ANALYSIS OF BENEFITS OF EPA OIL PROGRAM

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ABSTRACT

EPA Oil Program benefits were analyzed quantitatively with respect to *prevented* oil spills in non-marine navigable waters in EPA jurisdiction for oil spill response and from facilities. Spills per million barrels of petroleum consumption have decreased by nearly 50% since 1980. Spills into inland waters result in average annual costs and damages of $2.7 billion, including $936 million for response, $1.3 billion for environmental damages, and $445 million for socioeconomic damages (Etkin 2004*a*).

Comparisons of *actual* spillage and hypothetical spillage expected with increased petroleum consumption with no spill prevention measures show that spillage *prevented* by the EPA Oil Program and related measures of other authorities (US Coast Guard and state agencies) has increased from an average of 120 spills and 2 million gallons per year *prevented* during the 1980s to 600 spills and 13 million gallons per year in 2003. Increased benefits of spill prevention should be realized over the next decade as oil consumption rises and spill rates continue to fall. Costs *averted* due to prevented spillage averaged $1.3 billion annually since 1982, including: $391 million for response in EPA jurisdiction ($424 million for non-marine facilities); $224 million in environmental damages in EPA jurisdiction ($242 million for non-marine facilities); and $631million in socioeconomic damages in EPA jurisdiction ($676 million for non-marine facilities). In 2003, the annual cost of inland waterway oil spills was estimated at $1.1 billion. Without prevention measures, costs would be an estimated $3.4 billion. In 2003, there were an estimated $2.3 billion in costs averted for prevented spills in EPA jurisdiction and $2.1 billion in costs averted for non-marine facility spills.

INTRODUCTION

The EPA Oil Program and related state and federal measures have helped reduce oil spillage by imposing regulatory spill prevention requirements and fines and penalties for responsible parties, and increasing public awareness through educational programs. A *quantification* of the *value* or *benefit* of these prevention measures has not previously been conducted.

METHODOLOGY

An analysis of EPA Oil Program benefits with regard to reduced oil spill costs and damages was conducted using data in the EPA Jurisdiction- and EPA Facility-Oil Spill Databases (Tables 1 - 3). Estimated damages from spills that occurred in the past and projected to occur in the future were determined by the use of the EPA Basic Oil Spill Cost Estimation Model (EPA BOSCEM), as described briefly in Figure 1. [EPA BOSCEM is described in greater detail in Etkin, 2004*a*]. Historical data for oil spills in EPA's response jurisdiction and oil spills from facilities regulated by EPA were analyzed for trends and used to project future oil spillage into the next decade (through 2012) by performing a regression analysis to determine a best-fit slope of spill rate. Spills for 500 gallons or more were selected because they represent the spills most likely to create the greatest damage and, also, to eliminate the confounding factor of increased *reporting* of spills, though likely *not an increase in incidence*, of spills under this volume. Annual *numbers* of spills of 500 gallons or more rather than total annual spill volumes were used in rate analysis to remove the confounding factor of spill volumes from very large spills that overwhelm spill data in individual years. The rationalization for this was that any particular spill could result in a larger release but for certain chance occurrences in each spill event. Spill *numbers* are a more accurate reflection of the efficacy of prevention measures rather than spill volumes. Spill volumes are often a greater indicator of the efficacy of salvage or source control measures (*e.g.,* being able to detect and reduce the size of a release after the oil has starting leaking) than of prevention measures. Spill rates were also compared to annual US oil consumption to determine a rate of spillage per volume of oil consumed. Oil consumption was used as an indicator of oil production, transport, storage, and usage by both industry and the public. To estimate the rate of spillage that might have been expected had there been no spill prevention measures in place, it was assumed that spills would continue at a rate of the number of spills that occurred in the base year of 1982 per volume of consumed oil for that year. The year 1982 was selected as a base year because reliable oil consumption data was not available for 1980 – 1981. Spillage after this point was then assumed to continue at that rate of spill number per volume of oil consumption, so that spill numbers would rise with the annual increase in oil consumption. This spillage rate was termed "without-EPA Oil Program" spillage. The actual recorded rate of spillage was termed the "*with*-EPA Oil Program" spillage. The spill rates for both "*with*-" and "*without*-EPA Oil Program" were projected through the year 2012 based on the best-fit regression slope determined in the spill trend analysis. Spills "averted" were estimated by substracting *actual* spill numbers ("*with*-EPA Oil Program") from spill numbers expected as a function of oil consumption ("*without*-EPA Oil Program") (Figure 2).

Spill costs, as estimated by use of EPA BOSCEM, were used to place an estimated value on the response costs, and environmental and socioeconomic damages that occurred from past spills. Each spill in the database was assigned spill-specific criteria (spill volume, oil type, location-specific medium, -socio-economic/cultural value, -freshwater vulnerability, and -habitat/ wildlife *sensitivity* (as in Figure 1). The greater costs and damages from larger spills were factored in by the use of actual spill volumes in calculating total costs from per-gallon spill costs. EPA BOSCEM takes into account the different damages and costs related to oil type and location characteristics (*e.g.*, a diesel spill in an industrial area *vs.* a heavy fuel oil spill in a wetland teeming with a diversity of wildlife). Future spills were assumed to have a similar balance of characteristics (proportions of spills by oil type, volume, and location) as spills averaged across

2000 through 2002. Likewise, the estimated costs and damages for the hypothetical spills that would have occurred had there been no prevention measures in place ("*without*-EPA Oil Program") were calculated based on an assumption of spill characteristics similar to those for actual spills for each year from 1982 to 2002 and for the average of spills in 2000 – 2002 for future spills (2003 to 2012). Estimates of annual "cost savings" for averted spills were made by subtracting estimated costs and damages for actual oil spills ("*with*-EPA Oil Program") from estimated costs and damages for hypothetical spills that would have occurred without prevention measures of the EPA Oil Program and related state-level programs ("*without*-EPA Oil Program"). The analysis was conducted for two data sets – 42,860 oil spills within EPA's response jurisdiction (including vessel and mystery spills on inland waterways under EPA's response jurisdiction) and 41,069 oil spills from facilities (including those in the Great Lakes, which fall under US Coast Guard response jurisdiction). There is an overlap between the two databases – *i.e.,* spills that were both from facilities *and* in EPA response jurisdiction – of 40,399 spills. The results from both analyses were similar, as they involved largely the same set of data.

RESULTS

The historical and projected spill rates for spills of 500 gallons or more in navigable waters in EPA jurisdiction are shown in Figure 3, and for facility spills in Figure 4. The historical and projected future US oil consumption rate is shown in Figure 5 (based on US Energy Department of Energy 2001*a*, 2001*b*, 2001*c*, 2002). The spill rate (spill number) per million barrels of oil consumed in 1982 was 1.650 X 10^{-4} for EPA jurisdiction spills and 1.648 X10^{-4} for facility spills. If this spill rate continued following the increase in oil consumption – *i.e.,* the "*without*-EPA Oil Program" situation – the annual spill numbers would be as shown in Figures 6 and 7. [Greater detail on spill rate and trend analyses are presented in Etkin, 2004*b*.] The annual costs of oil spills "*with*-EPA Oil Program" and "*without*-EPA Oil Program" and the averted costs, based on EPA BOSCEM, are shown in Table 4 for EPA jurisdiction spills and in Table 5 for facility spills.

Costs *averted* due to prevented spillage averaged $1.3 billion annually since 1982, including: $391 million for response in EPA jurisdiction ($424 million for non-marine facilities); $224 million in environmental damages in EPA jurisdiction ($242 million for non-marine facilities); and $631million in socioeconomic damages in EPA jurisdiction ($676 million for non-marine facilities). Without prevention measures, costs would be an estimated $3.4 billion. In 2003, there were an estimated $2.3 billion in costs averted for prevented spills in EPA jurisdiction and $2.1 billion in costs averted for non-marine facility spills.

DISCUSSION

There has been tremendous progress in reducing oil spillage in the US, though spills in EPA response jurisdiction and from facilities still cause $1.8 billion annually. Clearly, the EPA Oil Program is not the *only* authority influencing the rate of oil spillage, as there are *state* and *local* spill prevention programs that complement EPA's efforts. However, the majority of state oil spill prevention and response programs are modeled after, or at least significantly influenced by, the federal program. Because of the great influence of the EPA Oil Program on state programs, a large part of the benefit from state-led spill prevention programs can be attributed to EPA. The US Coast Guard has also had an influence on vessel spillage in EPA jurisdiction, though vessel spills in inland waters represent less than 4% of total spill number and 1.5% of total gallons spilled in these waters.

At the same time, industry has taken voluntary actions, in many cases to pro-actively avoid regulatory action and to have more control over the manner in which prevention measures are implemented. There are also significant financial incentives for industry to reduce oil spillage, as spill response and damage settlements can be formidable. Industry has also, to some extent demonstrated concern about public image as people have become more educated on environmental issues (much to the credit of EPA).

ACKNOWLEDGEMENTS

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BIOGRAPHY

Dagmar Schmidt Etkin received her B.A. in Biology from University of Rochester, and her A.M. and Ph.D. in Biology (specializing in population biology, ecology, and statistical analysis) from Harvard University. She has analyzed and modeled oil spill data and impacts for 15 years.

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Table 1: Oil Spill Data Used in EPA Oil Program Cost-Benefit Analysis			
Database	**Years**	**Number Records**	**Spill Record Criteria for Inclusion in Database**
EPA Facility Oil Spill Database[1,2]	1980 to 2002	41,068	• At least 50 gallons spilled (as defined in Table 2) in one event in which at least 1 gallon enters a *non-marine* navigable waterway (as defined in Table 2) or its adjoining shoreline; • Arising from a "facility" as defined in Table 2 • Involving the release of "oil" as defined in Table 3 • Occurring during 1980 – 2002
EPA Jurisdiction Oil Spill Database[1,2]	1980 to 2002	42,860	• At least 50 gallons spilled (as defined in Table 2) in one event in which at least 1 gallon enters a *non-marine* navigable waterway (as defined in Table 2) or its adjoining shoreline that is under EPA jurisdiction for oil spill response as defined by memoranda of understanding or other agreements between US Coast Guard and EPA or otherwise stipulated in OPA 90; • Arising from any source type • Involving the release of "oil" as defined in Table 3 • Occurring during 1980 – 2002

[1]Databases custom-developed for EPA Oil Program from proprietary Environmental Research Consulting databases. [2]Note that there is overlap between databases, *e.g.*,facility spill also in EPA jurisdiction appears in both databases. 40,399 spills occurred from facilities in EPA jurisdiction and thus appear in both databases.

Table 3: Oil Types Included in EPA Jurisdiction- and EPA Facility-Oil Spill Databases
Crude: crude (unspecified); medium crude
Heavy Crude: heavy crude
Light Crude: light crude
Light Oil: absorption oil; light cycle oil; hydraulic oil; light 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
Light Fuel: No. 2 fuel oil; drill mud oil; naphtha
Volatile Distillate: gasoline; No. 1 fuel oil; crude condensate
Intermediate Fuel: No. 3 fuel oil; No. 4 fuel oil; transmix
Heavy Oil: heavy fuel; No. 6 fuel oil; residual oil; heavy oil
Tar: tar; asphalt; creosote; wash oil; tack oil
Wax: wax; paraffin; carnauba wax
Waste Oil: waste oil; oily waste
Other Oil: neatsfoot oil; dusting oil; penetrating oil; synthetic oil; road oil; resin oil; hot oil
Non-Edible Vegetable Oil: tung oil; tanner oil; tall oil; pine oil; linseed oil; castor oil
Mineral Oil: thermal oil; quench oil; mineral oil; insulating oil; heat transfer oil; transmission oil
Lube Oil: spindle oil; lubricating oil; gear oil; machine oil; compressor oil; crankcase oil; cycle oil
Edible Oil: vegetable oil; soybean oil; seal oil; safflower oil; peanut oil; palm oil; fish oil; croton oil; cottonseed oil; corn oil; coconut oil; canola oil
Animal Fat: tallow; sperm oil; lard; animal fat
Unknown Oil: unknown oil; unidentified oil

Table 2: Terms Used in Development of EPA Jurisdiction Oil Spill Database
Navigable Waters[1]: US waters *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 and 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, the use, degradation, or destruction of which could affect interstate or foreign commerce, including any such waters: (A) that are or could be used by interstate or foreign travelers for recreational or other purposes; or (B) from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (C) that are or could be used for industrial purposes by industries in interstate commerce. iv.) Tributaries of waters identified in (i) to (iii); and v.) Wetlands adjacent to waters identified in (i) to (iv).
Spill: 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.
Facility: Any mobile or fixed, onshore or offshore building, structure, installation, equipment, pipe, or pipeline (*other than a vessel)* used in oil well drilling operations, production, refining, storage, gathering, processing, transfer, distribution, and waste treatment, or in which oil is used.
Other Vessel: Vessel that carries oil as fuel and for other operational purposes (machine oil, *etc.*) but does *not* carry oil as cargo.

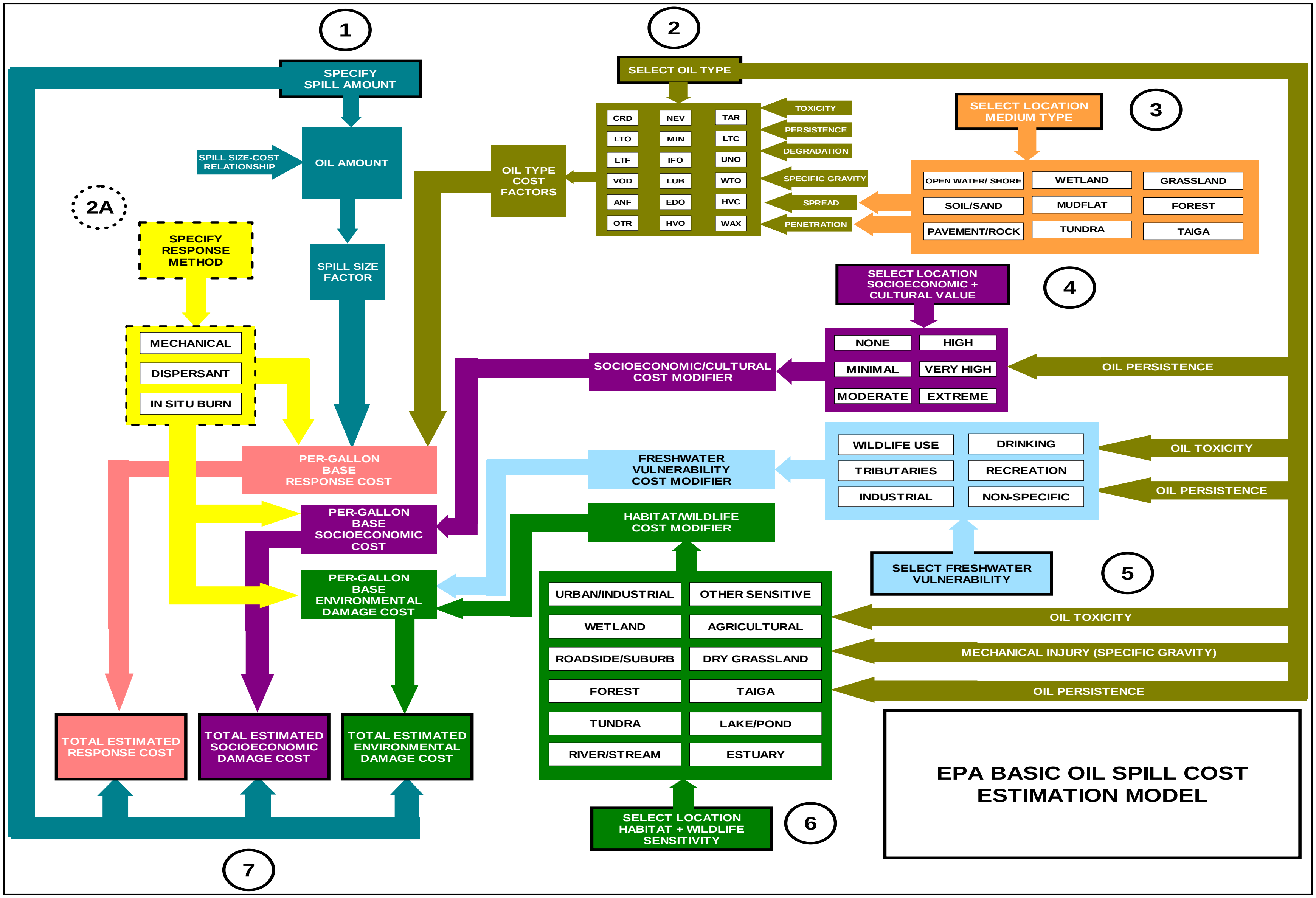

Figure 1: EPA Basic Oil Spill Cost Estimation Model (BOSCEM). The diagram shows cost-factor interrelationships and steps for estimating oil spill response-, environmental-, and socioeconomic costs. Users specify five variables for each spill – volume, oil type, and location-specific medium, -socio-economic/cultural value, -freshwater vulnerability, and -habitat/ wildlife sensitivity. Base costs and cost modifiers are derived from analyses of historical data and modeling of spill behavior, trajectories, and costs. ***Note: EPA BOSCEM is described in greater detail in another paper in these proceedings, Modeling Oil Spill Response and Damage Costs (Etkin).***

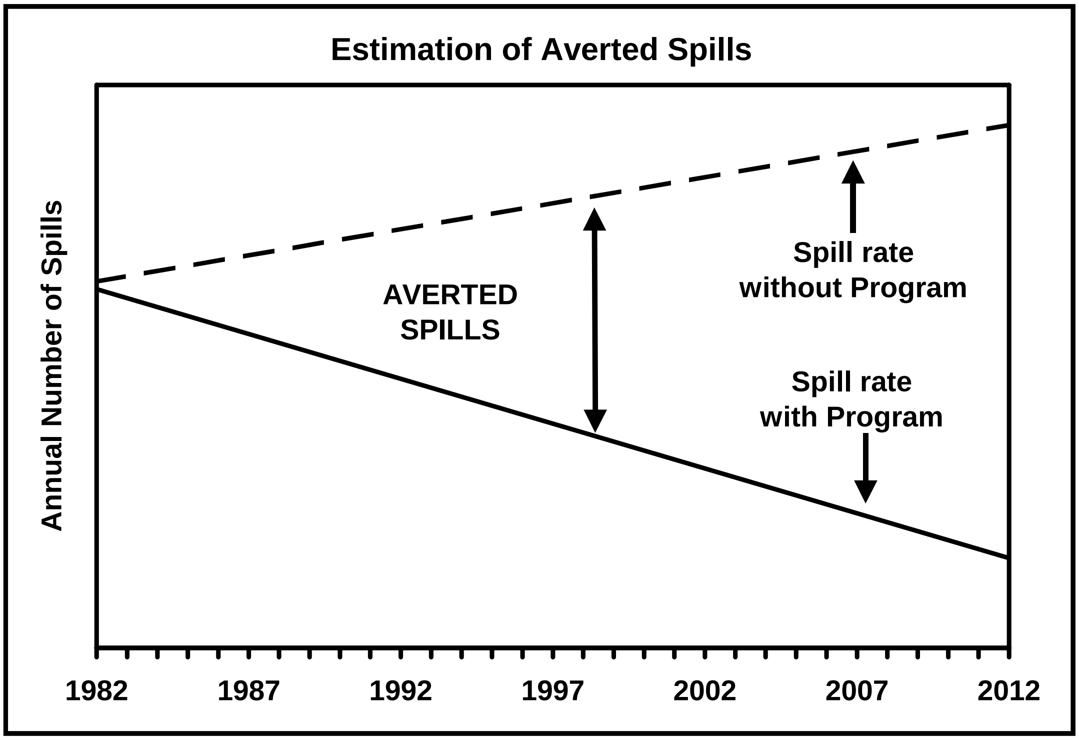

Figure 2: Estimated oil spills "averted" by prevention measures in the EPA Oil Program were determined based on the annual difference between *actual* spill numbers (solid line) ("with-EPA Oil Program") and *estimated* spill numbers that would have occurred as a strict function of annual oil consumption (dashed line) ("without-EPA Oil Program").

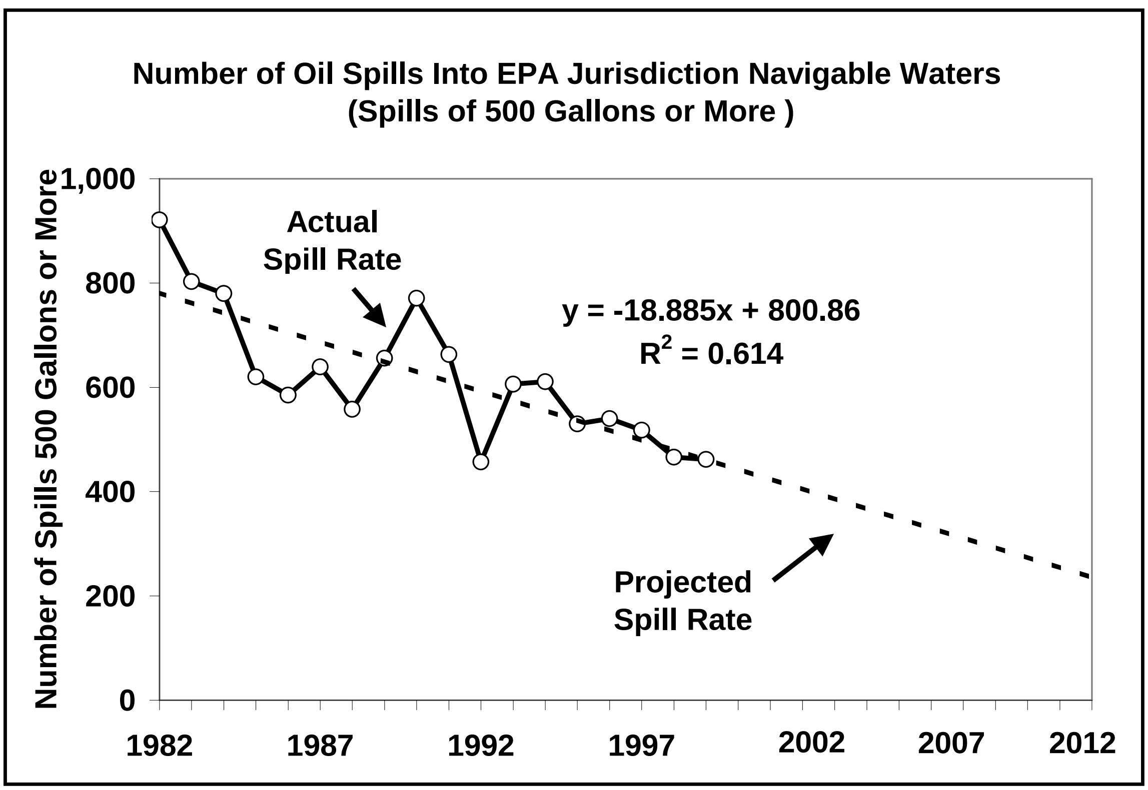

Figure 3: Plot of numbers of oil spills of 500 gallons or more into inland navigable waters under EPA jurisdiction for spill response shows decreasing spill rate. The projected spill rate continues on the same slope.

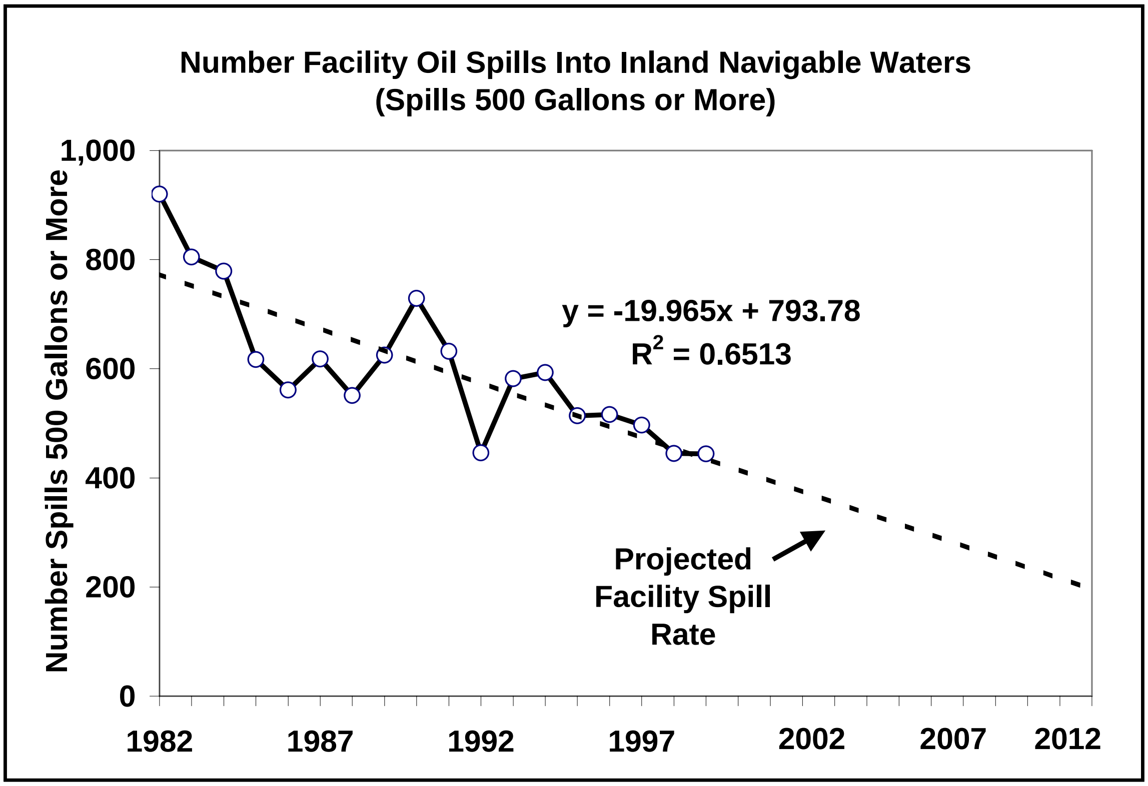

Figure 4: Plot of numbers of facility oil spills of 500 gallons or more into inland navigable waters shows decreasing spill rate. The projected spill rate continues on the same slope.

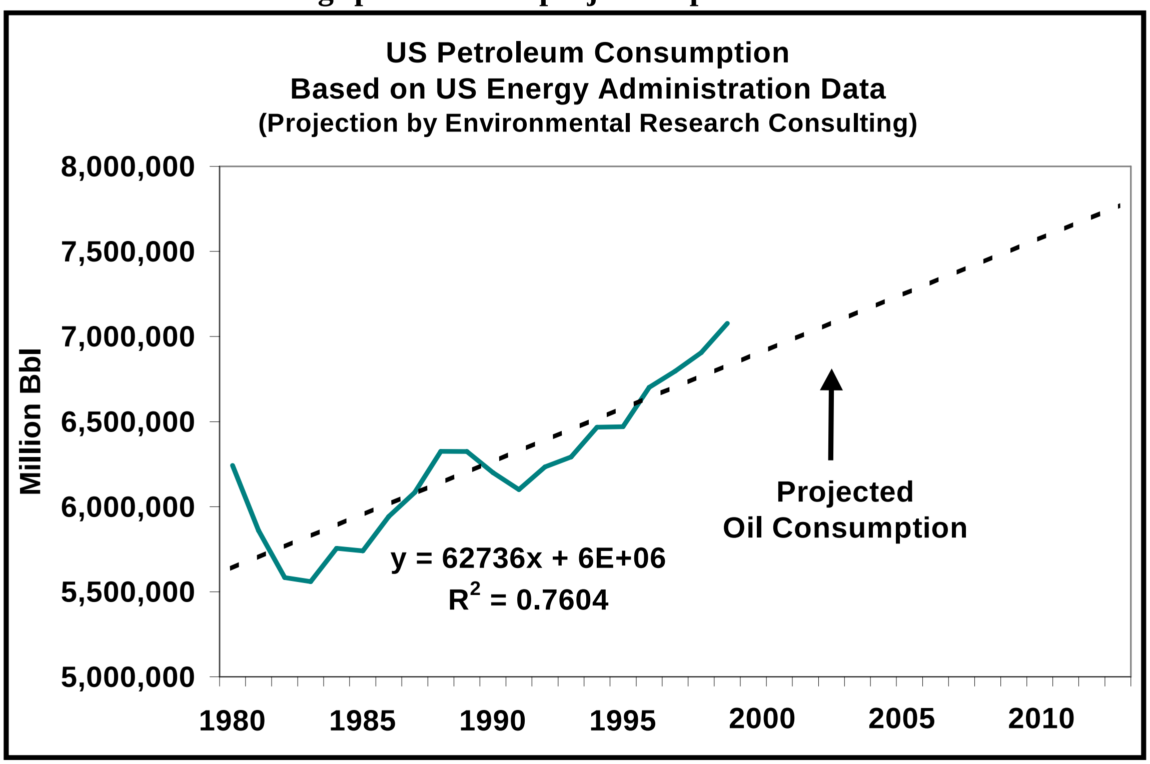

Figure 5: US annual petroleum consumption based on US Dept of Energy (2001*a,b,c;* 2002). Projection for future consumption based on best-fit regression slope.

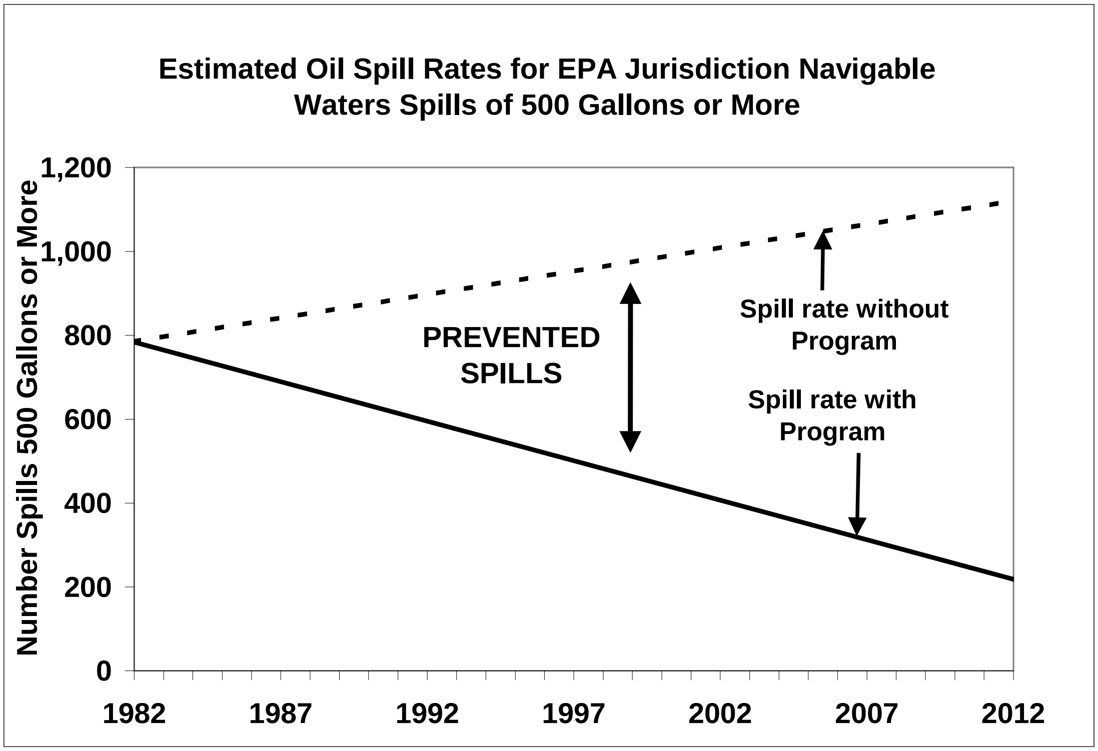

Figure 6: Estimated oil spill rates for EPA jurisdiction navigable waters. The differences between actual annual spill numbers "*with*-EPA Oil Program" and estimated spill numbers "without-EPA Oil Program" (following spills per million barrels oil consumed in 1982) are the numbers of prevented or averted spills.

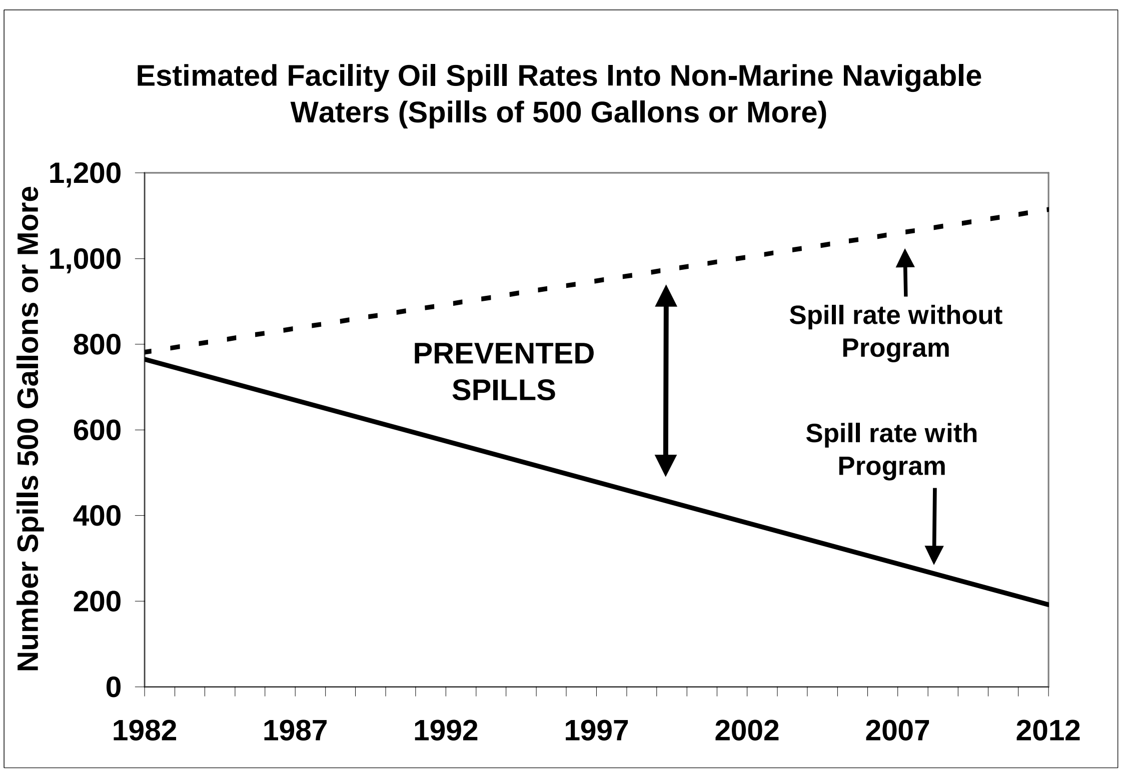

Figure 7: Estimated facility oil spill rates into inland navigable waters. The differences between actual annual spill numbers "*with*-EPA Oil Program" and estimated spill numbers "without-EPA Oil Program" (following spills per million barrels oil consumed in 1982) are the numbers of prevented or averted spills.

Table 5: Estimated Averted Costs for Oil Spills into EPA Jurisdiction Navigable Waters[1]				
Year	Estimated Cost Averted (Million 2002 $)			
	Response[2,3]	Socioeconomic Damage[2,3]	Environmental Damage[2,3]	Total[2,3] Cost Savings
1982	$0	$0	$0	$0
1983	$71	$33	$95	$198
1984	$153	$60	$166	$379
1985	$169	$81	$213	$463
1986	$146	$119	$341	$606
1987	$220	$132	$334	$686
1988	$239	$114	$349	$701
1989	$300	$148	$427	$875
1990	$376	$171	$498	$1,046
1991	$456	$185	$515	$1,156
1992	$372	$221	$679	$1,272
1993	$421	$261	$713	$1,395
1994	$422	$239	$676	$1,337
1995	$532	$263	$862	$1,657
1996	$611	$289	$855	$1,756
1997	$489	$318	$829	$1,637
1998	$614	$378	$1,052	$2,044
1999	$611	$305	$949	$1,865
2000	$535	$394	$912	$1,841
2001	$572	$359	$1,018	$1,949
2002	$628	$367	$1,273	$2,268
2003[4]	$667	$490	$1,136	$2,293
2004[4]	$693	$510	$1,181	$2,384
2005[4]	$716	$526	$1,219	$2,461
2006[4]	$409	$301	$696	$1,405
2007[4]	$423	$311	$721	$1,455
2008[4]	$440	$323	$749	$1,512
2009[4]	$465	$342	$792	$1,600
2010[4]	$482	$354	$821	$1,657
2011[4]	$504	$371	$859	$1,734
2012[4]	$524	$386	$893	$1,804
Total 1982 - 2002	**$7,937**	**$4,436**	**$12,758**	**$25,131**
Total 1982 - 2012	**$13,260**	**$8,350**	**$21,826**	**$43,436**

[1]As defined in Table 2. [2]Based on EPA Jurisdiction Oil Spill Database using EPA Basic Oil Spill Cost Estimation Model. [3]Assumes mechanical recovery operations (plus shoreline) with 0% on-water effectiveness during 1980 – 1984, 10% during 1985 – 1992, and 20% during 1992 – 2002. [4]Based on actual costs and spillage for 2000 adjusted for increased response effectiveness from 20% through 2005 to 50% for 2006 – 2012.

Table 5: Estimated Averted Costs for Facility Oil Spills into Inland Navigable Waters[1]				
Year	**Estimated Cost Averted (Million 2002 $)**			
	Response[2,3]	**Socioeconomic Damage[2,3]**	**Environmental Damage[2,3]**	**Total[2,3] Cost Savings**
1982	$0	$0	$0	$0
1983	$93	$43	$126	$262
1984	$195	$76	$205	$475
1985	$224	$107	$279	$610
1986	$185	$145	$393	$724
1987	$250	$150	$379	$779
1988	$274	$130	$401	$805
1989	$355	$175	$502	$1,032
1990	$408	$185	$534	$1,126
1991	$476	$190	$528	$1,194
1992	$372	$225	$687	$1,284
1993	$409	$247	$669	$1,326
1994	$464	$255	$718	$1,437
1995	$582	$289	$947	$1,817
1996	$691	$321	$950	$1,962
1997	$512	$344	$881	$1,737
1998	$672	$413	$1,160	$2,245
1999	$689	$334	$1,021	$2,044
2000	$604	$432	$995	$2,032
2001	$638	$395	$1,103	$2,136
2002	$588	$400	$1,333	$2,321
2003[4]	$647	$463	$1,066	$2,177
2004[4]	$674	$482	$1,111	$2,267
2005[4]	$721	$516	$1,188	$2,424
2006[4]	$411	$294	$678	$1,383
2007[4]	$432	$309	$712	$1,454
2008[4]	$452	$323	$744	$1,519
2009[4]	$468	$335	$772	$1,575
2010[4]	$483	$345	$795	$1,623
2011[4]	$500	$358	$824	$1,682
2012[4]	$520	$372	$856	$1,748
Total 1982 - 2002	**$8,681**	**$4,854**	**$13,811**	**$27,346**
Total 1982 - 2012	**$13,990**	**$8,652**	**$22,557**	**$45,199**

[1]As defined in Table 2. [2]Based on EPA Facility Oil Spill Database using EPA Basic Oil Spill Cost Estimation Model. [3]Assumes mechanical recovery operations (plus shoreline) with 0% on-water effectiveness during 1980 – 1984, 10% during 1985 – 1992, and 20% during 1992 – 2002. [4]Based on actual costs and spillage for 2000 adjusted for increased response effectiveness from 20% through 2005 to 50% for 2006 – 2012.

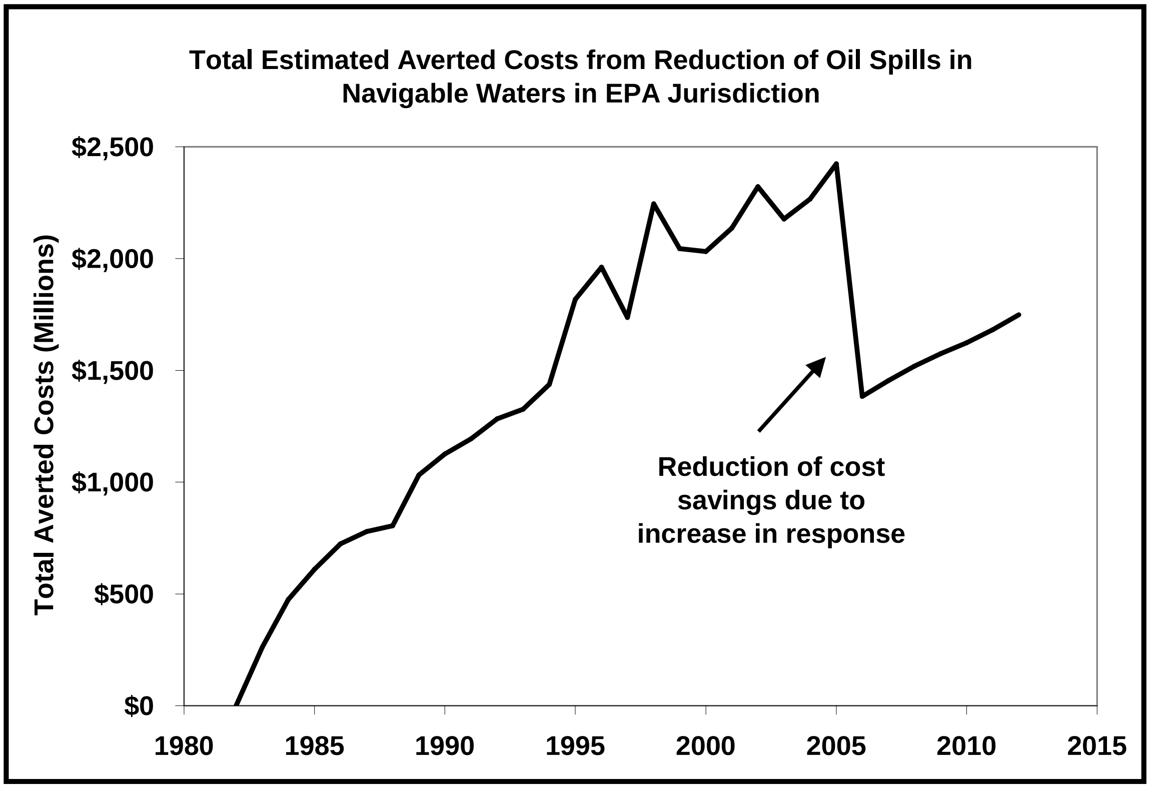

Figure 8: Total averted costs due to oil spills in EPA response jurisdiction due to the EPA Oil Program and related prevention efforts. Note that the cost savings is reduced with the expected increase in response effectiveness.

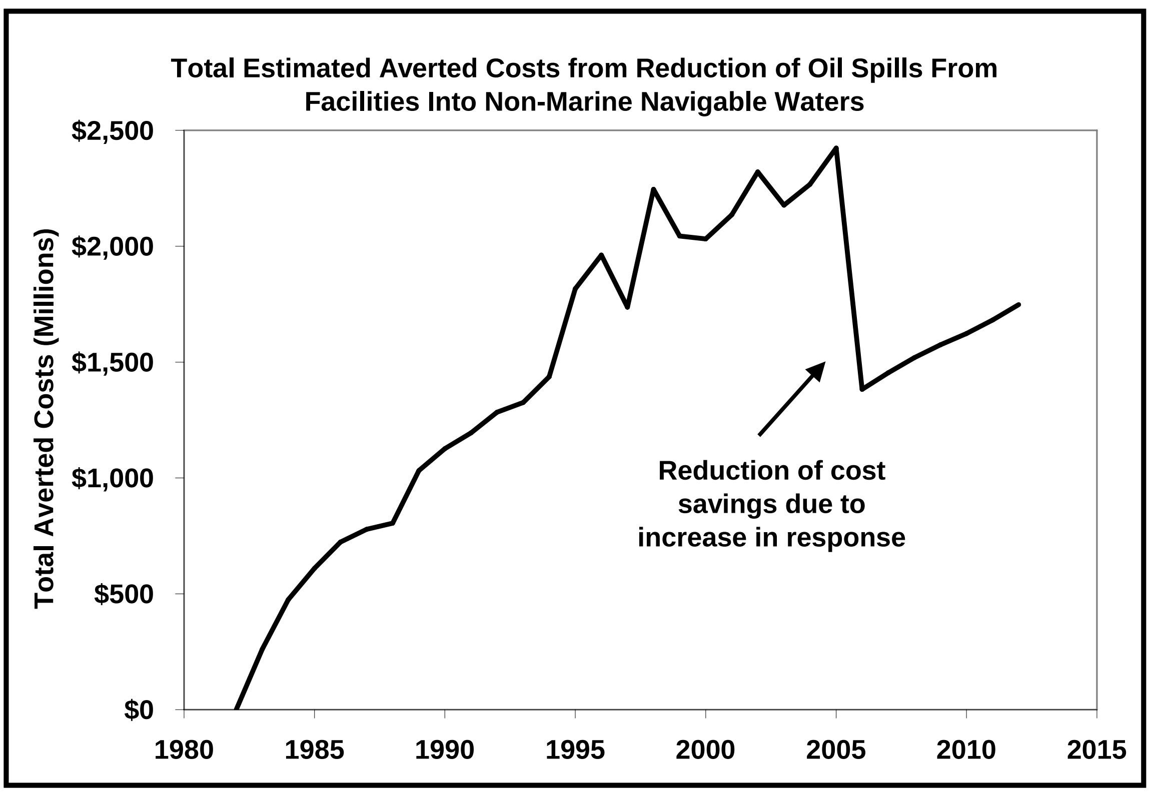

Figure9: Total averted costs due to facility oil spills in non-marine navigable waters due to the EPA Oil Program and related prevention efforts. Note that the cost savings is reduced with the expected increase in response effectiveness.