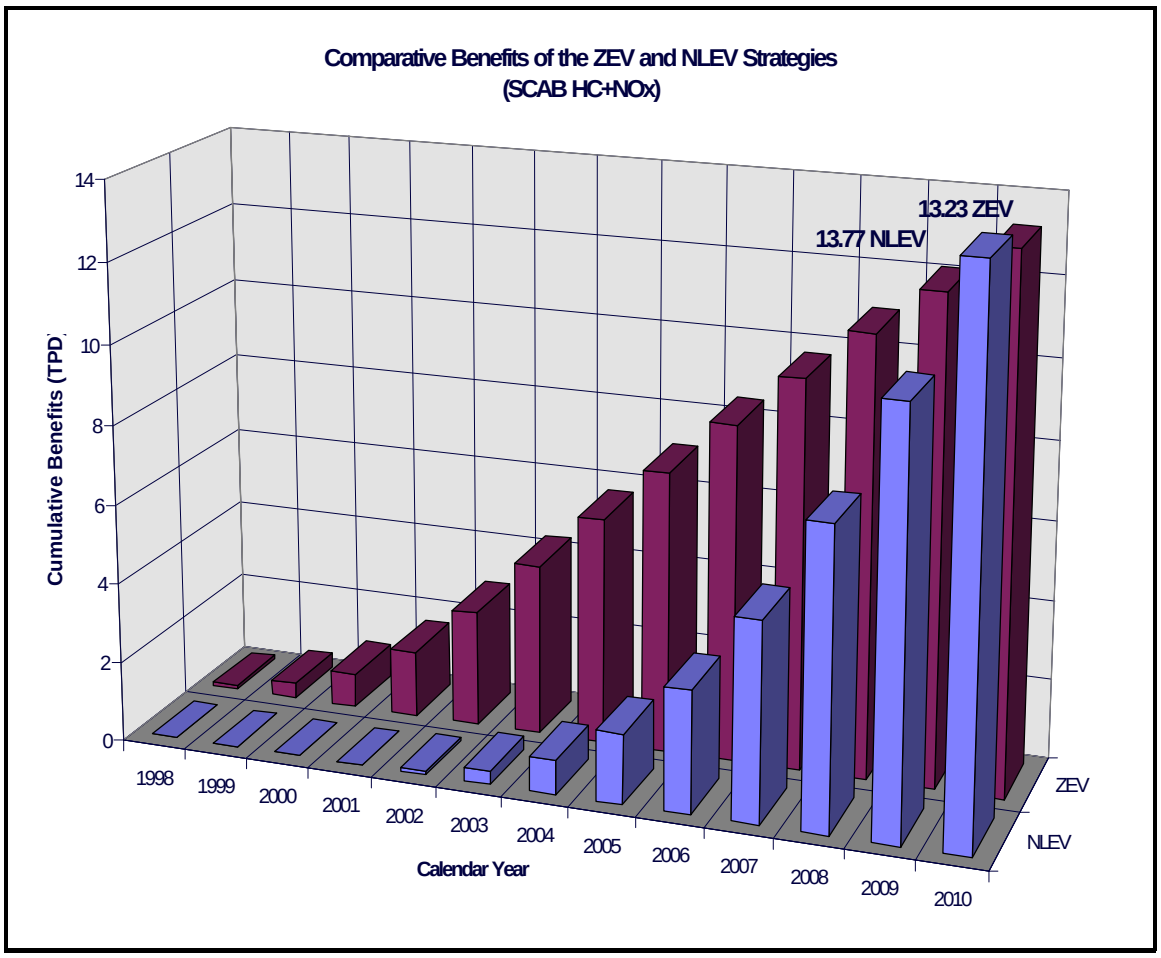
Scenario A - 2001 to 2003 Tier I Scenario B - 2001 to 2003 NLEV

TABLE 9
RELATIVE ZEV AND NLEV BENEFITS
SCAB TONS PER DAY

Year	Vehicle Type	HC Exhaust	HC Evap	Marketing (0.06 g/mi)	Power Plant HC (0.004 g/mi)	NOx Exhaust	Power Plant NOx (0.02 g/mi)	HC + NOx
ZEV Benefit								
2004	PCs		0.18	0.28	-0.02	1.17	-0.09	1.52
	LDTs		0.04	0.05	-0.00	0.45	-0.02	0.52
	Total							**2.04**
2010	PCs		0.34	0.13	-0.01	0.62	-0.04	1.04
	LDTs		0.11	0.03	-0.00	0.39	-0.01	0.52
	Total							**1.56**
NLEV Benefit								
2004	PCs	0.23				0.26		0.49
	LDTs	0.07				0.08		0.15
	Total							**0.64**
2010	PCs	1.52				1.83		3.35
	LDTs	0.31				0.49		0.80
	Total							**4.15**

As can be seen in Table 9, it appears that although the NLEV scenario falls short of achieving the equivalent benefits of ZEVs in the 2004 time frame, the strategy exceeds that of ZEVs by the year 2010. To determine when the entire shortfall associated with a delay in the ZEV requirement may be compensated by an NLEV strategy, the cumulative benefits (summation of the comparative ton per day per year emissions reductions) were also determined. This analysis was performed by calculating each scenario's potential benefit between 1998 and 2010. The results are shown in Figure 2 and show an equivalent cumulative benefit for NLEVs and ZEVs of approximately 13 tons/day for passenger cars in 2010.

Figure 2



The data provided on the following pages was used in the derivation of the activity assumptions for the California migrant fleet.

Base Assumption							
Average Age =			7.31				
Population=			9,425,536				
VMT=			301,337,000				
2001-2003 Populat		16.80%	1,583,584				
2001-2003 VMT		15.40%	46,418,714				
Trips			34,320,646				
	A	B	C	D=A*B	E=Dmy/Dtot	Year*B	F=Trips*E/POP*B
				WEIGHTED			
	ACCRUAL	REG	CUMUL	ACCURAL			
YEAR	RATE	FRACTION	MILES	RATE	TF	AGE	Trips/VD
2010	14169	0.0612	5313	867.143	0.085	123.012	5.056
2009	13563	0.09196	18876	1247.253	0.122	184.748	4.839
2008	12956	0.08717	31832	1129.375	0.111	175.037	4.623
2007	12349	0.08274	44181	1021.756	0.100	166.059	4.406
2006	11742	0.07807	55923	916.698	0.090	156.608	4.190
2005	11135	0.07299	67058	812.744	0.080	146.345	3.973
2004	10528	0.06756	77586	711.272	0.070	135.390	3.757
2003	9921	0.06187	87507	613.812	0.060	123.926	3.540
2002	9314	0.05604	96821	521.957	0.051	112.192	3.323
2001	8707	0.0501	105528	436.221	0.043	100.250	3.107
2000	8101	0.04417	113629	357.821	0.035	88.340	2.891
1999	7597	0.03839	121226	291.649	0.029	76.742	2.711
1998	7164	0.03294	128390	235.982	0.023	65.814	2.556
1997	6788	0.02795	135178	189.725	0.019	55.816	2.422
1996	6457	0.02351	141635	151.804	0.015	46.926	2.304
1995	6214	0.01964	147849	122.043	0.012	39.182	2.217
1994	6071	0.01637	153920	99.382	0.010	32.642	2.166
1993	5940	0.01364	159860	81.022	0.008	27.185	2.119
1992	5819	0.0114	165679	66.337	0.007	22.709	2.076
1991	5707	0.00936	171386	53.418	0.005	18.636	2.036
1990	5603	0.00797	176989	44.656	0.004	15.860	1.999
1989	5505	0.00702	182494	38.645	0.004	13.963	1.964
1988	5414	0.00612	187908	33.134	0.003	12.167	1.932
1987	5328	0.00526	193236	28.025	0.003	10.452	1.901
1986	5247	0.00493	198483	25.868	0.003	9.791	1.872
1985	5170	0.00413	203653	21.352	0.002	8.198	1.845
1984	5098	0.00335	208751	17.078	0.002	6.646	1.819
1983	5029	0.00262	213780	13.176	0.001	5.195	1.794
1982	4963	0.00203	218743	10.075	0.001	4.023	1.771
1981	4901	0.00188	223644	9.214	0.001	3.724	1.749
1980	4842	0.00186	228486	9.006	0.001	3.683	1.728
1979	4785	0.00171	233271	8.182	0.001	3.384	1.707
1978	4730	0.00175	238001	8.278	0.001	3.462	1.688
1977	4678	0.00137	242679	6.409	0.001	2.708	1.669
1976	4628	0.00095	247307	4.397	0.000	1.877	1.651
		1.00002		**10204.9059**	**1**	**2003**	

Migrant Fleet									
Average Age =			14.68						
Population=			1,625,339						
VMT=		10.71%	32,284,252						
2001-2003 Populatio		15.09%	245,295						
2001-2003 VMT		19.30%	6,230,960						
Trips		12.25%	4,204,593						
					E=				
	A	B	C	D=A*B	Dmy/Dtot	Year*B	A*B/365	F	F*B
				WEIGHTED					
	ACCRUAL	REG	CUMUL	ACCURAL				Trips/	
YEAR	RATE	FRACTION	MILES	RATE	TF	AGE	Avg. Mileage	VD	Wt Trips
2010	14169	0.000300602	5313	4.2592	0.0006	0.6042	0.0117	5.0557	0.0015
2009	13563	0.004371613	18876	59.2922	0.0082	8.7826	0.1624	4.8395	0.0212
2008	12956	0.008846289	31832	114.6125	0.0158	17.7633	0.3140	4.6229	0.0409
2007	12349	0.013003186	44181	160.5763	0.0221	26.0974	0.4399	4.4063	0.0573
2006	11742	0.02075872	55923	243.7489	0.0336	41.6420	0.6678	4.1897	0.0870
2005	11135	0.027638213	67058	307.7515	0.0424	55.4146	0.8432	3.9731	0.1098
2004	10528	0.038545773	77586	405.8099	0.0560	77.2457	1.1118	3.7565	0.1448
2003	9921	0.045038778	87507	446.8297	0.0616	90.2127	1.2242	3.5399	0.1594
2002	9314	0.050320785	96821	468.6878	0.0646	100.7422	1.2841	3.3234	0.1672
2001	8707	0.05555985	105528	483.7596	0.0667	111.1753	1.3254	3.1068	0.1726
2000	8101	0.058909416	113629	477.2252	0.0658	117.8188	1.3075	2.8905	0.1703
1999	7597	0.06333256	121226	481.1375	0.0664	126.6018	1.3182	2.7107	0.1717
1998	7164	0.045725868	128390	327.5801	0.0452	91.3603	0.8975	2.5562	0.1169
1997	6788	0.044815473	135178	304.2074	0.0420	89.4965	0.8334	2.4220	0.1085
1996	6457	0.044970069	141635	290.3717	0.0401	89.7603	0.7955	2.3039	0.1036
1995	6214	0.047306176	147849	293.9606	0.0405	94.3758	0.8054	2.2172	0.1049
1994	6071	0.054615101	153920	331.5683	0.0457	108.9025	0.9084	2.1662	0.1183
1993	5940	0.050269254	159860	298.5994	0.0412	100.1866	0.8181	2.1195	0.1065
1992	5819	0.043982376	165679	255.9334	0.0353	87.6129	0.7012	2.0763	0.0913
1991	5707	0.038142107	171386	217.6770	0.0300	75.9409	0.5964	2.0363	0.0777
1990	5603	0.026659109	176989	149.3710	0.0206	53.0516	0.4092	1.9992	0.0533
1989	5505	0.034088274	182494	187.6559	0.0259	67.8016	0.5141	1.9643	0.0670
1988	5414	0.034595003	187908	187.2973	0.0258	68.7749	0.5131	1.9318	0.0668
1987	5328	0.027818574	193236	148.2174	0.0204	55.2755	0.4061	1.9011	0.0529
1986	5247	0.021437221	198483	112.4811	0.0155	42.5743	0.3082	1.8722	0.0401
1985	5170	0.017726933	203653	91.6482	0.0126	35.1880	0.2511	1.8447	0.0327
1984	5098	0.015794491	208751	80.5203	0.0111	31.3363	0.2206	1.8190	0.0287
1983	5029	0.013999468	213780	70.4033	0.0097	27.7609	0.1929	1.7944	0.0251
1982	4963	0.01166336	218743	57.8853	0.0080	23.1168	0.1586	1.7709	0.0207
1981	4901	0.009327253	223644	45.7129	0.0063	18.4773	0.1252	1.7487	0.0163
1980	4842	0.011431467	228486	55.3512	0.0076	22.6343	0.1516	1.7277	0.0198
1979	4785	0.007807065	233271	37.3568	0.0052	15.4502	0.1023	1.7073	0.0133
1978	4730	0.005187533	238001	24.5370	0.0034	10.2609	0.0672	1.6877	0.0088
1977	4678	0.00351275	242679	16.4326	0.0023	6.9447	0.0450	1.6692	0.0059
1976	4628	0.002499291	247307	11.5667	0.0016	4.9386	0.0317	1.6513	0.0041
		1		**7250.0254**	**1.0000**	**1995**	**19.8631**		**2.5869**