RISK ASSESSMENT OF OIL SPILLS TO US INLAND WATERWAYS[1]

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ABSTRACT

A risk assessment of nearly 52,000 oil spills that have occurred in US inland navigable waterways since 1980 was conducted incorporating the *probability* of oil spills being from particular source types, oil types, and particular EPA regions coupled with the *consequences* (magnitude of impacts) of those spills. Results reveal that the greatest risk to inland waterways[2] lies with pipeline spills, particularly from crude pipelines in EPA Region 6. The next highest risk is with SPCC facility crude spills in the same region.

INTRODUCTION

Risk assessment incorporates an evaluation of both the *probability* and *consequences* of particular events. Wtih oil spills[3], risk assessment requires looking at the *frequency* of spill incidents from historical spill rates, as well as measuring the *consequences* or *potential impacts* (costs and damages) of spill incidents. Impacts vary with oil type, spill magnitude, and a variety of location-related factors (*e.g*., sensitive natural and socioeconomic resources, waterway type). This study looks at nearly 52,000 spills that have occurred since 1980 based on source type (facilities, vessels, pipelines, *etc*.), oil type[4], and EPA region to assess potential current and future risks from oil spills based on these factors. This type of analysis of spills provides insights into types of spills that may present the greatest risks to US inland navigable waterways.

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[1]Data, analyses, and opinions presented are solely those of the author and Environmental Research Consulting (ERC). This study is not related to any analytical studies conducted by ERC under contract to the EPA Oil Program.

[2] Inland navigable waterways in this study are defined as: inland navigable waterways, including fresh water (including the Great Lakes) or estuarine water subject to the inland (*i.e*., EPA) portion of the US Coast Guard-EPA memoranda of understanding for spill response jurisdiction. Waterways considered to be marine or ocean waters (saline content of 32 parts per thousand or 32 grams per kilogram) waters are excluded. "Navigable waterways" are defined as: waterways of the US and adjoining shorelines, including (i) all waters currently used, used in the past, or may be used in interstate or foreign commerce, including all waters subject to tidal ebb and flow; (ii) all interstate waters, including wetlands; (iii) all other waters such as intrastate lakes, rivers, and streams (including intermittent streams), mudflats, sandflats, wetlands, prairie potholes, wet meadows, playa lakes, or natural ponds; (iv) all impoundments of waters otherwise defined as U.S. waters; (v) tributaries of waters identified in (i) through (iv); and (vi) wetlands adjacent to waters identified in (i) through (v).

[3] Spills are defined as: discrete events of oil discharge by spilling, leaking, pumping, pouring, emitting, emptying, or dumping, excluding discharges in compliance with permits under Clean Water Act section 402, River and Harbor Act section 13, or MARPOL. Chronic releases of oil or releases that occur over a longer period of time (several months to years) are not included. In this study, only spills of 50 gallons or more for which at least one gallon enters an inland navigable waterway are considered.

[4] Petroleum-based oils and non-petroleum oils (animal fats and edible and non-edible vegetable oils) are included.

METHODOLOGY

Oil spill incident data for the years 1980 – 2003 were selected from Environmental Research Consulting (ERC)'s databases based on a spill size of at least 50 gallons, of which at least one gallon entered an inland navigable waterway. Each spill in the database is classified based on a number of data fields, including date, location criteria, source type, oil type, and volume. Spill frequency and volume spilled by source type, oil type, and year were determined. The impact of each spill in terms of spill response costs, environmental damages, and socioeconomic damages were determined based on oil type, location criteria, and spill size using the EPA Basic Oil Spill Cost Estimation Model (BOSCEM) (Etkin 2004).

The "risk" of each spill type (source, oil type, and EPA region) was determined based on the *probability* of a spill that had occurred was from a particular source type, oil type, and in a particular EPA region (based on spill *frequency*), multiplied by the magnitude of *impacts*[5] (based on average spill *volume* for that spill type and related response costs and environmental and socioeconomic damages) as in:

$$\textbf{Spill risk}_{ijk} = \textbf{probability spill}_{ijk} \cdot \textbf{average spill}_{ijk}\ \textbf{volume} \cdot \textbf{impacts spill}_{ijk},$$

Where *i* = spill source type, *j* = oil type, and *k* = EPA region

The risk of spills occurring in the first place were considered for pipeline-, vehicle-, and rail-transport related incidents[6] for which spill rates could be related to the amount of oil transported by each mode. This made it possible to compare the risk of spillage by transport mode based on the amount and distance that oil was transported. An analysis of the other source types that store and handle oil (SPCC facilities, non-SPCC facilities, and residential) was not possible due to the lack of reliable data on the amount of oil handled by these different facility types. In addition, the uses of these facilities were not comparable as was the case with transportation of crude oil and refined products by different transportation modes.

RESULTS

Spills by Source Type

The largest oil spill sources into inland waterways are SPCC facilities[7] and pipelines (Table 1). Ninety-four percent of the oil spilled during 1980 – 2003 came from these two source types. SPCC facilities were

[5] Impacts determined by application of EPA BOSCEM (Etkin 2004) based on oil type, volume, location type (*e.g.*, wetland, running water, roadside ditch) information is contained in each individual spill record in the ERC database.
[6] Analysis of vessel spills omitted because significant percentage of oil transport by vessel is on waterways outside of the inland waterways (*i.e.*, on marine waters) that are included in this study.
[7] "SPCC facilities" are those oil storing and handling facilities that are subject to the regulations in 40 CFR Part 112. "SPCC" is an acronym for "Spill Prevention, Control, and Countermeasure Plans". (Non-SPCC facilities are those facilities that are not subject to these regulations based on their smaller size or other criteria.)

also the sources of the largest number of spills. Pipelines and vehicles contributed the next largest number of spills. The average spill sizes vary considerably by source. Spills from SPCC facilities average nearly 6,000 gallons in volume. Pipeline spills tend to be much larger, averaging nearly 16,000 gallons. Railcar spills average 8,000 gallons. Vessel spills (primarily from inland barges) average 3,000 gallons. Vehicle spills[8] tend to be considerably smaller due to the smaller amount of oil contained in these sources. Residential spills (primarily from home heating oil tanks) are more than twice as frequent as vessel spills but tend to be considerably smaller, averaging 130 gallons[9]. The probability of spillage based on spill frequency by source type in 24 years of data is shown in Table 2.

Table 1: Summary of Oil Spillage to US Inland Waterways 1980 – 2003 By Source Type

Source Type	Number Incidents	% Total Number	Average Number	Total Volume	% Total Volume	Average Annual Volume	Average Spill Volume
SPCC	**26,375**	50.9%	1,099	**155,922,130**	55.1%	6,496,755	5,912
Pipelines	6,967	13.4%	290	110,397,511	39.0%	4,599,896	15,846
Vehicles	11,593	22.4%	483	7,838,499	2.8%	326,604	676
Vessels	1,573	3.0%	66	4,713,234	1.7%	196,385	2,996
Rail	265	0.5%	11	2,168,906	0.8%	90,371	8,185
Residential	3,707	7.2%	154	483,010	0.2%	20,125	130
Aircraft	420	0.8%	18	191,414	0.1%	7,976	456
Non-SPCC	41	0.1%	2	30,310	0.0%	1,263	739
Unknown	888	1.7%	37	1,399,771	0.5%	58,324	1,576
TOTAL	**51,829**	**100.0%**	**2,160**	**283,144,784**	**100.0%**	**11,797,699**	**5,463**

Table 2: Spill Probability by Source Type 1980 – 2003

	Probability Based on Spill Frequency		
	Average	Standard Deviation	Rank
SPCC Facilities	**0.533**	0.108	1
Vehicles	0.195	0.103	2
Pipelines	0.146	0.057	3
Residential	0.067	0.025	4
Vessels	0.031	0.024	5
Unknown	0.017	0.010	6
Aircraft	0.007	0.005	7
Rail	0.005	0.002	8
Non-SPCC Facilities	0.001	0.001	9

Spills by Oil Type

A summary of oil spillage based on oil type is shown in Table 3. The most frequent type of oil spilled is light fuel, followed by crude oil. The average volume of crude spills nearly three times that of light fuel. Volatile distillate are spilled at the third highest rate. The probability of spillage based on spill frequency by oil type in 24 years of data is shown in Table 4.

[8] Vehicle spills include spills of oil cargo as well as fuel. Automobile spills are generally excluded from this data set due to the minimum spill size of 50 gallons that exceeds the capacity of most automobile fuel tanks.
[9] The typical home heating oil tank holds 250 – 275 gallons.

Table 3: Oil Spillage to US Inland Waterways 1980 – 2003 By Oil Type						
Oil Types[10]	**Number Spills**	**Volume Spilled**	**Average Spill Size**	**% Total Number Spills**	**% Total Volume Spilled**	**Average Annual Spillage**
Crude	11,809	**135,158,696**	11,445	22.78%	47.73%	5,631,612
Volatile Distillate	7,417	56,822,936	7,661	14.31%	20.07%	2,367,622
Light Fuel	**21,220**	45,663,963	2,152	40.94%	16.13%	1,902,665
Heavy Fuel	1,260	12,367,934	9,816	2.43%	4.37%	515,331
Asphalt/Tar	793	8,815,116	11,116	1.53%	3.11%	367,297
Light Oils	3,379	7,392,086	2,188	6.52%	2.61%	308,004
Unknown Oil	1,751	5,403,287	3,086	3.38%	1.91%	225,137
Lubricating Oil	1,645	3,737,988	2,272	3.17%	1.32%	155,750
Waste Oil	1,358	3,461,648	2,549	2.62%	1.22%	144,235
Intermediate Fuel Oil	320	1,831,042	5,722	0.62%	0.65%	76,293
Animal Fat/Vegetable Oil	366	1,420,444	3,881	0.71%	0.50%	59,185
Other Oil	511	1,069,645	2,093	0.99%	0.38%	44,569
TOTAL	**51,829**	**283,144,785**	**5,463**	**100.00%**	**100.00%**	**11,797,699**

Table 4: Spill Probability by Oil Type 1980 – 2003			
	Probability Based on Spill Frequency		
	Average	**Standard Deviation**	**Rank**
Light Fuels	**0.3754**	0.140	1
Crude	0.2581	0.128	2
Volatile Distillate	0.1526	0.042	3
Light Oils	0.0590	0.024	4
Lubricating Oil	0.0318	0.007	5
Unknown Oil	0.0314	0.016	6
Heavy Fuel	0.0266	0.010	7
Waste Oil	0.0247	0.012	8
Asphalt/Tar	0.0154	0.006	9
Other Oil	0.0107	0.009	10
Animal Fat/Vegetable Oil	0.0076	0.004	11
Intermediate Fuel Oil	0.0067	0.004	12

Spills by Oil Type Within Sources

Source types were analyzed for oil types as shown in Table 5. Spills from SPCC facilities were most likely to be of light fuels, as was the case with spills from vehicles, vessels, rail, residences, non-SPCC facilities and spills from unknown sources. Spills from pipelines were most likely to be crude spills. Spills from aircraft were most likely to be volatile distillates (*i.e.*, jet fuel). Probabilities of spills by oil type within source types are shown in Table 6. Volumes spilled in each category are shown in Table 7.

[10] Oil categories are: *Animal fat/vegetable oil* (tallow, sperm oil, lard, animal fat, vegetable oil, soybean oil, seal oil, corn oil, canola oil, safflower oil, peanut oil, palm oil, fish oil, croton oil, coconut oil, cottonseed oil, tung oil, linseed oil, tanner oil, tall oil, pine oil, castor oil); *crude*; *heavy oil* (heavy fuel, No. 6 fuel, bunker, residual oil, heavy oil); *light fuel* (diesel, No. 2 fuel, naphtha); *light oil* (mineral oil, thermal oil, transmission oil, insulating oil, quench oil, heat transfer oil, absorption oil, light cycle oil, light oil, hydraulic oil, cutting oil, decant oil, catalytic feedstock, emulsion oil, spray oil, petroleum distillate, carbolic oil, gas oil, lean oil, clarified oil, produced oil, process oil, petrolatum); *volatile distillate* (gasoline, jet fuel, No. 1 fuel, crude condensate); *intermediate fuel oil* (IFO, No. 3 fuel, No. 4 fuel, transmix); *asphalt/tar* (tar, asphalt, asphalt emulsion, creosote, tack oil, wash oil); *waste oil*; *lubricating oil* (spindle oil, lube oil, gear oil, machine oil, compressor oil, crankcase oil, motor oil, cycle oil); and *other oil* (neatsfoot oil, dusting oil, penetrating oil, synthetic oil, road oil, resin oil, hot oil, wax, paraffin).

Table 5: Number of Spills By Oil Type Within Source Types 1980 – 2003									
Oil Type	**SPCC**	**Pipelines**	**Vehicles**	**Vessels**	**Rail**	**Residential**	**Non-SPCC**	**Aircraft**	**Unknown**
AFVO	289	4	48	11	4	0	2	0	8
Asphalt/Tar	564	1	173	39	3	0	2	0	11
Crude	5,669	5,899	95	75	5	1	3	0	62
Heavy Fuel	965	24	111	112	1	20	4	1	22
IFO	235	8	26	28	1	14	1	0	7
Light Fuel	6,900	380	9,063	789	232	3,461	14	16	365
Light Oils	2,945	16	314	44	2	11	6	2	39
Lube Oil	1,307	28	155	99	8	11	0	0	37
Other Oil	395	28	45	25	1	2	0	3	12
Unknown Oil	1,151	81	263	31	3	42	2	11	167
Volatile Distillate	4,970	482	1,175	208	3	95	5	387	92
Waste Oil	985	16	125	112	2	50	2	0	66
TOTAL	**26,375**	**6,967**	**11,593**	**1,573**	**265**	**3,707**	**41**	**420**	**888**

Table 6: Probability of Spillage By Oil Type Within Sources (By Spill Number)									
Oil Type	**SPCC**	**Pipelines**	**Vehicles**	**Vessels**	**Rail**	**Residential**	**Non-SPCC**	**Aircraft**	**Unknown**
Light Fuel	**0.2616**	0.0545	**0.7818**	**0.5016**	**0.8755**	**0.9336**	**0.3415**	0.0381	**0.4110**
Crude	0.2149	**0.8467**	0.0082	0.0477	0.0189	0.0003	0.0732	0.0000	0.0698
Volatile Distillate	0.1884	0.0692	0.1014	0.1322	0.0113	0.0256	0.1220	**0.9214**	0.1036
Light Oil	0.1117	0.0023	0.0271	0.0280	0.0075	0.0030	0.1463	0.0048	0.0439
Lube Oil	0.0496	0.0040	0.0134	0.0629	0.0302	0.0030	0.0000	0.0000	0.0417
Unknown Oil	0.0436	0.0116	0.0227	0.0197	0.0113	0.0113	0.0488	0.0262	0.1881
Waste Oil	0.0373	0.0023	0.0108	0.0712	0.0075	0.0135	0.0488	0.0000	0.0743
Heavy Fuel	0.0366	0.0034	0.0096	0.0712	0.0038	0.0054	0.0976	0.0024	0.0248
Asphalt/Tar	0.0214	0.0001	0.0149	0.0248	0.0113	0.0000	0.0488	0.0000	0.0124
Other Oil	0.0150	0.0040	0.0039	0.0159	0.0038	0.0005	0.0000	0.0071	0.0135
AFVO	0.0110	0.0006	0.0041	0.0070	0.0151	0.0000	0.0488	0.0000	0.0090
IFO	0.0089	0.0011	0.0022	0.0178	0.0038	0.0038	0.0244	0.0000	0.0079

Table 7: Volume of Oil Spilled By Oil Type Within Source Types 1980 – 2003									
Oil Type	**SPCC**	**Pipelines**	**Vehicles**	**Vessels**	**Rail**	**Residential**	**Non-SPCC**	**Aircraft**	**Unknown**
AFVO	1,050,655	12,655	212,729	2,223	135,000	0	2,250	0	4,932
Asphalt/Tar	7,724,435	94,000	788,717	71,665	130,150	0	259	0	5,890
Crude	44,541,073	89,648,980	191,301	295,942	281,000	126	10,836	0	189,438
Heavy Fuel	10,170,005	143,078	193,601	1,700,933	70,000	2,925	554	1,500	85,338
IFO	1,624,540	31,972	15,475	53,205	100,000	850	250	0	4,750
Light Fuel	33,074,657	5,890,768	3,017,166	1,562,612	950,156	456,971	5,841	4,118	701,674
Light Oil	6,543,853	694,594	96,389	12,854	3,050	967	664	400	39,315
Lube Oil	2,807,356	474,274	89,472	31,346	294,400	1,322	0	0	39,818
Other Oil	968,278	29,332	48,849	14,335	100	500	0	1,100	7,151
Unknown Oil	4,040,190	579,571	586,740	12,815	61,000	4,296	920	7,933	109,822
Vol. Distillate	40,257,831	12,668,447	2,498,017	914,626	140,400	11,638	8,596	176,363	147,018
Waste Oil	3,119,257	129,840	100,043	40,678	3,650	3,415	140	0	64,625
TOTAL	**155,922,130**	**110,397,511**	**7,838,499**	**4,713,234**	**2,168,906**	**483,010**	**30,310**	**191,414**	**1,399,771**

Spills by EPA Region

Oil spills were analyzed by source type *and* EPA regions. Table 8 shows the probability of spillage *within* source types (*e.g.*, the probability that a spill from an SPCC facility would occur in Region 6). Table 9

shows the probability of spills within EPA region (*e.g.*, the probability that a spill in Region 6 would come from an SPCC facility). In all regions, the most likely source of spills is an SPCC facility.

Table 8: Probability of Oil Spillage By EPA Region Within Source Type (Based on Spill Number)

Region	SPCC	Pipelines	Vehicles	Vessels	Rail	Resid-ential	Non-SPCC	Aircraft	Unknown	Total
1	0.1359	0.0122	0.2144	0.1163	0.0453	**0.6183**	0.0976	0.0810	0.2005	0.1709
2	0.0402	0.0078	0.0323	0.0915	0.0038	0.0256	0.1220	0.1119	0.0586	0.0354
3	0.1078	0.0655	0.0646	0.1208	0.0906	0.0461	0.0244	0.1024	0.1295	0.0886
4	0.1214	0.0548	0.0889	0.2136	0.1057	0.0227	0.0488	0.1262	0.1047	0.1006
5	**0.2081**	0.1437	**0.3236**	0.0998	**0.2717**	0.1829	0.2195	0.1286	**0.2083**	**0.2199**
6	0.1562	**0.5194**	0.0646	**0.2295**	0.1170	0.0135	**0.2927**	0.0619	0.0957	0.1747
7	0.0412	0.0611	0.0277	0.0102	0.0491	0.0113	0.0488	0.0429	0.0225	0.0375
8	0.0713	0.0644	0.0620	0.0064	0.0717	0.0178	0.0732	0.0643	0.0788	0.0626
9	0.0380	0.0632	0.0331	0.0496	0.0453	0.0057	0.0000	0.1024	0.0327	0.0388
10	0.0798	0.0081	0.0887	0.0623	0.2000	0.0561	0.0732	**0.1786**	0.0687	0.0711

Table 9: Probability of Oil Spillage By Source Type Within EPA Region (Based on Spill Number)

Region	SPCC	Pipelines	Vehicles	Vessels	Rail	Residential	Non-SPCC	Aircraft	Unknown
1	**0.4047**	0.0096	0.2806	0.0207	0.0014	0.2587	0.0005	0.0038	0.0201
2	**0.5785**	0.0295	0.2045	0.0785	0.0005	0.0518	0.0027	0.0256	0.0284
3	**0.6192**	0.0993	0.1631	0.0414	0.0052	0.0372	0.0002	0.0094	0.0250
4	**0.6145**	0.0732	0.1978	0.0645	0.0054	0.0161	0.0004	0.0102	0.0178
5	**0.4817**	0.0878	0.3292	0.0138	0.0063	0.0595	0.0008	0.0047	0.0162
6	**0.4551**	0.3997	0.0827	0.0399	0.0034	0.0055	0.0013	0.0029	0.0094
7	**0.5586**	0.2191	0.1651	0.0082	0.0067	0.0216	0.0010	0.0093	0.0103
8	**0.5799**	0.1383	0.2218	0.0031	0.0059	0.0204	0.0009	0.0083	0.0216
9	**0.4988**	0.2191	0.1911	0.0388	0.0060	0.0105	0.0000	0.0214	0.0144
10	**0.5709**	0.0152	0.2788	0.0266	0.0144	0.0564	0.0008	0.0203	0.0165
Total	**0.5089**	0.1344	0.2237	0.0303	0.0051	0.0715	0.0008	0.0081	0.0171

Combined Probabilities

The probability that a spill will be in a particular EPA region, involving a particular oil type and spill source is shown in Table A-1 (Appendix). From the perspective of spill frequency alone, the most likely spills are shown in Table 10.

Table 10: Most Likely Spills Based on Spill Frequency

Rank	Source	Oil Type	Region
1	pipeline	crude	6
2	vehicle	light fuel	5
3	SPCC	crude	6
4	residential	light fuel	1
5	vehicle	light fuel	1
6	SPCC	light fuel	5
7	SPCC	light fuel	1
8	SPCC	volatile distillate	6
9	SPCC	light fuel	10
10	SPCC	volatile distillate	4
11	SPCC	light fuel	4
12	SPCC	crude	5
13	pipeline	crude	5
14	SPCC	crude	3
15	vehicle	light fuel	4

Changes in Spill Trends

From 1980 – 2003 there have been some changes in the trends of oil spillage with regard to oil and source type. Figure 1 indicates that there was a steady decrease in spillage from SPCC facilities during the 1980s and a leveling-off of this probability since 1990. There is a slight decrease in spill probabilities from pipelines, as well as an increase in the probability that a spill will be from a vehicular source. Figure 2 shows the probabilities of spillage by oil type over 1980 – 2003. There are decreases in spillage of crude and volatile distillates, and a sharp increase in spillage of light fuels during this time period.

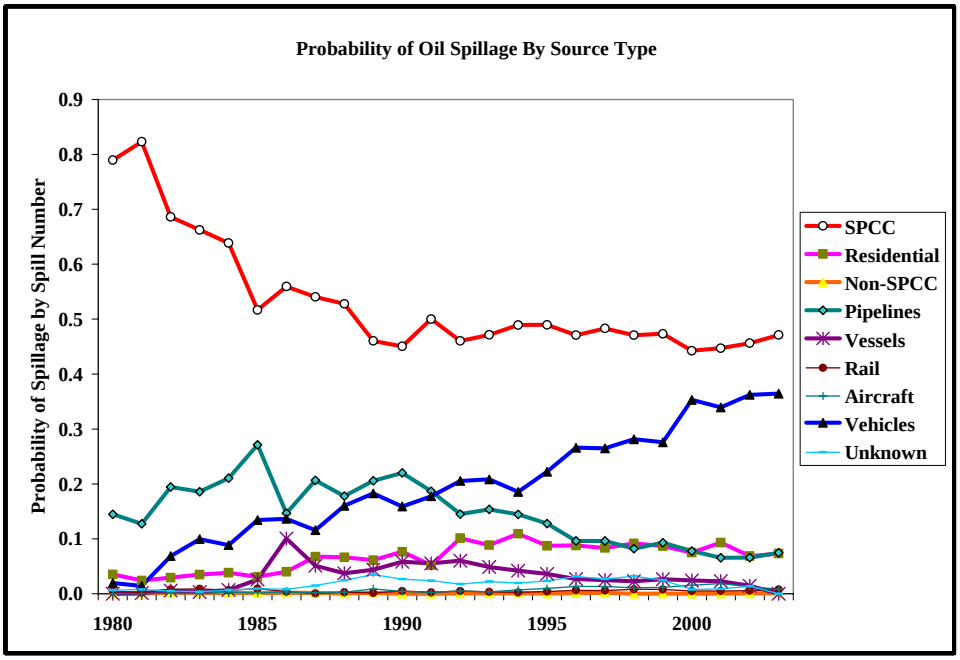

Figure 1: Trends in Probability of Oil Spillage by Source Type

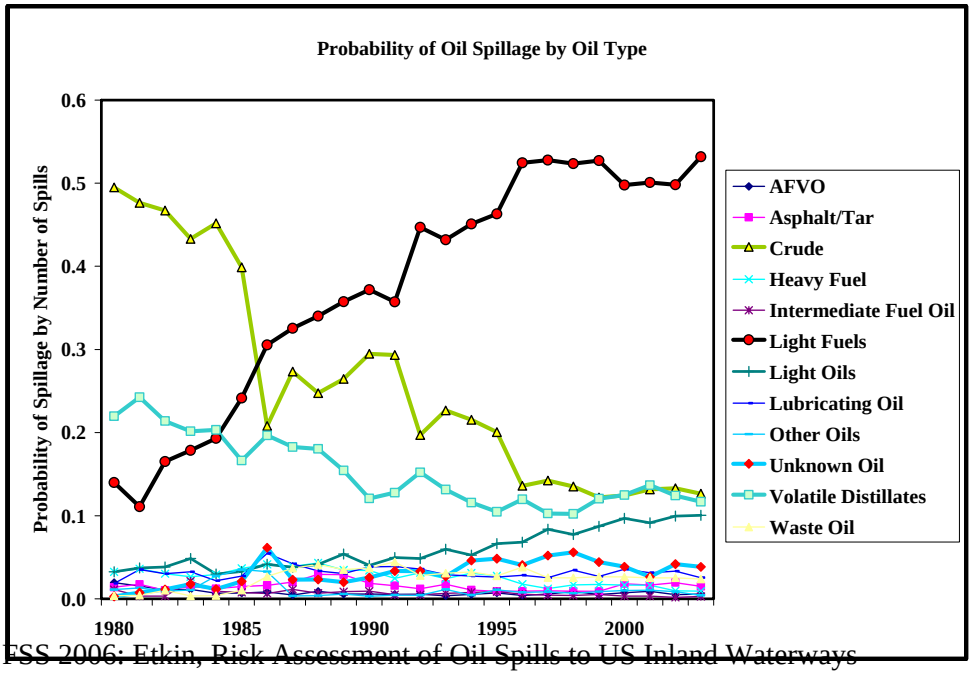

Figure 2: Trends in Probability of Oil Spillage by Oil Type

Spillage by Transport Mode

Crude and refined petroleum product transport by transport mode in ton-miles[11] is shown in Tables 10 – 11. Oil spillage by oil transport mode is shown in Table 12 for crude and refined products.

Table 10: Annual US Crude Oil Transport[12]

Year	Pipelines		Water Carriers		Vehicles		Rail		Total Billion Ton-Miles
	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	
1980	362.6	48.2%	387.4	51.4%	2.5	0.3%	0.5	0.1%	753.0
1985	334.4	42.5%	449.2	57.1%	1.8	0.2%	0.8	0.1%	786.2
1990	334.8	53.3%	291.2	46.4%	1.5	0.2%	0.7	0.1%	628.2
1995	335.9	57.3%	247.7	42.3%	1.7	0.3%	0.8	0.1%	586.1
1996	338.3	62.3%	202.4	37.3%	1.7	0.3%	0.8	0.1%	543.2
1997	337.4	69.3%	147.3	30.3%	1.7	0.3%	0.5	0.1%	486.9
1998	334.1	73.6%	117.9	26.0%	1.6	0.4%	0.5	0.1%	454.1
1999	321.1	75.9%	100.0	23.6%	1.4	0.3%	0.5	0.1%	423.0
2000	283.4	75.4%	91.0	24.2%	1.2	0.3%	0.4	0.1%	376.0
2001	277.0	73.6%	98.1	26.0%	1.1	0.3%	0.4	0.1%	376.6
2002	286.6	74.6%	95.7	24.9%	1.2	0.3%	0.5	0.1%	384.0
2003	284.5	74.8%	94.1	24.7%	1.3	0.3%	0.5	0.1%	380.4

Table 11: Annual US Refined Petroleum Transport[13]

Year	Pipelines		Water Carriers		Vehicles		Rail		Total Billion Ton-Miles
	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	Billion Ton-Miles	% Total	
1980	225.6	45.8%	230.4	46.8%	24.3	4.9%	12.0	2.4%	492.3
1985	229.9	56.2%	141.2	34.5%	26.9	6.6%	11.3	2.8%	409.3
1990	249.3	55.6%	157.8	35.2%	28.2	6.3%	13.3	3.0%	448.6
1995	265.2	57.8%	153.2	33.4%	24.6	5.4%	15.9	3.5%	458.9
1996	280.9	58.6%	154.1	32.2%	28.0	5.8%	16.0	3.3%	479.0
1997	279.1	59.4%	148.3	31.6%	26.0	5.5%	16.2	3.4%	469.6
1998	285.7	60.1%	147.1	30.9%	26.7	5.6%	16.2	3.4%	475.7
1999	296.6	60.5%	147.5	30.1%	27.6	5.6%	18.2	3.7%	489.9
2000	293.9	59.1%	153.4	30.8%	30.1	6.1%	19.9	4.0%	497.3
2001	299.1	60.6%	145.9	29.6%	29.7	6.0%	18.5	3.8%	493.2
2002	299.6	62.3%	131.9	27.4%	29.4	6.1%	19.7	4.1%	480.6
2003	305.7	60.8%	146.0	29.0%	31.9	6.3%	19.3	3.8%	502.9

Ninety-nine percent of crude oil transport and 70 percent of refined product transport is by pipeline. Analyses of volume spilled per volume transported indicate that for crude, rail transport results in more than twice as much spillage than pipelines, and five times as much as motor carrier or vehicular transport. For refined products, pipeline transport is the least risky mode. Rail transport results in 45 times more spillage than pipelines. Vehicular transport results in over 67 times more spillage than pipeline transport.

[11] A ton-mile is one ton of oil (roughly 294 gallons) being transported one mile.
[12] Source: Bureau of Transportation Statistics
[13] Source: Bureau of Transportation Statistics

Table 12: Oil Spillage to Inland Waterways By Transport Mode 1980 – 2003[14]							
Oil Type	**Result**	**Oil Spill Volume**			**Oil Spillage Per Transport[15] (Gallons Spilled/Billion Gallons Transported)**		
		Pipelines	**Vehicles**	**Rail**	**Pipelines**	**Vehicles**	**Rail**
Crude	**TOTAL**	89,648,980	191,301	351,000	38.3	15.5	80.1
	Average	3,735,374	7,971	14,625	37.7	16.7	85.6
	SD	1,882,938	6,803	37,244	18.4	15.0	237.6
Refined Products	**TOTAL**	20,606,036	7,334,426	1,749,256	8.8	595.4	399.3
	Average	858,585	305,601	72,886	9.0	695.5	426.9
	SD	662,946	209,813	115,596	7.7	627.2	648.0

Risk Analysis

A summary of relative risk of oil spills based on the product of the probability of a spill being of a certain category and the consequences of those oil spills (*i.e.*, the impacts based on response costs, socioeconomic damages, and environmental damages) is shown in Table 13. Detailed table of risks by source type, oil type, and EPA region are shown in Table A-2 in the Appendix. Across all oil types and EPA regions, SPCC facilities present the greatest spill risk, followed by pipelines. The greatest risk across all source types and EPA regions lies with crude spills. Within SPCC facilities, the greatest risks are from spills of crude oil, light fuels, and volatile distillates in that order. With apparent shifts in the types of oils spilling (as seen in Figure 2), there may be increasing risks from light fuels and somewhat less from crude spills in the future.

Table 13: Relative Risk by Oil Type and Source Type (Across All EPA Regions)[16]										
Oil Type	**Risk by Source Type**									
	SPCC	**Pipeline**	**Vehicle**	**Residential**	**Vessels**	**Rail**	**Non-SPCC**	**Aircraft**	**Unknown**	**TOTAL**
Light Fuel	**$342,573**	$40,453	$16,088	$2,204	$11,411	$9,730	$49	$20	$8,040	**$430,569**
Crude	**$434,575**	**$690,517**	$2,088	$0	$1,921	$2,158	$120	$1	$2,032	**$1,133,412**
Vol. Distil.	**$305,492**	$65,095	$26,071	$88	$6,433	$717	$89	$1,297	$1,442	**$406,724**
Light Oil	$65,017	$4,547	$465	$2	$91	$38	$2	$2	$467	**$70,631**
Lube Oil	$70,843	$9,075	$1,649	$14	$547	$2,948	$0	$0	$993	**$86,069**
Unknown	$44,600	$5,216	$6,290	$26	$119	$468	$7	$73	$1,053	**$57,851**
Waste Oil	$70,874	$1,173	$2,273	$35	$749	$96	$1	$0	$1,561	**$76,761**
Heavy Fuel	$196,760	$2,841	$5,105	$5	$32,065	$1,261	$7	$40	$2,236	**$240,320**
Asphalt/Tar	$146,407	$1,694	$20,833	$0	$1,781	$2,345	$3	$0	$147	**$173,211**
Other Oil	$10,322	$295	$496	$0	$130	$1	$0	$9	$69	**$11,322**
AFVO	$10,813	$139	$2,345	$0	$18	$1,037	$24	$0	$51	**$14,427**
IFO	$14,129	$282	$152	$2	$575	$430	$0	$0	$44	**$15,615**
TOTAL	**$1,712,407**	**$821,326**	**$83,853**	**$2,377**	**$55,840**	**$21,230**	**$302**	**$1,441**	**$18,135**	**$2,716,911**

[14] Analysis of vessel spills omitted because significant percentage of oil transport by vessel is on waterways outside of the inland waterways (*i.e.*, on marine waters) that are included in this study.
[15] Oil transport data from Bureau of Transportation Statistics
[16] Risk is product of *probability* of spillage and *consequences* of spills (response cost and socioeconomic and environmental damages, as determined by EPA BOSCEM).

Results reveal that the greatest risk to inland waterways lies with pipeline spills, particularly from crude pipelines in EPA Region 6. The next highest risk is with SPCC facility crude spills in the same region.

DISCUSSION

It is clear that overall spill risk for all spill types and, particularly for the highest risk spill types (crude spills in EPA Region 6) can be reduced by decreasing the probability of a spillage through spill prevention measures and by increasing the consequences to spillers for spills that do occur (through fines, increased liability for damages). In addition, spill risk can be lessened by reducing the *frequency* of high-impact spills, *i.e.*, those spills that occur in the most sensitive areas, involve the largest volumes, and are composed of the most persistent and/or toxic oil types. Focusing prevention measures in the most environmentally- and socioeconomically-sensitive locations, reducing the volume of spillage in individual incidents through rapid spill detection, response, and source control[17], shifting usage from more persistent and toxic oil types to lesser-impact spills, and increasing spill prevention measures for the oil types with the greatest impacts. Reducing the *consequences* or *impacts* will also reduce the risk to the environment and society from inland oil spills. This can best be accomplished by better spill response that more effectively removes oil from the environment before it can cause long-term or short-term impacts. Better spill response means increasing response capability and decreasing response time.

BIOGRAPHY

Dagmar Schmidt Etkin received her B.A. in Biology from University of Rochester, and her A.M. and Ph.D. degrees in Biology (specializing in population biology, ecology, and statistical analysis) from Harvard University. She has analyzed and modeled oil spill data and impacts for 17 years.

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[17] "Source control" involves measures that reduce the flow of oil from a source once detected, e.g., shutting off or stemming the flow from a leaking pipeline or removing remaining oil from pipeline segments, storage tanks, or tank barges and trucks.

APPENDIX

Table A1: Probability of Oil Spill Being of Particular Oil Type from Particular Source by EPA Region[18]

Source	Oil Type	EPA Region									
		1	2	3	4	5	6	7	8	9	10
SPCC	Light Fuel	0.0246	0.0058	0.0130	0.0161	0.0301	0.0097	0.0044	0.0086	0.0036	0.0171
	Crude	0.0001	0.0004	0.0151	0.0104	0.0156	0.0433	0.0052	0.0098	0.0058	0.0037
	Vol. Distill.	0.0139	0.0038	0.0080	0.0163	0.0204	0.0101	0.0062	0.0077	0.0033	0.0062
	Light Oil	0.0103	0.0043	0.0051	0.0062	0.0137	0.0047	0.0014	0.0033	0.0036	0.0042
	Lube Oil	0.0030	0.0013	0.0028	0.0032	0.0063	0.0031	0.0014	0.0009	0.0009	0.0023
	Unknown	0.0041	0.0008	0.0024	0.0023	0.0048	0.0020	0.0003	0.0017	0.0005	0.0032
	Waste Oil	0.0032	0.0008	0.0017	0.0017	0.0055	0.0021	0.0004	0.0010	0.0007	0.0021
	Heavy Fuel	0.0066	0.0018	0.0021	0.0021	0.0023	0.0014	0.0002	0.0014	0.0003	0.0005
	Asphalt/Tar	0.0005	0.0003	0.0029	0.0013	0.0027	0.0008	0.0004	0.0016	0.0002	0.0003
	Other Oil	0.0003	0.0005	0.0011	0.0010	0.0017	0.0016	0.0003	0.0002	0.0003	0.0007
	AFVO	0.0003	0.0001	0.0004	0.0011	0.0020	0.0007	0.0006	0.0001	0.0001	0.0001
	IFO	0.0022	0.0006	0.0005	0.0001	0.0008	0.0001	*	*	0.0001	0.0001
Pipeline	Light Fuel	0.0010	0.0002	0.0006	0.0008	0.0012	0.0015	0.0009	0.0005	0.0004	0.0004
	Crude	0.0001	0.0005	0.0074	0.0060	0.0154	0.0642	0.0063	0.0071	0.0066	0.0003
	Vol. Distill.	0.0002	0.0002	0.0005	0.0005	0.0021	0.0032	0.0009	0.0008	0.0006	0.0003
	Light Oil	*	*	*	*	0.0001	0.0001	*	*	*	*
	Lube Oil	*	*	*	0.0001	0.0001	0.0001	*	*	0.0001	*
	Unknown	0.0002	*	0.0001	*	0.0003	0.0003	*	*	0.0006	*
	Waste Oil	*	*	*	*	0.0001	0.0001	*	*	*	*
	Heavy Fuel	*	0.0001	0.0001	*	0.0001	*	*	0.0001	0.0001	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	0.0002	*	0.0001	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	0.0001	*	*	*	*	*	*	*	*	*
Vehicle	Light Fuel	0.0391	0.0050	0.0098	0.0142	0.0601	0.0108	0.0046	0.0101	0.0051	0.0161
	Crude	*	*	0.0002	0.0001	0.0004	0.0005	*	0.0005	0.0001	*
	Vol. Distill.	0.0039	0.0013	0.0022	0.0034	0.0046	0.0014	0.0009	0.0019	0.0013	0.0017
	Light Oil	0.0008	0.0003	0.0006	0.0007	0.0024	0.0003	0.0002	0.0002	0.0002	0.0005
	Lube Oil	0.0003	0.0001	0.0003	0.0003	0.0008	0.0004	0.0001	0.0001	0.0002	0.0003
	Unknown	0.0016	0.0001	0.0005	0.0002	0.0013	0.0001	*	0.0003	0.0001	0.0008
	Waste Oil	0.0004	0.0001	0.0001	0.0003	0.0008	0.0001	0.0001	0.0002	*	0.0002
	Heavy Fuel	0.0012	0.0001	0.0002	0.0002	0.0002	0.0001	*	0.0001	0.0001	*
	Asphalt/Tar	0.0003	0.0001	0.0003	0.0003	0.0010	0.0005	0.0001	0.0005	0.0002	0.0002
	Other Oil	*	0.0001	0.0001	0.0001	0.0003	0.0001	*	0.0001	0.0001	0.0001
	AFVO	0.0001	*	*	0.0001	0.0003	0.0001	0.0001	*	0.0001	*
	IFO	0.0003	0.0001	0.0001	*	*	*	*	*	*	*
Residential	Light Fuel	0.0423	0.0018	0.0030	0.0016	0.0116	0.0010	0.0008	0.0013	0.0003	0.0030
	Crude	*	*	*	*	*	*	*	*	*	*
	Vol. Distill.	0.0004	*	0.0001	*	0.0007	*	*	*	*	0.0007
	Light Oil	0.0001	*	*	*	0.0001	*	*	*	*	*
	Lube Oil	0.0001	*	*	*	*	*	*	*	0.0001	*
	Unknown	0.0003	*	0.0001	*	0.0001	*	*	*	*	0.0002
	Waste Oil	0.0005	*	*	*	0.0003	*	*	*	*	0.0001
	Heavy Fuel	0.0002	*	*	*	0.0002	*	*	*	*	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	0.0003	*	*	*	*	*	*	*	*	*

[18] Probabilities of less than 0.0001 are designated with *.

Source Type	Oil Type	1	2	3	4	5	6	7	8	9	10
Vessel	Light Fuel	0.0019	0.0011	0.0016	0.0036	0.0013	0.0030	0.0002	0.0002	0.0009	0.0015
	Crude	*	*	*	0.0001	0.0001	0.0011	*	*	0.0001	*
	Vol. Distill.	0.0006	0.0006	0.0007	0.0007	0.0004	0.0006	0.0001	*	0.0003	0.0001
	Light Oil	*	*	0.0002	0.0002	0.0001	0.0002	*	*	*	*
	Lube Oil	0.0003	*	0.0001	0.0005	0.0003	0.0006	*	*	*	*
	Unknown	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	*	*	0.0001	0.0001
	Waste Oil	0.0003	0.0002	0.0003	0.0005	0.0002	0.0006	*	*	*	0.0001
	Heavy Fuel	0.0003	0.0005	0.0003	0.0003	0.0002	0.0006	*	*	*	*
	Asphalt/Tar	*	*	0.0001	0.0002	0.0003	0.0001	*	*	*	*
	Other Oil	*	*	*	0.0002	0.0002	0.0001	*	*	*	*
	AFVO	0.0001	*	*	0.0001	*	*	*	*	*	*
	IFO	*	0.0002	0.0002	*	*	*	*	*	*	*
Rail	Light Fuel	0.0002	*	0.0004	0.0004	0.0013	0.0006	0.0002	0.0003	0.0002	0.0009
	Crude	*	*	*	*	*	*	*	*	*	*
	Vol. Distill.	*	*	*	*	*	*	*	*	*	*
	Light Oil	*	*	*	*	*	*	*	*	*	*
	Lube Oil	*	*	*	*	*	*	*	*	*	*
	Unknown	*	*	*	*	*	*	*	*	*	*
	Waste Oil	*	*	*	*	*	*	*	*	*	*
	Heavy Fuel	*	*	*	*	*	*	*	*	*	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	*	*	*	*	*	*	*	*	*	*
Non-SPCC	Light Fuel	0.0001	*	*	*	*	0.0001	*	0.0001	*	*
	Crude	*	*	*	*	*	0.0001	*	*	*	*
	Vol. Distill.	*	*	*	*	0.0001	*	*	*	*	*
	Light Oil	*	0.0001	*	*	*	*	*	*	*	*
	Lube Oil	*	*	*	*	*	*	*	*	*	*
	Unknown	*	*	*	*	*	*	*	*	*	*
	Waste Oil	*	*	*	*	*	*	*	*	*	*
	Heavy Fuel	*	*	*	*	*	0.0001	*	*	*	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	*	*	*	*	*	*	*	*	*	*
Aircraft	Light Fuel	*	*	*	*	0.0001	*	*	*	*	0.0002
	Crude	*	*	*	*	*	*	*	*	*	*
	Vol. Distill.	0.0006	0.0009	0.0008	0.0010	0.0010	0.0005	0.0003	0.0005	0.0008	0.0010
	Light Oil	*	*	*	*	*	*	*	*	*	*
	Lube Oil	*	*	*	*	*	*	*	*	*	*
	Unknown	*	*	*	*	*	*	*	*	*	0.0002
	Waste Oil	*	*	*	*	*	*	*	*	*	*
	Heavy Fuel	*	*	*	*	*	*	*	*	*	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	*	*	*	*	*	*	*	*	*	*
Unknown	Light Fuel	0.0018	0.0005	0.0009	0.0007	0.0014	0.0003	0.0001	0.0007	0.0001	0.0006
	Crude	*	*	0.0001	0.0001	0.0002	0.0005	*	0.0001	*	0.0001
	Vol. Distill.	0.0003	0.0001	0.0002	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001
	Light Oil	0.0001	*	0.0001	0.0001	0.0002	*	*	0.0001	0.0001	0.0001
	Lube Oil	0.0001	*	0.0001	0.0002	0.0001	0.0001	0.0001	*	*	0.0001
	Unknown	0.0005	0.0003	0.0005	0.0003	0.0008	0.0004	0.0001	0.0002	0.0002	*
	Waste Oil	0.0003	0.0001	0.0002	0.0001	0.0003	0.0001	*	0.0001	0.0001	0.0001
	Heavy Fuel	0.0003	*	*	*	0.0001	*	*	*	*	*
	Asphalt/Tar	*	*	0.0001	*	*	*	*	0.0001	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	0.0001
	AFVO	*	*	*	*	*	0.0001	*	*	*	*
	IFO	0.0001	*	*	*	*	*	*	*	*	*

Table A2: Risk from Oil Spills By Source Type, Oil Type, and EPA Region[19]											
Source	**Oil Type**	**EPA Region**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
SPCC	**Light Fuel**	$12,341	$28,788	$56,686	$68,888	$58,726	$53,286	$17,681	$18,123	$10,816	$17,238
	Crude	$125	$1,407	$6,402	$18,443	$97,952	$200,197	$25,136	$35,545	$33,272	$16,097
	Vol. Distill.	$20,748	$13,176	$28,733	$46,125	$84,549	$40,291	$20,661	$24,194	$12,631	$14,384
	Light Oil	$896	$5,779	$6,731	$1,780	$6,617	$12,786	$479	$16,415	$13,019	$516
	Lube Oil	$830	$6,813	$5,515	$12,651	$6,016	$24,856	$1,110	$2,566	$9,065	$1,421
	Unknown	$6,374	$2,943	$1,149	$4,000	$9,899	$9,475	$1,282	$2,370	$354	$6,752
	Waste Oil	$564	$3,579	$4,760	$12,306	$15,504	$23,087	$378	$3,075	$2,000	$5,621
	Heavy Fuel	$71,777	$14,231	$11,058	$19,988	$14,891	$31,634	$143	$12,888	$19,308	$841
	Asphalt/Tar	$13,553	$3,575	$7,958	$68,256	$24,364	$5,115	$3,476	$11,479	$7,888	$744
	Other Oil	$176	$113	$342	$788	$1,048	$4,503	$487	$752	$802	$1,312
	AFVO	$90	$171	$596	$2,333	$2,104	$1,936	$1,703	$42	$901	$938
	IFO	$1,431	$8,561	$2,215	$19	$1,359	$200	$172	$3	$162	$6
Pipeline	**Light Fuel**	$2,118	$635	$5,380	$3,066	$5,570	$12,366	$4,673	$2,557	$1,702	$2,387
	Crude	$9	$792	$5,039	$26,104	$78,008	$419,346	$41,625	$59,380	$59,195	$1,019
	Vol. Distill.	$366	$449	$1,577	$1,247	$17,769	$24,336	$4,611	$10,070	$2,493	$2,177
	Light Oil	$1	*	$53	*	$688	$3,701	$13	*	*	$91
	Lube Oil	$402	*	$50	$1,542	$3,334	$2,135	$39	$109	$1,418	$45
	Unknown	$101	*	$232	$4	$1,493	$2,641	$1	$3	$664	$77
	Waste Oil	*	$2	$2	*	$37	$952	*	*	$180	*
	Heavy Fuel	$79	$209	$1,180	*	$15	$22	$5	$561	$767	$1
	Asphalt/Tar	*	*	$1,694	*	*	*	*	*	*	*
	Other Oil	*	$56	*	$1	$29	$108	$6	$87	$5	$2
	AFVO	*	*	*	*	$5	$134	*	*	*	*
	IFO	$63	*	*	*	$44	*	$163	*	$11	*
Vehicle	**Light Fuel**	$2,615	$1,438	$1,156	$1,484	$3,730	$1,170	$331	$1,236	$1,675	$1,253
	Crude	*	$6	$141	$108	$161	$712	$1	$847	$108	$3
	Vol. Distill.	$3,163	$2,971	$2,749	$3,929	$4,416	$1,576	$984	$2,122	$1,947	$2,212
	Light Oil	$14	$30	$16	$41	$297	$14	$18	$20	$4	$12
	Lube Oil	$75	$190	$302	$53	$254	$351	$14	$263	$111	$37
	Unknown	$144	$47	$151	$68	$4,723	$302	$4	$497	$39	$316
	Waste Oil	$248	$129	$288	$553	$560	$105	$80	$255	$6	$48
	Heavy Fuel	$3,247	$222	$419	$471	$328	$159	*	$7	$254	$1
	Asphalt/Tar	$886	$125	$903	$1,365	$11,331	$1,834	$319	$3,110	$589	$369
	Other Oil	$1	$68	$16	$47	$124	$89	*	$23	$119	$9
	AFVO	$74	$1	$105	$211	$1,603	$183	$147	*	$20	$1
	IFO	$22	$6	$83	$17	$23	*	*	*	*	*
Residential	**Light Fuel**	$1,367	$62	$112	$45	$419	$25	$25	$33	$10	$105
	Crude	*	*	*	*	*	*	*	*	*	*
	Vol. Distill.	$86	*	*	*	$1	*	*	*	*	$1
	Light Oil	$1	*	*	*	*	*	*	*	*	$1
	Lube Oil	$2	*	*	*	$2	*	*	*	$5	$4
	Unknown	$14	*	*	*	$4	*	*	*	*	$8
	Waste Oil	$8	*	*	*	$7	*	*	*	*	$19
	Heavy Fuel	$5	*	*	*	*	*	*	*	*	$1
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	$2	*	*	*	*	*	*	*	*	*

[19] Risk is product of *probability* of spillage and *consequences* of spills (response cost and socioeconomic and environmental damages, as determined by EPA BOSCEM).

Source Type	Oil Type	1	2	3	4	5	6	7	8	9	10
Vessel	Light Fuel	$154	$404	$456	$1,529	$105	$1,321	$87	$8	$6,897	$450
	Crude	*	$861	$1	$95	$11	$848	*	*	$104	*
	Vol. Distill.	$209	$2,804	$247	$1,090	$1,321	$467	$1	$2	$7	$286
	Light Oil	$1	$1	$11	$8	$45	$12	$1	*	*	$11
	Lube Oil	$43	$3	$298	$69	$27	$92	$10	*	$1	$3
	Unknown	$7	$12	$8	$2	$1	$85	*	*	$2	$2
	Waste Oil	$25	$470	$60	$69	$32	$86	*	*	$2	$4
	Heavy Fuel	$77	$2,123	$178	$4,757	$2,375	$22,553	*	*	$4	*
	Asphalt/Tar	$6	$2	$19	$1,412	$68	$274	*	*	*	*
	Other Oil	*	$2	*	$12	$66	$24	*	*	$26	*
	AFVO	$2	$10	*	$5	*	$1	*	*	*	*
	IFO	$47	$52	$462	$1	*	$2	*	*	$10	$1
Rail	Light Fuel	$107	*	$1,524	$2,096	$1,716	$571	$817	$759	$833	$1,306
	Crude	*	*	$914	$691	*	*	*	$92	$461	*
	Vol. Distill.	*	*	*	$2	*	*	*	*	*	$716
	Light Oil	*	*	*	$38	*	*	*	*	*	*
	Lube Oil	$2	*	*	*	$2	$414	$811	$1	$1,718	*
	Unknown	*	*	*	$292	*	*	$177	*	*	*
	Waste Oil	$1	*	*	*	$95	*	*	*	*	*
	Heavy Fuel	*	*	*	*	$1,261	*	*	*	*	*
	Asphalt/Tar	*	*	*	$180	$2,165	*	*	*	*	*
	Other Oil	*	$1	*	*	*	*	*	*	*	*
	AFVO	*	*	*	$154	$691	*	*	$192	*	*
	IFO	*	*	*	*	*	*	*	*	*	$430
Non-SPCC	Light Fuel	$1	*	*	$1	*	$27	*	$4	*	$16
	Crude	*	*	*	*	*	$120	*	*	*	*
	Vol. Distill.	*	*	*	*	$89	*	*	*	*	*
	Light Oil	*	$1	*	*	*	*	*	*	*	*
	Lube Oil	*	*	*	*	*	*	*	*	*	*
	Unknown	*	*	*	*	*	$3	*	*	*	$5
	Waste Oil	*	*	*	$1	*	*	*	*	*	*
	Heavy Fuel	*	*	*	*	*	$6	$1	*	*	*
	Asphalt/Tar	*	*	*	*	$3	*	*	*	*	*
	Other Oil	*	*	*	*	*	*	*	*	*	*
	AFVO	*	*	*	*	$1	*	$23	*	*	*
	IFO	*	*	*	*	*	*	*	*	*	*
Aircraft	Light Fuel	*	*	$1	*	$2	*	*	*	*	$17
	Crude	*	*	*	*	*	*	$1	*	*	*
	Vol. Distill.	$22	$193	$18	$376	$46	$182	$240	$130	$46	$45
	Light Oil	*	*	*	*	*	$2	*	*	*	*
	Lube Oil	*	*	*	*	*	*	*	*	*	*
	Unknown	*	*	*	*	*	*	*	*	*	$72
	Waste Oil	*	*	*	*	*	*	*	*	*	*
	Heavy Fuel	*	*	*	*	*	*	*	$40	*	*
	Asphalt/Tar	*	*	*	*	*	*	*	*	*	*
	Other Oil	*	$7	*	$2	*	*	*	*	*	*
	AFVO	*	*	*	*	*	*	*	*	*	*
	IFO	*	*	*	*	*	*	*	*	*	*
Unknown	Light Fuel	$140	$57	$377	$63	$6,736	$35	$270	$304	$5	$51
	Crude	*	$77	$34	$86	$83	$1,608	*	$127	$1	$18
	Vol. Distill.	$271	$365	$421	$77	$123	$94	$6	$7	$75	$3
	Light Oil	$2	$1	$4	$5	$450	*	*	$1	$2	$2
	Lube Oil	$31	$1	$745	$20	$9	$175	$5	*	$1	$7
	Unknown	$159	$37	$199	$24	$186	$365	$28	$9	$43	$2
	Waste Oil	$32	$267	$47	$55	$25	$496	$1	$630	$5	$2
	Heavy Fuel	$1,968	*	$1	$211	$52	$1	*	$2	*	*
	Asphalt/Tar	$10	*	$2	$1	$2	*	*	$85	*	$48
	Other Oil	*	$44	*	*	$2	$12	*	$5	*	$6
	AFVO	$4	*	*	*	$2	$45	*	*	*	*
	IFO	$43	*	*	*	*	*	*	*	*	$1