Environmental Research Consulting



Hudson River Oil Spill Risk Assessment

Volume 6: Risk Mitigation

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Acknowledgments

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The HROSRA research team acknowledges the invaluable inputs and discussions with Scenic Hudson over the course of the study period (September 2017 through May 2018), including the selection and development of the hypothetical spill scenarios. The contents of the report, data, analyses, findings, and conclusions are solely the responsibility of the research team and do not constitute any official position by Scenic Hudson. The Hudson River Oil Spill Risk Assessment was conducted as an independent, objective, technical analysis without any particular agenda or viewpoint except to provide quantitative and qualitative information that could be used to work to a common goal of spill prevention and preparedness. The study is intended to inform officials, decision-makers, stakeholders, and the general public about oil spill risk in the Hudson River.

The diligent efforts of the RPS SIMAP modeling team of Jenna Ducharme, Matt Frediani, Deborah Crowley, Emily Skeehan, and Matt Bernardo provided the necessary data, results, maps, and graphics that formed the foundation of much of the analysis in the HROSRA.

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Cover Photograph Credits

The photographs on the report cover were taken by Dagmar Schmidt Etkin (Esopus Meadows Lighthouse and articulated tank barge) and Steve Kardian (bald eagle) on the Hudson River.

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Acronyms and Abbreviations

ACC: Alternate Classification Cities

ACP: Area Contingency Plan

AFFF: aqueous film forming foam

AFPM: American Fuel & Petrochemical Manufacturers

AIS: Automatic Identification System

AMPD: average most-probable discharge

ANPRM: Advance Notice of Proposed Rulemaking

ATB: articulated tank barge

ATON: aids to navigation

bbl: bbl of oil (equivalent of 42 gallons)

BNM: Broadcast Notice to Mariners

BSEE: Bureau of Safety and Environmental Enforcement

BWI: boating while intoxicated

CBR: crude-by-rail

CEMS: Crew Endurance Management Systems

CFR: *Code of Federal Register*

cm: centimeter

CO: carbon monoxide

COFR: Certificate of Financial Responsibility

CONUS: continental US

COTP: Captain of the Port

DOT: Department of Transportation

ECP: electronically-controlled pneumatic [braking]

EDRC: Estimated Daily Recovery Capacity

EPA: Environmental Protection Agency

ERC: Environmental Research Consulting

ERG: Emergency Response Guidebook

ERSP: Estimated Recovery System Potential

FID: flame ionization detector

FOSC: Federal On-Scene Coordinator

FRA: Federal Railroad Administration

FRP: facility response plan

FWPCA: Federal Water Pollution Control Act

g/ml: grams per milliliter

GIS: geographic information system

GPM: gallons per minute

GRP: geographic response plan

GRS: geographic response strategy

H_2S: hydrogen sulfide

HAZWOPER: Hazardous Waste Operations and Emergency Services

HFO: heavy fuel oil

HHO: home heating oil

HOS: Hours of Service

HROSRA: Hudson River Oil Spill Risk Assessment

HVPA: High-Volume Port Area

IC: Incident Commander

ICS: Incident Command System

IFO: intermediate fuel oil

IMH: Incident Management Handbooks

IMT: Incident Management Team

ITB: integrated tank barge

ITOPF: International Tanker Owners Pollution Federation

kts: knots

LDH: large-diameter hose

LEL: lower exposure level

LNG: liquefied natural gas

LNM: Local Notice to Mariners

LO: Liaison Officer

MARAD: Maritime Administration

mmHg: millimeters mercury

MMPD: maximum most-probable discharge

mPas: megapascals

mph: miles per hour

MSIB: Marine Safety Information Bulletin

MTSRU: Marine Transportation System Recover Unit

MV: motor vessel

NCP: National Contingency Plan

NEPA: National Environmental Policy Act

NFPA: National Fire Protection Association

NIMS: National Incident Management System

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NPFC: National Pollution Funds Center

NRT: National Response Team

NSFCC: National Strike Force Coordination Center

NTVRP: Non-tank Vessel Response Plan

NWR: National Wildlife Refuge

NYSDEC: New York State Department of Environmental Conservation

O_2: oxygen

OCIMF: Oil Company International Marine Forum

OPA: oil-particulate aggregate

OPA90: Oil Pollution Act of 1990

OSHA: Occupational Safety and Health Administration

OSLTF: Oil Spill Liability Trust Fund

OSP: Oil Sand Product

OSRO: Oil Spill Removal Organization

PAH: polynuclear aromatic hydrocarbons

PAWSA: Ports and Waterways Safety Assessment

PCB: polychlorinated biphenyl

PG: packing group

PHMSA: Pipeline and Hazardous Material Safety Administration

PID: Photoionization Detector

POTW: publicly-owned treatment works

PPE: personal protective equipment

PREP: Preparedness for Response Exercise Program

PSC: Port State Control

PTC: positive train control

QRG: Quick Response Guide

RP: responsible party

RRI: Response Resource Inventory

RRT: Regional Response Team

SCAT: Shoreline Cleanup Assessment Technique

SCBA: self-contained breathing apparatus

SIRE: Ship Inspection Report Program

SMFF: Salvage and Marine Firefighting

SOSC: State On-Scene Coordinator

SPCC: Spill Prevention, Control, and Countermeasures

SSC: Scientific Supporter Coordinator (NOAA).

STCW: Standards of Training, Certification, and Watchkeeping

TMSA: Tanker Management Self-Assessment

TMSS: Towing Management Safety System

UC: Unified Command

UEL: upper exposure level

USACE: US Army Corps of Engineers

USCG: US Coast Guard

USFWS: US Fish and Wildlife Service

VHF: very high frequency

VOC: volatile organic compound

VRP: vessel response plan

VTM: vessel traffic management

VTS: Vessel Traffic Service

WB&C Williams Boots & Coots Company

WCD: worst-case discharge

WCD1: Worst-Case Discharge Tier 1

WCD2: Worst-Case Discharge Tier 2

WCD3: Worst-Case Discharge Tier 3

YC: Yacht Club

Hudson River Oil Spill Risk Assessment Report Volumes

The Hudson River Oil Spill Risk Assessment (HROSRA) is composed of seven separate volumes that cover separate aspects of the study.

Executive Summary (HROSRA Volume 1)

The first volume provides an overall summary of results in relatively *non-technical* terms, including:

- Purpose of study;
- Brief explanation of risk as "probability times consequences" and the way in which the study addresses these different factors;
- Brief discussion of oil spill basics;
- Results – the "story" of each spill scenario, including the oil trajectory/fate/exposure, fire/explosion brief story (if applicable), and a verbal description of the consequence mitigation (response – spill and fire emergency); and
- Brief summary of spill mitigation measures with respect to response preparedness and prevention.

HROSRA Volume 2

The second volume provides an overview of the study approach and general introduction to unique features of the Hudson River.

HROSRA Volume 3

The third volume reviews the potential sources of oil spillage. It also presents the analyses of the probability of occurrences of spills of varying sizes from the potential sources under different conditions of traffic and oil transport.

HROSRA Volume 4

The fourth volume presents the analyses of the potential consequences or impacts of hypothetical spills, including the trajectory and fate of spills to the water, and the potential exposure of resources above thresholds of concern, based on oil modeling (including Appendices with detailed figures, etc.).

HROSRA Volume 5

The fifth volume presents the analyses of potential consequences or impacts of hypothetical fire and explosion events that may occur in addition to oil spills.

HROSRA Volume 6

The sixth volume presents the analyses of spill mitigation measures to reduce the risk of spills through prevention, preparedness, and response. The volume includes response and preparedness considerations for the specific modeled scenarios, as well as overall response issues for the Hudson River. It also includes more generic descriptions of prevention measures (vessels, trains, facilities, etc.).

HROSRA Volume 7

The seventh volume presents the summary tables with data – including probabilities, spill modeling, fire/explosion analysis, and response considerations for each of the 72 modeled spill scenarios. This volume pulls together everything from HROSRA Volumes 3, 4, 5, and 6.

Research Team

Dagmar Schmidt Etkin, PhD (Environmental Research Consulting)

Dr. Etkin has 42 years of experience in environmental analysis–14 years investigating issues in population biology and ecological systems, and 28 years specializing in the analysis of oil spills. Since 1999, she has been president of Environmental Research Consulting (ERC) specializing in environmental risk assessment, and spill response and cost analyses. She has been an oil spill consultant to the US Coast Guard, EPA, NOAA, Army Corps of Engineers, the Bureau of Ocean Energy Management, the Bureau of Safety and Environmental Enforcement, various state governments, the Canadian government, the oil and shipping industries, and non-governmental organizations. She is internationally recognized as a spill expert and has been a member of the UN/IMO/UNEP/UNESCO Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) since 1997. She has a BA in Biology from University of Rochester, and received MA and PhD from Harvard University in Organismic/Evolutionary Biology, specializing in ecological modeling and statistics.

Deborah French McCay, PhD (RPS Ocean Science)

Dr. French McCay (formerly Dr. French) specializes in quantitative assessments and modeling of aquatic ecosystems and populations, oil and chemical transport and fates, and biological response to pollutants. She has developed water quality, food web and ecosystem models for freshwater, marine and wetland ecosystems. She is an expert in modeling of oil and chemical fates and effects, toxicity, exposure and the bioaccumulation of pollutants by biota, along with the effects of this contamination. Her population modeling work includes models for plankton, benthic invertebrates, fisheries, birds and mammals. These models have been used for impact, risk, and natural resource damage assessments, as well as for studies of the biological systems. She has provided expert testimony in hearings regarding environmental risk and impact assessments. She has over 30 years of experience in analyzing oil spills and is considered one of the leading international experts on the fate and effects of oil spills. She has a BA in Zoology from Rutgers College, and a PhD in Biological Oceanography from the Graduate School of Oceanography, University of Rhode Island.

Jill Rowe (RPS Ocean Science)

Jill Rowe specializes in biological and environmental data gathering, analysis and management; natural resource damage assessment (NRDA) modeling and analysis of pollutant fates and effects; ecological risk assessment; impact assessment of dredging and development projects, preparing sections of Environmental Impacts Statements; providing NEPA support, and GIS mapping and analysis. Ms. Rowe has applied her marine biological and GIS expertise to biological data set development, as well as mapping habitats and biological resource distributions that could ultimately be affected by oil/chemical spills and development projects. She performs quantitative assessments and modeling of aquatic ecosystems and populations, pollutant transport and fates, and biological response to pollutants. The populations to which she applies these models include plankton, benthic invertebrates, fisheries, birds and mammals. She has analyzed data and has applied water quality, food web and ecosystem models to case studies in freshwater, marine and wetland ecosystems. She has a BA in Biology from DePauw University, and an MS in Marine Biology from the College of Charleston.

Deborah Crowley (RPS Ocean Science)

Deborah Crowley is a senior consulting environmental scientist and project manager at RPS. She has experience working on issues and projects related to various aspects of environmental science such as environmental data analysis, hydrodynamic and water quality modeling and analysis, coastal processes, oil and gas fate and transport assessment in the environment, operational discharge modeling and assessment, renewable energy project development assessment support, environmental impact assessment in coastal and marine environments and permitting and regulatory compliance analysis and support. Ms. Crowley's experience with renewable energy projects includes cable burial studies, wind resource assessment, climatology assessment including extremal analysis, wind turbine siting, turbine power production and site capacity analysis, turbine impacts assessment, turbine visualizations, regulatory, permitting and zoning review, planning and management of terrestrial met tower deployment and associated data management and analysis. Areas of experience include numerical modeling, model development and application, field program design and support, data analysis and visualization in Matlab™ and geospatial analysis in ArcGIS™. She has a BS in Mechanical Engineering from Worcester Polytechnic Institute and an MS in Civil & Environmental Engineering from University of Rhode Island.

John W. Joeckel (SEAConsult LLC)

Mr. Joeckel is an executive management professional with a broad-based background in multi-modal transportation, oil, chemical and gas industry sectors, and manufacturing and production. He has extensive experience in legislative advocacy and regulatory compliance, crisis and consequence management, emergency preparedness and response, including hands-on response as an Incident Commander on multiple major emergency incidents and development of all hazard response/crisis management programs and plans including training and exercises. He has experience in ports, waterways and facility maritime security vulnerability analysis and security plan development including personnel training and exercise. Mr. Joeckel has a BS in Maritime Transportation from SUNY Maritime College, as well as many years of training in oil spill response. He has been involved in response research and development and supervising many spill response operations, including the BP Gulf of Mexico Deepwater Horizon incident, the Enbridge Pipeline Michigan oil tar sands crude oil spill in the Kalamazoo River, and the Exxon Valdez spill in Alaska.

Andrew J. Wolford, PhD (Risknology, Inc.)

Dr. Wolford is founder and President of Risknology, Inc., a company specializing in risk analysis of hazardous facilities. He is an expert risk engineer with 29 years of experience. He has directed risk assessments on a diverse range of engineered systems including; offshore and onshore oil and gas installations, mobile offshore drilling units, marine and land-based transportation systems, chemical and nuclear fuel processing plants, nuclear power and test reactors, and the Space Shuttle program. He has a BA in Physics from Wittenberg University, a BA in Nuclear Engineering from Georgia Institute of Technology, and a ScD from Massachusetts Institute of Technology.

Oil Spill Risk Mitigation

Oil spill risk is made of two distinct and independent components – the probability or likelihood of oil spills and the potential consequences and impacts of spills that might occur. Risk mitigation reduces risk by decreasing one or both of these components. In other words, the mitigation of spill risk can be addressed in two different ways – by reducing the probability that a spill will occur or by reducing the consequences or impacts of spillage (Figure 1).

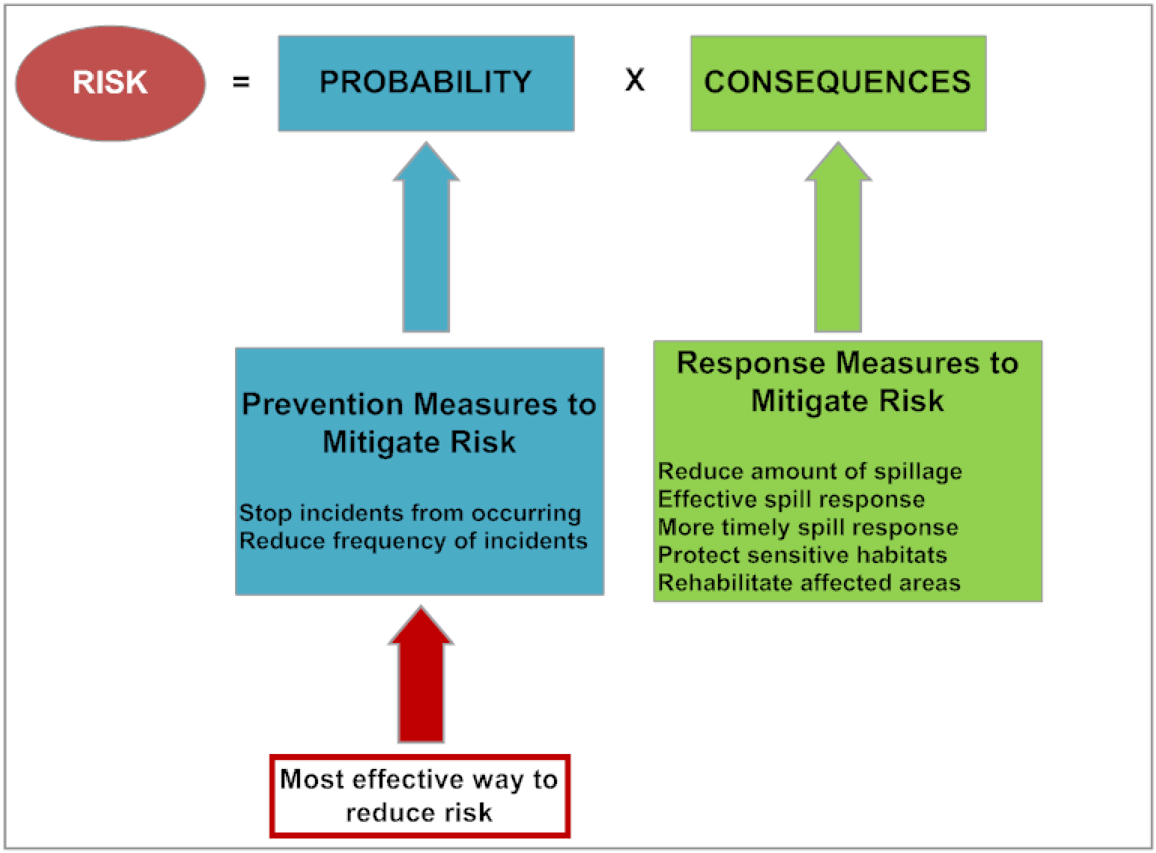

Figure 1: Mitigating Oil Spill Risk

Risk Mitigation through Prevention

The most effective measures to mitigate oil spill risk address the reduction or elimination of the probability of spills occurring in the first place. This is generally achieved by either stopping or adjusting the activities that might lead to accidents and situations that might in turn lead to spillage.

In order for a spill to occur from a tank vessel, for example, there needs to be an accident, failure, or operations error of some kind. Then the accident, failure, or operations error needs to result in a release of oil through a break in the hull and cargo or bunker (fuel) tank, or a breach of a hose or pipe.

Reducing or even eliminating tank vessel traffic on the Hudson River would clearly reduce the tank vessel-related spill risk. The fewer tank vessel trips, the lower the probability of spills. But this would not be an economically-feasible or practical approach. Reducing the likelihood of accidents, failures, and operations errors that may result in spills would also mitigate the risk. Examples of this strategy would include crew training and vessel traffic systems. Reducing the likelihood of these incidents resulting in the release of oil is also important in risk mitigation. This strategy would include double hulls for cargo tanks on tank vessels (already in place) and for bunker (fuel) tanks (in place to some degree). Alarm systems that detect leaks would be another example.

Risk Mitigation through Response

Overall, there have been great strides in reducing oil spill frequency worldwide, yet oil spills do still occur and can be expected to occur for some time. Further mitigating oil spill risk requires planning and preparedness to respond effectively to spills. Spill response includes:

- Reducing the amount of oil released into the environment through source control;
- Preventing or reducing the spread of oil that has spilled;
- Tracking and monitoring the spread of oil on the water surface and ground;
- Protecting the most sensitive and valued resources from oiling;
- Diverting the spreading oil away from the most sensitive areas to less sensitive areas where removal is likely to be more effective and less intrusive;
- Containing oil on the water surface and removing as much oil as possible;
- Removing oil and oiled debris from shorelines;
- Locating and removing submerged oil in sediment;
- Disposing of collected oil and oily debris; and
- Restoring the oil-impacted shoreline and sediment areas to the extent possible.

Every way in which these response steps can be made more effective, efficient, and timely reduces the consequences of the spillage.

Prevention of Risk Escalation

It should be recognized that some factors can actually increase or escalate oil spill risk (Figure 2) by increasing the likelihood of a spill or by decreasing the effectiveness of spill response. Insuring that the escalation of risk is minimized is also an essential part of risk mitigation.

When spill probability changes due to increased or new spill sources (e.g., the introduction of crude-by-rail traffic or increases in tank vessel traffic), new risk mitigation strategies may be required. Reductions in previously-existing prevention measures, for example due to budget restrictions or reductions in training, can have a negative effective and increase spill risk.

For spill response, any factors that increase response time or decrease effectiveness will also reduce the mitigation of risk. In some cases, intervening factors, such as stormy weather, may preclude effective response operations. However, training, planning, and preparedness will help to increase timeliness and effectiveness of spill response.

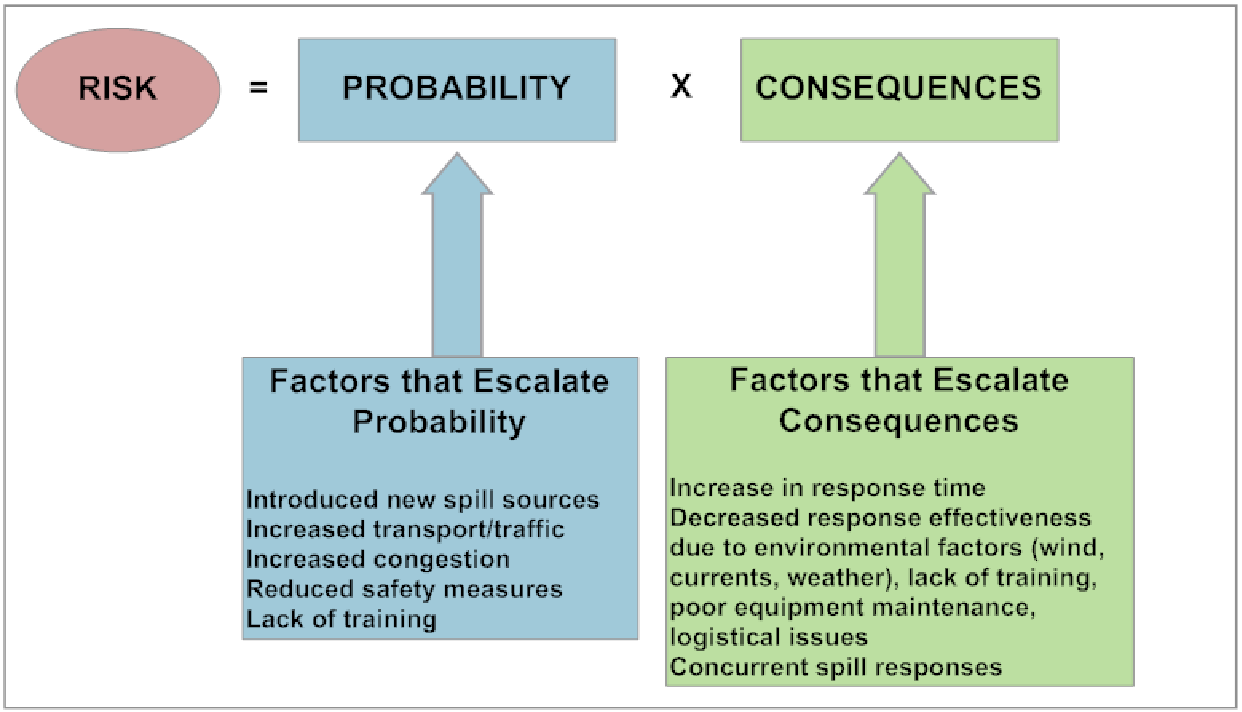

Figure 2: Escalating Oil Spill Risk

Risk Mitigation through Spill Response

Once oil spills into water, responders are confronted with a race against time and the forces of physics, chemistry, and biology in their quest to remedy the situation and minimize damages. Oil spreads quickly into a thin sheen (less than the width of a hair) on the water and starts to evaporate, disperse, dissolve, and move with the winds and currents.

Despite decades of research and development, there are no fool-proof solutions. Each response strategy presents potential benefits and drawbacks. The strategic decision-making process is often a matter of evaluating tradeoffs – e.g., birds in the marsh may be spared, but fish are impacted; the oil can be kept out of this wetland, but a sandy beach will be oiled instead. The response itself may have impacts (e.g., toxicity, marsh trampling, or air pollution). Ultimately, the *net benefit to the environment* needs to be paramount.

Basic Oil Spill Response Strategies and Tactics

Once oil has spilled into a waterway, such as the Hudson River, there are a number of response strategies that can be taken to remove the oil. Each approach has its benefits, challenges, and potential drawbacks, as summarized in Table 1. Shoreline and nearshore response are summarized in Table 2. Most spill response operations will involve a combination of strategies. Note that the application of some highly-effective on-water response methods would not be appropriate for the Hudson River. They are therefore not included in the summary. These methods include chemical dispersants[1] and in situ burning.[2]

The effectiveness of any spill response strategy will vary by the environmental conditions, timing, and oil properties, as well as strategic application by the responders. On-scene decisions made by responders about the placement of boom, maintenance of deployed boom, tracking of the spill trajectory, equipment condition, and prioritizing of actions in an ever-changing and challenging playing field will all affect the success of the operations. High° of responder preparedness and coordination amongst the various players from previous training exercises and actual spill experience will all increase the effectiveness of the response operations.

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[1] Chemical dispersants act like detergents to break the oil physically and chemically into smaller droplets that are more bio-available to naturally-occurring microbes that can metabolize and break down the oil into harmless components. The chemicals are applied by sprays from airplanes or from boats in a concentration of about 1 - 2 parts dispersant to 20 parts oil. This is a highly effective way to keep oil off sensitive shorelines and near-shore areas. It leads to the breakup of about 50 to 98% of the oil. Chemically-dispersed oil is one-tenth to one-hundredth as toxic as the fresh oil that has spilled. If the oil is broken up offshore there is significantly less shoreline cleanup required (which can have its own negative impacts). Near-shore impacts are reduced protecting many bird species and other wildlife in wetlands. This methodology has been used extensively and successfully around the world. Chemical dispersants are not approved for use in nearshore and inland waterways. Dispersants do drive oil components into the water column (below the surface). This may cause some toxic impacts to fish and invertebrates in the water. Near-shore use is restricted in most areas because the dispersed oil has less area in which to dilute and disperse.

[2] In situ burning is another highly-effective oil response strategy. Oil is corralled with fire-proof boom into a relatively thick layer on the surface and ignited with gels (usually from helicopters) to burn off the oil. As much as 98% of the oil will be burned, leaving some residue on the surface. As with dispersants, the oil is kept off of the shoreline and out of sensitive near-shore areas. The oil burns creating black plumes of smoke that may cause temporary human health problems from high particulate matter. Burns cannot be conducted downwind or near to populated areas. There are often permitting issues due to air pollution concerns. The particulates that are released in a burn are not unlike what would be released if that oil were burned as a fuel.

Table 1: On-Water Spill Response Strategies						
Strategy	**How it Works**	**When Appropriate**	**Effectiveness**	**Benefits**	**Challenges**	**Drawbacks**
Mechanical Containment and Recovery (Booms and Skimmers)	Oil on the water surface is herded or contained by booms that float on the water surface. Oil is vacuumed up or removed from the water surface with skimming devices or vessels.	This strategy works best when there is a relatively thick layer of oil on the water surface and the oil is not too frothy (mousse-like) and not too viscous (thick and resistant to flow). The boom containment will only be effective if the currents do not exceed 0.7 – 1 knot. This approach is appropriate for Hudson River, though there will be significant challenges with currents in many locations.	Offshore, rarely more than 5 to 10% of oil is recovered. It may be more effective in more sheltered areas with calmer water. It is possible to remove more oil (25% or more) in situations in which the spill site (e.g., offloading tanker) is already boomed off and the removal equipment is nearby.	There is very little, if any, additional environmental impact. The only conceivable impacts would be the impacts of the boats that are involved in the operations.	In a large spill, it may be difficult to track oil movement to locate areas with high oil concentrations that would lend themselves to effective removal. It takes time to get equipment in place during which time oil may have spread or moved due to wind and current action. High current velocities and waves can preclude effective containment booming. Availability of storage barges or tanks for oil/water mixtures is often a limiting factor and may cause delays. This technique can be difficult to carry out under stormy conditions.	This is a very labor- and equipment-intensive strategy that is generally not very effective. Large volumes of oily water mixture are recovered, often with very small percentages of oil content. The mixture needs to be collected and stored and then needs to be processed to remove the small percentage of oil and often the remaining oil-tainted water cannot be disposed of without hazardous material disposal permits.
Sorbents	Mats and pads that act like sponges are applied to the oil on the water surface to remove the oil.	On-water sorbent placement can be effective in small areas with low concentrations of oil, especially if there is a need to have a minimally-	Sorbents vary in effectiveness based on the materials involved and for the oil types and conditions of the spill.	Sorbent application is relatively non-invasive and does not require large machinery.	Placing the sorbents on the water surface in an effective manner can be difficult especially in inaccessible areas.	Once sorbent pads and mats absorb oil they need to be replaced. Oil-soaked sorbents become hazardous waste that needs to be disposed. Some

Table 1: On-Water Spill Response Strategies

Strategy	How it Works	When Appropriate	Effectiveness	Benefits	Challenges	Drawbacks
		invasive response.				sorbents are reusable. Sorbents cannot be effectively applied on a large scale or in situations in which there are high concentrations of oil.
On-Water Augmented Bioremediation	Genetically-engineered oil-eating bacteria are applied to the water to break down the oil.	This technique may be appropriate for small-scale spills particularly on land.	Few tests that have been conducted for on-water applications of oil-eating bacteria have given disappointing results.	There are no documented benefits to this strategy.	Applying bacteria solution or dry mixture to make contact with surface oil can be difficult. There are relatively small supplies of bacteria available.	Addition of non-indigenous bacteria species may be of concern.
Natural Removal	The oil is not removed offshore but rather left to break up on its own with wave action and natural weathering.	Natural removal may be the best alternative (i.e., with the best longer-term environmental benefit) when there is a very exposed rocky shoreline with high wave energy or exposed marsh area with a good deal of water flushing through tidal flow. In very remote areas, this may be the only practical and safe alternative.	This can be highly effective when the wave energy and natural flushing action is high. It works best for less persistent oils, though it can also break down more persistent oils given enough time.	There is no environmental impact from the response itself unlike some other more aggressive methods that can cause more harm than good. It is always possible to implement a response at a time that is safer or more logistically feasible (e.g., in summer rather than during winter).	It is often difficult to convince the public and government officials that nothing should be done for the time being. The ultimate effectiveness of this strategy might not be demonstrated for months to years.	Natural removal may not be completely effective, especially with more persistent (heavier) oils or if the wave or flushing action of the water is not sufficient. The opportunity for an effective on-water response may be lost.

Table 2: Shoreline/Nearshore Oil Spill Response Strategies

Strategy	How it Works	When Appropriate	Effectiveness	Benefits	Challenges	Drawbacks
Protective/ Deflective Booming	Booms are placed to prevent oil from entering particularly sensitive shoreline or near-shore areas. The oil is deflected to other areas where it is easier to remove the oil mechanically or remove it from the shoreline or where the damage will be less than in the sensitive area under protection.	This strategy is appropriate when there is particular concern about a shoreline area, such as a wetland or bird nesting habitat.	Protective booming can be highly effective if coastal currents and tidal currents do not exceed 0.7 to 1.0 knots or booms are placed angles to partially compensate for the currents since booms can withstand higher currents if placed at angle to current direction.	Keeping oil out of sensitive areas can significantly reduce damages to these areas.	Booms often need to be moved with the incoming and outgoing tides. The condition and placement of the boom (proper anchoring, etc.) will determine effectiveness. Booms that have been stored for long periods without inspection and repair or replacement are often	Placing boom in one location means that the oil has to go somewhere else. There will need to be a tradeoff decision-making process.
Sorbent Booms and Pads	Sausage-like booms filled with sorbent materials are placed in the water to soak up oil on the water surface that may come in proximity of the boom. (Sorbent mats can also be used for this purpose.)	This relatively low-invasive strategy is appropriate in very low wave, calm water areas when there are low concentrations of oil in marshes or other near-shore areas.	Sorbent booming can be fairly effective if the water is very calm and oil concentrations are low.	The sorbent booms may keep minimal amounts of oil out of sensitive areas.	Sorbent placement can be difficult in relatively inaccessible areas. The continuous replacement of the sorbents can be labor intensive.	This strategy does not work in locations with high concentrations of oil or if the water is rough. As with sorbent pads, the booms need to be replaced and disposed when they are soaked with oil. The large numbers of people involved can cause more harm to the marsh through trampling.

Table 2: Shoreline/Nearshore Oil Spill Response Strategies

Strategy	How it Works	When Appropriate	Effectiveness	Benefits	Challenges	Drawbacks
Marsh Flushing	Seawater is pumped through the marsh to flush out and dilute the oil that is sticking to marsh grass.	Marsh flushing is an appropriate strategy when there are moderate to higher concentrations of oil.	The flushing can be very effective in removing and diluting the oil.	The flushing procedure simulates and enhances natural tidal movements to promote the natural recovery of an oiled marsh.	Logistical access with pumps and hoses can be difficult. Access to the marsh may be difficult from the land side requiring boat access.	The flushing action may take considerable time and the results of the operations may not be immediately apparent.
Marsh Grass Cutting	Heavily oiled areas of marsh grasses are cut and removed.	This relatively high-impact strategy is appropriate if oiling is very heavy and other alternatives have been exhausted and there are other more sensitive locations (e.g., bird nesting areas) proximate to the marsh that will be oiled or re-oiled if the oil is not aggressively removed from that marsh.	The grass cutting can be relatively effective in removing gross contamination in some marsh areas.	The removal of the heavily-oiled marsh grass may protect other more sensitive areas.	Bringing people and equipment into a marsh often causes more harm to the marsh than the oil itself. Decision-making on tradeoffs (i.e., this marsh area is protected at the expense of another area) needs to be addressed. Disposal of the oiled grasses and debris needs to be addressed.	The marsh areas in which grasses were cut often take much longer to recover than oiled areas that were not cut.
Mechanical Removal	Heavy machinery (e.g., bulldozer) is brought in to remove oiled sediments, grasses, and debris.	The very high impact strategy is appropriate in marshes only if all other methods have failed and it is essential to remove gross contamination to prevent the oiling or re-oiling of even more sensitive areas.	Mechanical removal can be relatively effective in removing gross contamination in some marsh areas and on sandy beaches.	The removal of the heavily-oiled sediments, grasses, and debris may protect other more sensitive areas. Heavily-oiled sandy beach areas can be cleaned	Bringing people and equipment into a marsh often causes more harm to the marsh than the oil itself. Decision-making on tradeoffs (i.e., this marsh area is protected at the expense of another area) needs to be	The marsh areas in which the equipment and personnel worked often take much longer to recover than oiled areas that were not cut.

Table 2: Shoreline/Nearshore Oil Spill Response Strategies						
Strategy	**How it Works**	**When Appropriate**	**Effectiveness**	**Benefits**	**Challenges**	**Drawbacks**
		Mechanical removal may be appropriate on heavily-oiled sandy beaches (e.g., swimming beaches) that need to be cleaned relatively quickly.		effectively in this manner.	addressed. Disposal of the oiled grasses, sediments, and debris needs to be addressed. In sandy beach areas, the sand needs to be replaced with clean sand.	
Natural Recovery	The shoreline or marsh area is left alone to allow natural tidal flushing and wave action to break the oil down to enhance biodegradation.	Exposed shoreline areas that are subject to high wave action and/or storms are ideal locations for natural recovery. Marshes and other areas in which aggressive cleaning may cause more harm than the oil itself are also ideal candidates for this approach.	This can be highly effective when the wave energy and natural flushing action is high. It works best for less persistent oils, though it can also break down more persistent oils given enough time.	There is no impact to the environment from the response itself unlike some other more aggressive methods that can cause more harm than good in the long-term. It is always possible to implement a response (e.g., a shoreline cleanup) if the action of storms and tides are not sufficiently effective or at a time that is safer or more logistically feasible (e.g., in summer rather than during a stormy, dark winter).	It is often difficult to convince the public and government officials that nothing should be done for the time being. The ultimate effectiveness of this strategy might not be demonstrated for months to years.	Natural removal may not be completely effective, especially with more persistent (heavier) oils or if the wave or flushing action of the water is not sufficient. The opportunity for an effective on-water response may be lost.

Table 2: Shoreline/Nearshore Oil Spill Response Strategies

Strategy	How it Works	When Appropriate	Effectiveness	Benefits	Challenges	Drawbacks
Manual Shoreline Cleanup	Tar balls, oily patches, and oiled debris are picked up manually with shovels, gloved hands, and rakes.	Lightly- or moderately-oiled sandy or pebbly shorelines lend themselves to manual cleanup operations.	The cleanup process can be very effective.	No heavy equipment is needed and unskilled workers can easily be trained to participate in the cleanup operations.	Workers need to be trained to recognize oil and reduce personal exposure. The collected oily debris needs to be disposed.	The process is labor-intensive and time-consuming.
High-Pressure Water Washing	High-pressure hoses are used to spray the oil off of affected substrates. The oil is collected from the water with skimmers, vacuum pumps, and/or sorbents.	Seawalls, piers, boats, and other hard surfaces that do not otherwise support biological species and that can withstand high-pressure water can be treated this way.	This technique is very effective especially on lighter oils.	The structures can be effectively cleaned.	Logistical issues with access and equipment availability may be present.	This approach should not be used on shorelines that support marine life. Damage from high-pressure washing is far greater than the oil itself.
Fertilizer-Enhanced Bioremediation	Natural biodegradation of oil through action of naturally-occurring microbes is enhanced through addition of fertilizers that contain limiting nutrients. Addition of certain mineral nutrients (nitrates or phosphates) enhances growth of microbes that can then better break down oil. This technique has been used successfully for land-based spills.	This technique may be appropriate on some rocky shorelines.	Enhanced-bioremediation can be reasonably effective in helping to breakdown oil though it may not give any benefits beyond what might be accomplished naturally.	Natural biodegradation may be enhanced.	Proper application of the fertilizer usually needs to be done manually and is labor-intensive. Workers need to be protected from exposure to the fertilizers.	The application may cause health impacts in the workers applying the fertilizers. Application of additional fertilizers may not be necessary and may cause problems with eutrophication.

Booming

The most important characteristic of a boom is how it is deployed in order for the boom to achieve its capacity to contain or deflect oil and this is largely determined by the boom's behavior in relation to water movement and conditions. The boom should be flexible enough to conform to wave motion yet sufficiently rigid to provide a barrier so as to retain as much oil as possible. Standard booms are typically not capable of retaining oil against a relative water current of more than 0.7 knots at right angles to the boom, irrespective of boom size or construction. A recent development has been boom arrangements specifically constructed to work in moving water or towed behind a vessel and where available, can prove effective in areas with relatively strong water currents.

Other important boom characteristics are strength, ease and speed of deployment, reliability, weight and cost. It is essential that a boom is sufficiently robust for its intended purpose and will tolerate inexpert handling, since trained personnel are not always available. Strength is also required to withstand the forces of water and wave action when being towed into position. A boom should be as straightforward as possible to deploy so as to ensure the safety of response personnel and allow for rapid deployment and recovery from the often confined and difficult working environment of a response vessel. Practical limitations of boom strength and ease of handling mean that, in general, a single boom arrangement will be limited to a maximum of 1,000-1,300 feet and commonly much shorter than this.

But if the boom is not deployed in the right location and deployed in a correct manner to protect, divert, and contain, then the boom is practically useless. Boom must be deployed ahead of the spill so proper planning must be accomplished so that the boom can be deployed ahead of the spill. The boom, once deployed, needs to be tended to ensure debris does not affect its capability and that changing current direction due to tide changes are also planned for ahead of time for a boom deployed for a flood tide, may not be effective on the ebb.

The USCG Research and Development Center[3] provides guidance concerning controlling and recovering oil spills in fast moving water above 0.75 knots (0.86 mph). Spill response in current velocities of waterways above 0.75 knots is difficult to accomplish because oil entrains under booms and skimmers in swift currents.

Therefore, boom deployment requires setting the boom at angles to the river current, the higher current velocity, the more severe the angle required at the shoreline, however, as the angle becomes more severe, i.e., the degree of the angle decreases, the outreach of the boom into the river also decreases thus, more oil flowing in the river will bypass the boom and travel further down river/down current, necessitating additional boom deployments downstream in an attempt to catch the bypassing oil elsewhere along the river. Figure 3 would suggest that on the Hudson, for a 1 knot current, the onshore boom angle should be reasonably close to 45° for the boom to remain effective.

[3] Hansen and Coe 2001.

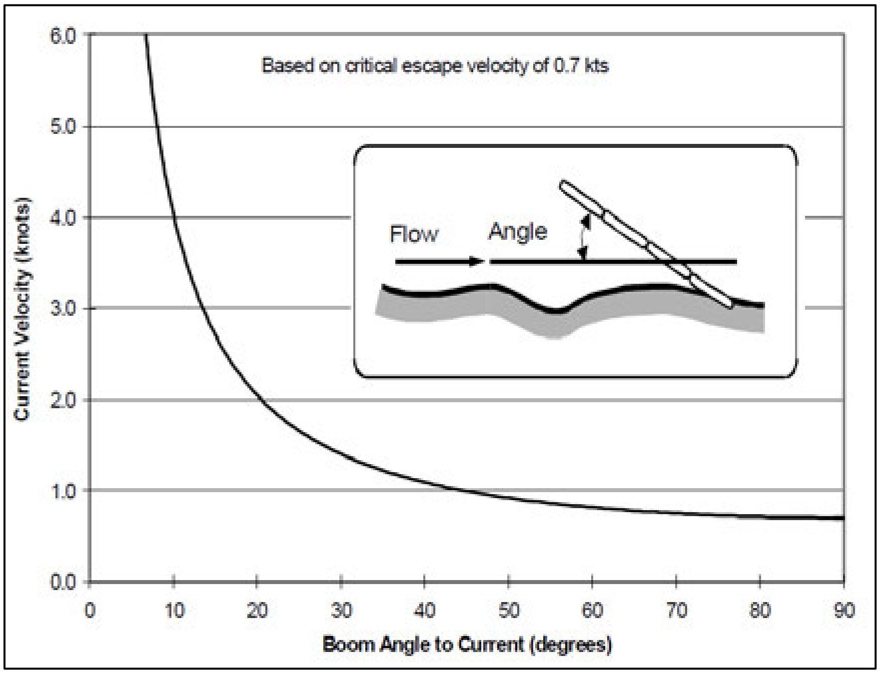

Figure 3: Maximum Deployment Angles Required to Prevent Oil Entrainment[4]

As a river, the Hudson has a current with varying velocities that necessitates the responder to deploy boom appropriately to take advantage of the current as an ally instead of the enemy. River current direction and velocity is also important when planning for and operating floating mechanical recovery platforms, e.g., skimmers, since current velocity, coupled with speed of the skimmer through the water, if not operated properly, would also see inefficiencies from entrainment, over-splash of the skimmer swath, or inability of the skimmer to catch the oil.

More experience and skill is needed to successfully complete responses. Timely response efforts are required in order to minimize environmental damage, economic losses and associated cleanup costs. Some containment and control devices slow or divert the surface current and oil without causing entrainment, which allows recovery with most conventional skimmer designs. Specialized fast-water skimmers can also remove oil as it passes by at high speeds. Oil can also be diverted away from sensitive areas or to containment or recovery devices near shore where currents are slower due to bottom frictional effects. In some cases the techniques and equipment presented for fast water conditions can also be applied successfully as high-speed recovery systems in slow current conditions, thus improving oil recovery rates and coverage factors where advancing systems are used.[5]

An oil spill incident on the Hudson River will involve, in the majority of instances, response in fast currents. This is an important issue that responders must deal with in a Hudson River spill. Fast currents present particular challenges in spill preparedness and response.

[4] Hansen and Coe 2001.
[5] Hansen and Coe 2001.

Theoretically, oil moves 100% with the velocity of the current in the direction of the current, and 3% of the wind velocity in the direction the wind is blowing to. A one (1) knot current velocity, theoretically will transport the oil one nautical mile in one hour, thus the need for responders to plan on boom and other response resource deployment in sufficient time ahead of the oil arrival to contain the oil for removal, or deploy boom in protection and or deflection configurations to mitigate economic and or environmentally sensitive areas from oil impact. Thus, rapid decisions are required to get out ahead of a spill.

Fast currents reduce the effectiveness of boom and skimming equipment, thereby necessitating additional resources to make up for that loss of effectiveness as well as deploying those resources in an appropriate manner to compensate to a degree, the high current velocities that cause that loss of effectiveness.

Table 3 depicts the current velocities at various locations on the Hudson River which verifies the one knot and above velocities which requires Responsible Parties and their contracted Oil Spill Removal Organizations (OSROs) to preplan for and implement deployment strategies at the time of a spill incident to compensate for fast currents.

Table 3: Current Velocity Measurements on Hudson River[6]

Location	Latitude	Longitude	Current Velocity (kts)[7]		
			Average	% > 0.7 kts[8]	Maximum
George Washington Bridge	40.848550	-73.950317	1.1	59.5%	2.97
Tappan Zee	41.067433	-73.881533	0.7	45.0%	2.15
Haverstraw	41.209167	-73.951333	0.7	47.4%	1.87
Stony Point	41.241583	-73.966683	0.8	56.3%	1.78
Bear Mountain Bridge	41.315917	-73.983850	0.7	40.2%	1.59
Beacon-Newburgh Bridge	41.516583	-73.991683	0.7	52.8%	1.33
Roseton	41.562467	-73.970533	0.8	61.9%	1.56
Mid-Hudson Suspension Bridge	41.701667	-73.945850	1.0	70.0%	1.84
Kingston Point	41.918267	-73.959500	1.0	74.4%	1.58
Kingston-Rhinecliff Bridge	41.977383	-73.952267	0.7	52.6%	1.27
Silver Point	41.138183	-73.908517	0.9	67.8%	1.49
Hudson	42.247883	-73.818600	1.0	76.0%	1.58
Coxsackie	42.351267	-73.789883	1.1	75.1%	1.61
Houghtaling Island	42.422417	-73.780067	0.8	64.9%	1.32
Castleton-on-Hudson Bridge	42.504433	-73.777383	0.7	41.8%	1.14
Port of Albany	42.623100	-73.755600	0.5	5.2%	0.74
Troy (Below Locks)	42.734050	-73.690783	0.9	78.2%	1.15

6 Based on ERC analysis of NOAA Tides and Currents https://tidesandcurrents.noaa.gov/cdata/StationList?type=Current+Data&filter=historic&pid=15
7 Near surface or as close to surface as uppermost measurements taken in each location.
8 See Figure 4.

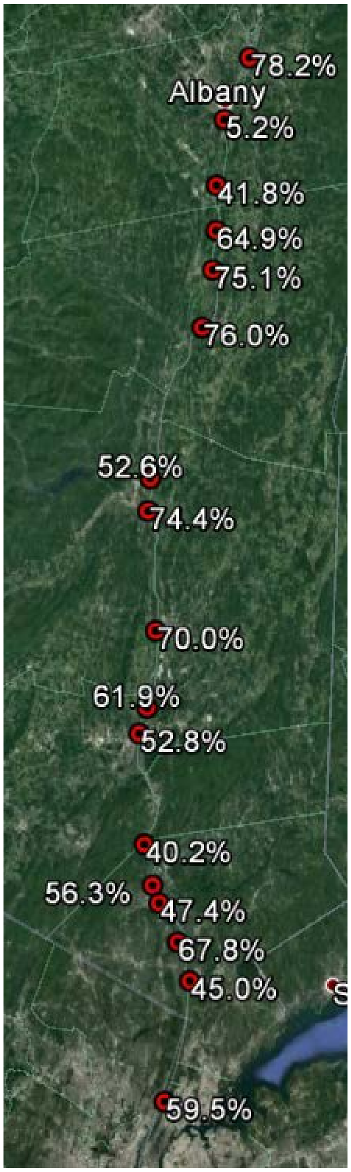

Figure 4: Percentage of Current Velocity Exceeding 0.7 knots at Various River Points

The fact that current velocity exceeds the capacity of booms 40% to nearly 80% of the time in many sections of the Hudson River means that there will be significant challenges in booming for both protective and deflective booming of sensitive sites, as well as and for mechanical containment and recovery. The specific issues for spill response for the different modeled scenarios are discussed under the section "Response Considerations for the HROSRA Modeled Scenarios" in this volume. Response considerations are also summarized in the HROSRA Volume 7 for all the modeled scenarios.

The Hudson River is also a tidal estuary meaning that the current flows two ways, one way as the tide ebbs and the other as the tide floods, thus the responder needs to plan ahead to take advantage of two differing tides and currents. Tides also change the level of the river, so boom deployments need to be monitored as the tide ebbs and floods to ensure the booms maintain their desired effectiveness. In tidal areas, all booms must be stabilized to stay in place during slack and reversing currents. The configuration should not rely on the force of the current to maintain its shape.

Oil that has been collected during an ebb tide by a diversionary boom angled to the shore will be lost on a reversing flood tide unless it is skimmed or contained from escaping. Booms often have to be moved as the tide starts to shift in order to protect sensitive areas or contain oil during the flow reversal. Booms should be configured to withstand and be effective in the most severe current predicted for the next tidal cycle. If the boom is to remain in the same position during both tides then it should be anchored on both upstream and downstream sides to keep it in place and to prevent anchor dislodgment.

The presence of tides on a navigable river will significantly complicate an oil spill response. Approximately every six hours the tidal currents will change from maximum flood to maximum ebb tide. This requires constant tending of the deflection boom as the current changes. Tidal current reversals often require that the equipment be repositioned on each tidal change, up to 4 times in each 24-hour period. Maximum currents in fast water tidal rivers vary between 1 and 3 knots, which is lower than the inland rivers. The ebb current is usually slightly stronger than the flood tide due to fresh water runoff. Rains will dramatically increase ebb tides while diminishing and delaying flood tides. Local conditions can dramatically change the time and magnitude of maximum currents and slack water. Strong winds can pile up water against coastal areas and accentuate high tides or reduce low tides depending upon the timing.[9]

Fast water accelerates many spill processes necessitating quicker and more efficient responses compared to stagnant water or slow-moving current conditions. The severity of the impact of oil depends on many factors including the properties of the oil itself. Natural conditions such as current speed, turbulence, temperature and wind also influence the behavior of oil in water. Some physical and chemical properties of oil are important to consider when developing a spill response strategy, selecting tactics and choosing the best equipment.

The USCG provides important guidance concerning the need to pre-plan and ultimately implement an oil spill response which requires responders to have knowledge and understanding of the following criteria:[10]

- **The ability to read currents and flow patterns of the river:** Selection of a good location to deploy the oil containment system is dependent upon prior planning and understanding of the currents. Drift studies, oceanographic surveys, river runoff histories, tidal current tables and charts, and computer modeling are all useful tools to understand the flow patterns and to develop strategies. The day of the spill may present different current and circulation patterns or other factors that require accurate field observations. Reading the currents and flow patterns require practice and understanding of the hydrodynamics involved. Several things may be helpful to define these patterns. Selection of a containment area where a lower current exists is desirable. This will allow wider deflection angles and reduce drag forces on the boom.
- **Knowledge of the natural collection sites on the river:** Natural collection sites should be identified and categorized in Area Contingency Plans (ACP) as part of the planning process to select control points for spill response operations. This can be effectively accomplished by surveying the coastline and then conducting an investigation of promising sites by land or water. Viable control points should afford favorable currents, helpful circulation patterns and effective logistics support such as roads, wide-open banks, sufficient water depth for fully loaded vessel and good mooring selections. These sites also collect oiled debris that will complicate the collection and removal process. Cleaning the site before the oil arrives is recommended.
- **The ability to estimate current and deflection angles:** An accurate determination of current direction and velocity is important in order to select the proper tactic and deploy the equipment correctly. Current meters can be used to measure the velocity, but they are not always practical during a spill response. The current velocity profile can be estimated by observing the incline of buoys, floating debris, and the amount of turbulence around buoys and pilings. Current speed can be calculated by timing the movement of floating debris over a measured distance. The chip log technique only requires floating debris, a tape measure or two buoys spaced a measured distance apart, and a stopwatch.

Oil will be lost under a boom when the current exceeds about 0.75 knots. This value is independent of boom skirt depth. Wind loads are not significant in high-current areas but the loads created by wind-

[9] Hansen and Coe 2001.
[10] Hansen and Coe 2001.

induced currents can affect the equipment performance so the effect of the wind must be included. Once the current is known, the angle for boom deployment can be determined. Oil losses can be minimized if the angle is set at a maximum angle as shown in Figure 3.

The US Coast Guard Sector NY/NJ and the State of New York, with the assistance of the Area Committee, completed the development of the Hudson River Geographic Response Strategies (GRSs) for the Hudson River in 2017. An example is shown below in Figure 5, which depicts the various boom configurations, marina locations and staging areas located on the Hudson River at river miles 1-4. This is vital information provided for responders especially for the early hours in an incident when decisions regarding deployment of boom are critical. These GRSs are available for the full length of the river.

Figure 5: USCG Geographic Response Strategies (GRS) in the Albany Area[11]

[11] USCG Sector New York/New Jersey.

Boom deployment shown in Figure 6 and Figure 7 depict boom designated as "deflection, protection, recovery and containment and secondary." Boom is named for the use it is placed in when deployed. The same type of boom is used, but named according to its use.

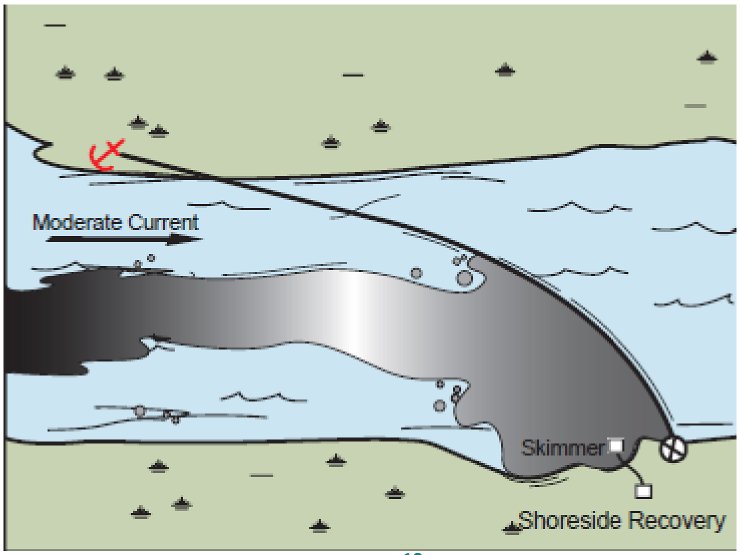

Figure 6: Single Boom Diversion Configuration[12]

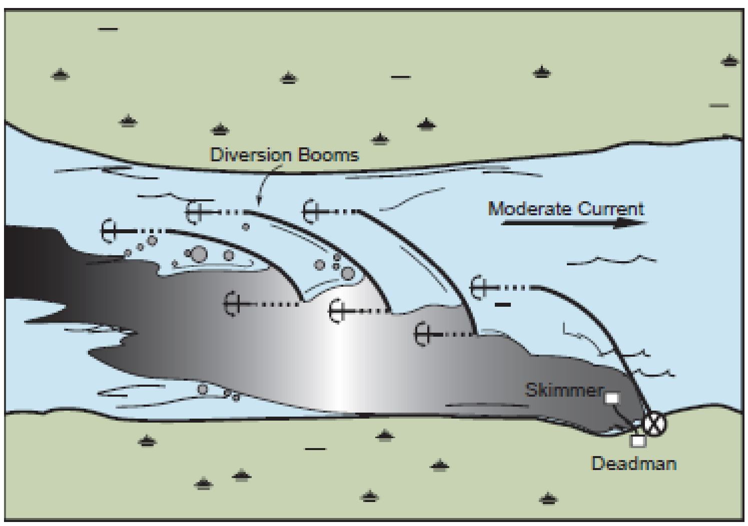

Figure 7: Cascade Boom Diversion Configuration[13]

Diversion booming can be used for containment or exclusion. Containment booming moves oil from fast flow areas in the center of the river to calm water in a protected inlet along the bank. The objective of the Diversion Boom tactic is to redirect the spilled oil from one location or direction of travel to a specific site for recovery. For the purposes of maintaining consistent and clear terms, diversion is always associated with oil recovery, in contrast with the term deflection, which is used to describe the tactic where oil is redirected away from an area but not recovered. The diversion boom tactic is for water-born

[12] ADEC 2014.
[13] ADEC 2014.

spills where there is some current, usually from 0.5 to 3.0 knots. The boom is placed at an optimum angle to the oil trajectory, using the movement of the current to carry oil along the boom to a recovery location. The angle is chosen to prevent oil from entraining beneath the boom skirt. Oil can be diverted to a shoreline or away from a shoreline or shoal waters.

Deflection booming is used to keep oil away from water intakes and environmentally sensitive areas. The objective of deflection boom is to direct spilled oil away from a location to be protected or simply to change the course of the slick. For the purposes of maintaining consistent and clear terms, "deflection" is used to describe the tactic where oil is redirected away from an area but not recovered, in contrast with the term "diversion", which is always associated with oil recovery. The deflection boom tactic is for waterborne spills where there is some current, usually from 0.5 to 3.0 knots. The boom is placed at an optimum angle to the oil trajectory, using the movement of the current to carry oil along the boom and then releasing it into the current again with a new trajectory. The angle is chosen to prevent oil from entraining beneath the boom skirt. Boom may be held in place by anchors, vessels, or a boom control device. Deflection boom may be used to temporarily avoid impacts to a sensitive area, but there is no recovery associated with the tactic, thus no oil is removed from the environment.

In a cascade array as shown in Figure 8, several booms are deployed in a cascade configuration when a single boom cannot be used because of fast current or because it is necessary to leave openings in the boom for vessel traffic, etc. This configuration can be used in strong currents where it may be impossible to effectively deploy one continuous section of boom. Shorter sections of boom used in a cascade deployment are easier to handle in faster water, thereby increasing efficiency. Additional equipment may be required to set and maintain this system as compared to the single boom configuration.

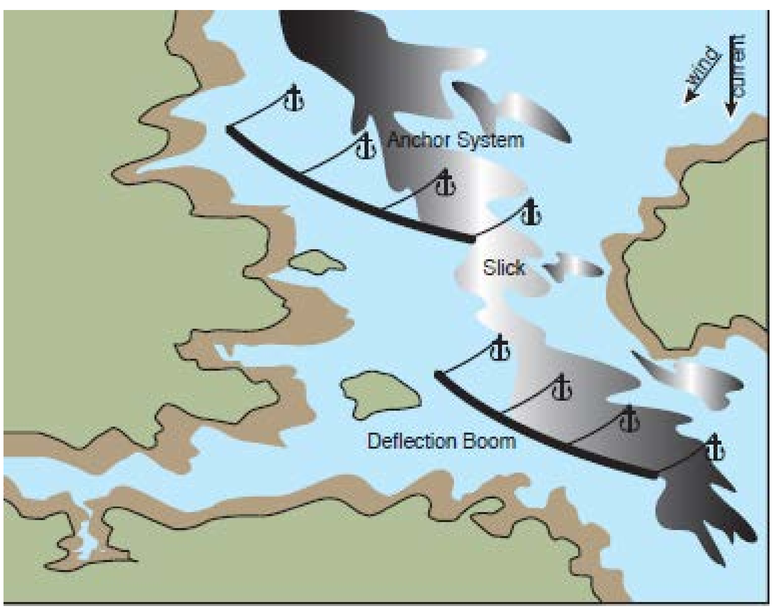

Figure 8: Deflection Booming, Fixed Cascaded Array[14]

[14] ADEC 2014.

Exclusion booming, as shown in Figure 9 , is a fixed-boom strategy, with the objective of prohibiting oil slicks from entering a sensitive area. This technique requires the area to be completely boomed off, forming a protective barrier. Conventional oil boom, tidal-seal boom, or a combination of each can be used to exclude spilled oil from a sensitive area. Typically, tidal-seal boom is deployed at the shoreline/water interface on both shores and is secured or anchored into position. Conventional oil boom is then connected to the tidal-seal boom and is secured with additional anchor systems to form a barrier and to maintain shape.

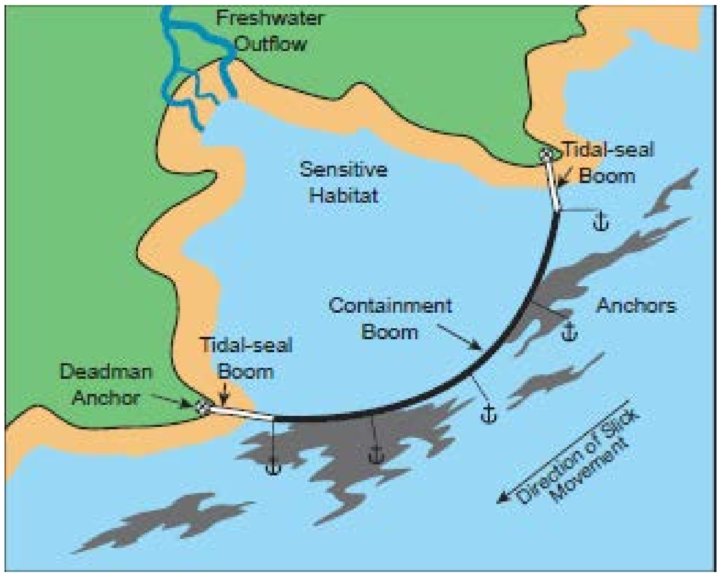

Figure 9: Exclusion Boom Configuration[15]

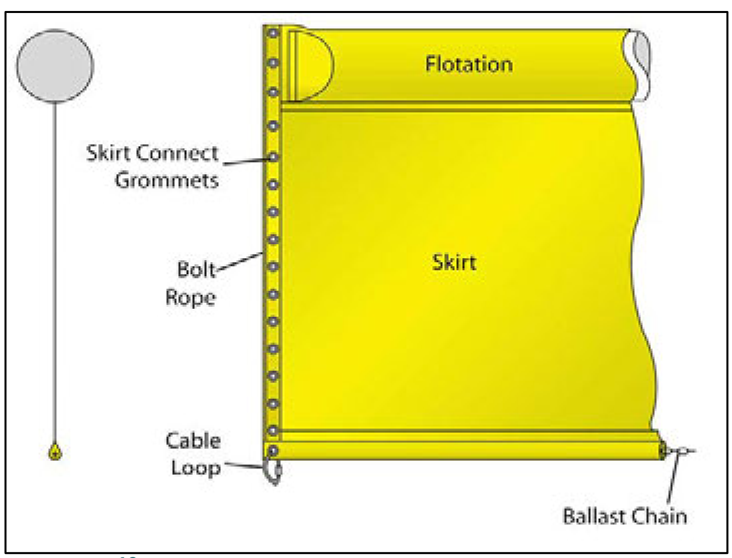

Figure 10: Parts of a Boom[16]

[15] Source: ADEC 2014.
[16] Source: Elastec; Massachusetts Department of Environmental Protection

Skimmers/Mechanical Recovery

Inland river oil spill responses primarily use skimmer equipment to remove the pollution from the environment and uses of in-situ burning is a limited methodology due to various safety factors along the river, and the use of dispersants are prohibited, thus, mechanical removal is the primary tool for responders.

Skimmers separate oil from water using one of two principles. Oleophilic skimmers employ oil-attracting coatings on the surface of a drum, brush, or other shape to physically attract and separate oil from the underlying water, whereas, "weir skimmers," use gravity to separate oil from water.

International Tanker Owners Pollution Federation (ITOPF) advises that skimmers function to remove oil from the water surface and incorporate an oil recovery element, a form of flotation or support and transfer device, e.g., pump, to transfer recovered oil and water to storage tanks.[17]

The optimal skimmer design will depend on the viscosity of the oil to be recovered and the prevailing sea conditions. Because skimmers float on the water surface, they experience many of the same operational difficulties as booms, particularly those posed by wind, waves and currents. Even moderate wave motion greatly reduces the effectiveness of most skimmer designs.

The simplest skimmers are suction devices which remove oil from the water surface directly or via a weir. These designs tend to pick up a lot of water at the same time as the oil unless operating in very calm conditions. More complex units rely on the adhesion of oil to metal, plastic discs or oleophilic belts or ropes. Others employ brush systems or are designed to generate vortices to concentrate and recover the oil.

Once operating, skimmers can recover oil at a rapid rate and therefore it is important to have adequate temporary oil storage facilities available, otherwise lack of storage space may become a bottleneck to continued oil recovery. Temporary storage needs to be easy to handle and set up, and easy to empty once full so that it can be used repeatedly. Suitable units include barges and portable tanks which can be set up on vessels of opportunity.

Floating debris can compromise skimmer efficacy. Where debris is common, skimmers may need 'trash screens' and regular unblocking. They will also need continuous maintenance by technicians and a supply of spare parts.

Once oil recovery is completed, skimmers will need to be cleaned, overhauled and repaired, ready for use in the next spill. It is also important to inspect and test equipment regularly so that it is in good working order, and to maintain personnel training standards by regular drills.

Given the practical challenges of operating and coordinating multiple vessels to handle long lengths of boom and skimmers in less than ideal conditions or within confined waterways, specialized vessels have been built which incorporate sweeping/deflection arms (booms), skimming devices and on board oil

[17] ITOPF 2012. (ITOPF is a not-for-profit marine ship pollution response advisers providing impartial advice worldwide on effective response to spills of oil & chemicals at sea. ITOPF has responded to over 700 incidents involving oil or chemical spills worldwide.

storage. These vessels will still have operational limitations and their efficiency will mainly be determined by the inbuilt oil recovery system or skimmer which is deployed.

Table 4: Generic Characteristics of Commonly Encountered Oleophilic Skimmers[18]

Type	Recovery Rate	Oils	Sea State	Debris	Ancillaries
Disc	Dependent on number of discs. Tests show grooved discs can be highly effective.	Most effective in medium viscosity oils.	In low waves and current can be highly selective with little water entrained water. Can be swamped in choppy waters.	Can be clogged by debris.	Separate power pack, hydraulic and discharge hoses, pump and suitable storage required.
Rope Mop	Dependent on rope number and velocity. Generally low throughput.	Most effective in medium oils although can be effective in heavy oil.	Very little or no entrained water. Can operate in choppy waters.	Able to tolerate significant debris, ice and other obstructions.	Small units have built in power supply and storage. Larger units require separate ancillaries.
Drum	Dependent on drum number and size. Grooved drums more effective.	Most effective in medium viscosity oils.	In low waves and current can be highly selective with little entrained water. Can be swamped in choppy waters.	Can be clogged by debris.	Separate power pack, hydraulic and discharge hoses, pump and suitable, storage required.
Brush	Throughput dependent on brush number and velocity. Generally mid-range.	Different brush sizes for light, medium and heavy oils.	Relatively little free or entrained water collected. Some designs can operate in choppy waters, others swamped in waves.	Effective in small debris but can be clogged by large debris.	Separate power pack, hydraulic and discharge hoses, pump and suitable storage required.
Belt	Low to mid-range	Most effective in medium to heavy oils.	Can be highly selective with little entrained water. Can operate in choppy waters.	Effective in small debris but can be clogged by large debris.	Can deliver oil directly to storage at top of belt. Ancillaries required to discharge from vessel to shore.

Table 5: Generic Characteristics of Commonly Encountered Non-Oleophilic Skimmers[19]

Type	Recovery Rate	Oils	Sea State	Debris	Ancillaries
Vacuum/ Suction	Dependent upon vacuum pump. Generally low to mid-range.	Most effective in light to medium oils.	Used in calm waters. Small waves will result in collection of excessive water. Addition of a weir more selective.	Can be clogged by debris.	Vacuum trucks and trailers are generally self-contained with necessary power supply, pump and storage.
Weir	Dependent upon pump capacity, oil type, etc. Can be significant.	Effective in light to heavy oils. Very heavy oils may not flow to weir.	Can be highly selective in calm water with little entrained oil. Can be easily swamped with increase in entrained water.	Can be clogged by debris; some pumps can cope with small debris.	Separate power pack, hydraulic and discharge hoses, pump and storage. Some skimmers have built-in pumps.

[18] Source: ITOPF
[19] Source: ITOPF

Table 5: Generic Characteristics of Commonly Encountered Non-Oleophilic Skimmers[19]					
Type	**Recovery Rate**	**Oils**	**Sea State**	**Debris**	**Ancillaries**
Belt	Low to medium	Most effective in heavy oils.	Can be highly selective with little entrained water. Can operate in choppy waters.	Effective in small debris. Clogged by large debris.	Can deliver oil directly to storage at the top of the belt. Ancillaries required to discharge from a vessel to shore.
Drum	Mid-range	Effective with heavy oils.	Can be highly selective in calm water with little entrained oil. However, can be swamped in waves.	Can be clogged by debris; some pumps can cope with small debris.	Separate power pack, hydraulic and discharge hoses, pump and storage. Some skimmers have built in pumps.

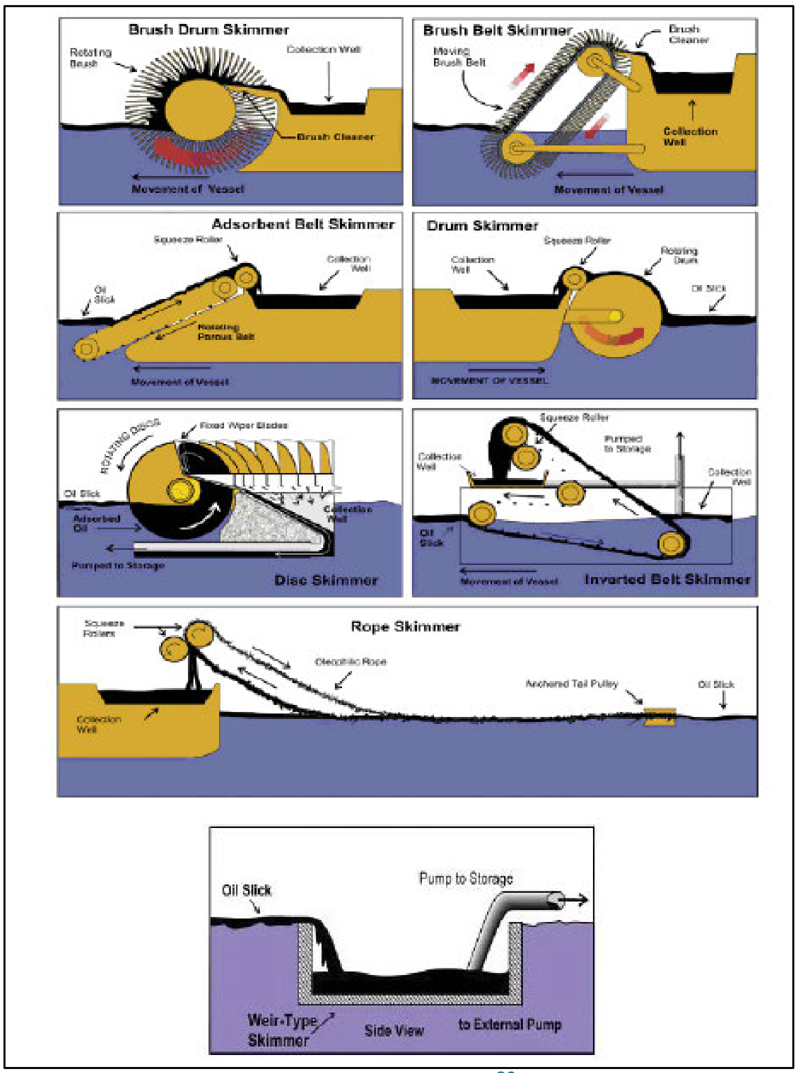

Figure 11: Oleophilic Skimmers and Weir Skimmers[20]

[20] Federici and Mintz 2014.

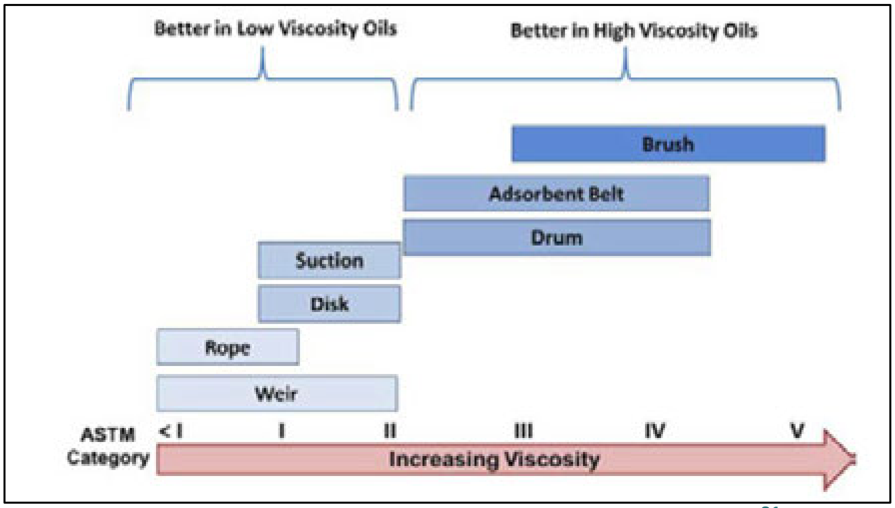

Figure 12: Most Effective Skimmer Types by Oil Type and Viscosity[21]

The Incident Management Team (IMT) needs to be aware of the type of oil spilled, and the type of mechanical recovery systems that the Oil Spill Response Organization (OSRO) is using for that type of oil. The skimmer system should be matched as much as feasible to the effectiveness for that oil type. Using any skimmer system with any oil may not produce the most effective results.

The most prevalent removal system on an inland river spill incident is the use of diversionary booming to move the oil from mid-stream to a shore-side recovery point where a vacuum truck is located on the shore with a skimmer head in the apex of the diversionary boom removing the oil as it arrives into the collection point, this is shown in Figure 4. Thus, ideally the diversionary boom placement will have a recovery area accessible for the operation of a vacuum truck. The hose from the vac-truck (vacuum truck) should have a floating skimmer head on the end so that water intake is kept minimal and oil intake is maximized to avoid premature filling of the vac-truck storage with more water than oil which reduces the vac-truck operating time and requires significant water handling/disposal activities.

Temporary Storage Capability

Temporary storage for recovered oil & water mixtures is one of the most significant problems in any spill response effort. Many modern skimmer systems have the capability to recover oil at a very rapid rate, included in that oil is usually a high percentage of water, which often means that all available storage volume is filled very quickly. At this point the response effort comes to a grinding halt if handling of storage onboard floating skimmers or vac-truck tanks have not been arranged ahead of time.

Regulations require an owner or operator to evaluate the availability of adequate temporary storage capacity to sustain the effective daily recovery capacities from equipment identified in the plan. Because of the inefficiencies of oil spill recovery devices, response plans must identify daily storage capacity equivalent to twice the effective daily recovery capacity required on-scene. This temporary storage capacity may be reduced if a facility owner or operator can demonstrate by waste stream analysis that the

[21] Federici and Mintz 2014.

efficiencies of the oil recovery devices, ability to decant waste, or the availability of alternative temporary storage or disposal locations will reduce the overall volume of oily material storage.

A Recovered Oil and Water Management Plan, or a Waste Disposal Plan, should be developed by the Responsible Party (RP) to ensure oil & water mixtures are appropriately handled in compliance with all regulatory requirements. This plan would detail the waste stream process and should provide guidance concerning the recovered oil and water mixtures being immediately transported to designated waste staging areas to bulk storage fractionation tanks (frac-tanks) used in the spill response operations. A series of frac-tanks should be arranged and connected for sequential settling of the oil & water mixture so that as each frac-tank settles, the water and oil are separated out to other tanks for further settling/separation of the remaining oil & water until as much as feasible the last tanks have only water or only oil to be separately disposed of.

Tank gauging must be conducted at that time to document the volumes of oil and water recovered. Tank gauging is critical, many response operations fail to conduct gauging and keep track of the oil recovered versus the oil & water mixture and thus, at the conclusion of a response, the necessary information concerning the amount of oil recovered is not accurately available. So appropriate tank, drum, container gauging, accompanied by accurate documentation, is a critical component of all response actions.

Once the oil & water mixture has been transferred to the frac-tanks and allowed to settle, as much liquid oil as possible should be separated. Potential management methods for recovered liquid hydrocarbons include: re-injection or recycling into a crude or bunker fuel process stream, oil reclamation, and/or recycling at other oil industry facilities. The volume and the presence or absence of other potential contaminants in the oil must be determined prior to recycling.

Oily water recovered as part of the cleanup process can be addressed by one of the following methods:

- Reclaimed along with entrained oil by a third-party oil reclaimer retained by the RP;
- Injected into an RP refinery wastewater or bilge water treatment plant, if available;
- Injected into a nearby publicly-owned treatment works (POTW) wastewater influent stream (local, state, or federal approval required); or
- Treated on-site in a portable, temporary wastewater treatment system in accordance to applicable surface-water quality standards and discharged (state/federal permit approval required).

Shoreline Cleanup Assessment Technique (SCAT) Operations

While on-water recovery and protection of sensitive shoreline features are priorities for spill response operations, in most spills there are impacts to shorelines. A vital part of a spill response is the assessment of shoreline impacts and the cleanup of oiled areas.

The Shoreline Cleanup Assessment Technique (SCAT) is a systematic method for surveying an affected shoreline that was developed during the response to the 1989 Exxon Valdez oil spill. The SCAT approach uses standardized terminology to document shoreline oiling conditions. [The classifications of shoreline oiling and shoreline type applied in SCAT, as well as recommendations for cleanup options by shoreline type are detailed in Appendix A.] It is designed to support decision-making for shoreline cleanup as a regular part of an oil spill response. SCAT surveys generally begin early in the response operations to assess baseline and initial shoreline conditions and ideally continue to work in advance of operational cleanup. SCAT surveys continue during response to verify shoreline oiling, cleanup effectiveness, and final evaluations to ensure cleanup meets agreed-upon endpoints.

The SCAT process involves eight basic steps (Figure 13):

- Conduct reconnaissance survey(s);
- Segment the shoreline;
- Assign teams and conduct SCAT surveys (Figure 14);
- Develop cleanup guidelines and endpoints;
- Submit survey reports (Figure 15) and shoreline oiling sketches (Figure 16) to ICS Planning;
- Monitor effectiveness of cleanup;
- Conduct post-cleanup inspections; and
- Conduct final evaluation of cleanup activities.

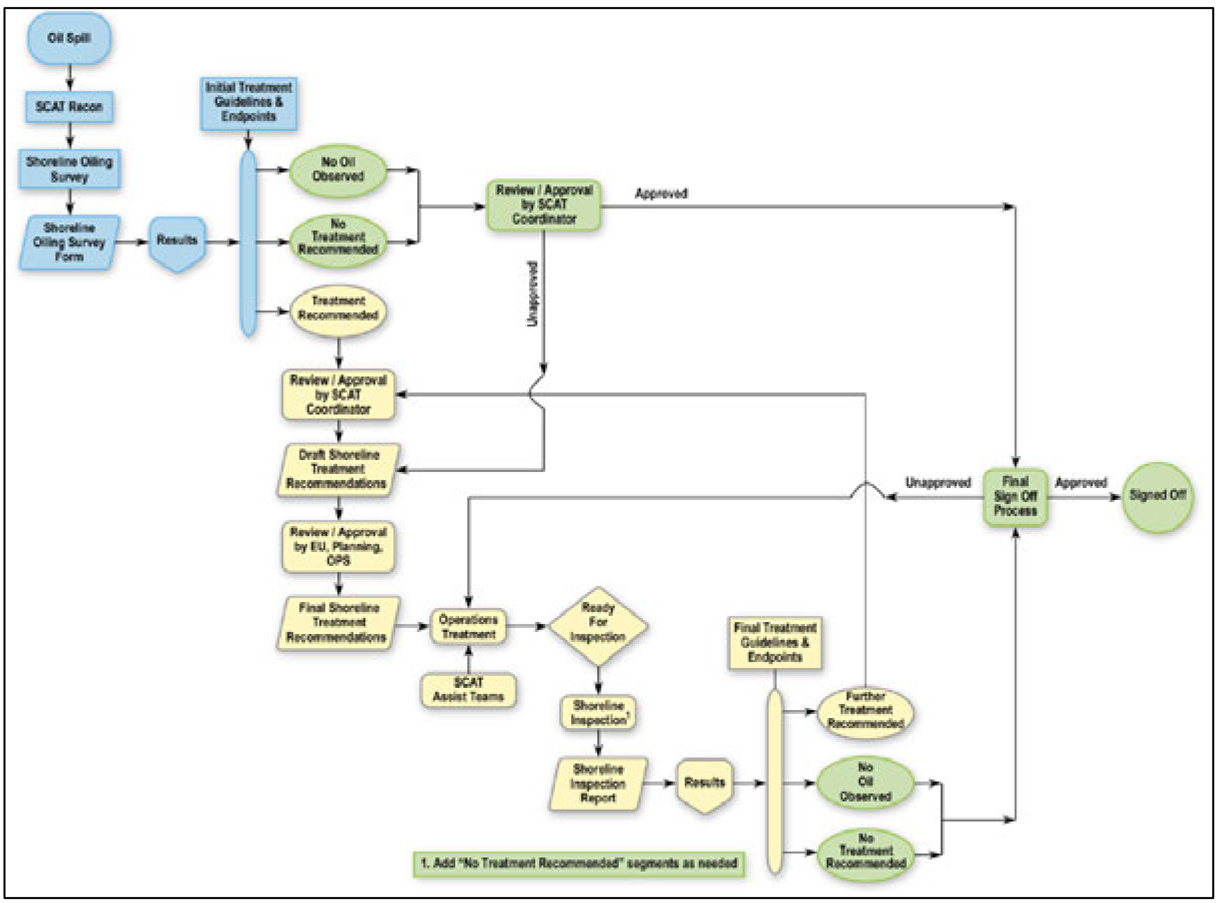

Figure 13: SCAT Process Flow Chart[22]

[22] NOAA 2013.

RIVER BANK (SOS) FORM ______________________________ **Page**_____ **of** _____

1.GENERAL INFORMATION		**Date** (dd/Month/yyyy)	**Time** (24h standard/daylight) ____:____ to ____:____	**Water Level** Low / Mean / Bankfull / Overbank Falling / Steady / Rising
Segment ID:	**Bank:** L / R	**Segment Name:**		
Ops Zone:		**Survey Type:**	**STR:**	
Survey By: Foot __ ATV__ Boat__ Helicopter__ Other ____________			Weather: Sun / Clouds / Fog / Rain / Snow / Windy / Calm	

2. SURVEY TEAM	Name	Organization	Name	Organization
Team Number				

3. SEGMENT		Total Length: meters	Length Surveyed: meters	Datum:
Survey Start GPS:	WP:	LAT: .	LONG: .	
Survey End GPS:	WP:	LAT: .	LONG: .	

4a. RIVER BANK TYPE : *Indicate only ONE Primary(dominant) type and ALL Secondary types. CIRCLE those OILED*

BEDROCK: Cliff____ Ramp____ Shelf____
MAN-MADE: Solid______ Permeable______
Description:________________________________
ESI Code (primary) ________ (secondary)________

UNCONSOLIDATED: Clay____ Mud____ Sand____ Mixed Fine____ Shell ____
Mixed Coarse ____ Pebble-Cobble____ Boulder ___ Rubble____
Marsh/Swamp____ Peat/Organics ____ Wooded ____ Vegetated ____
Other: ________________________________ Undercut Bank (Y / N)

4b. OVERBANK / BACKSHORE TYPE : *Indicate only ONE Primary (P) and ANY Secondary (S) types.*

Cliff/Bluff:____ ht.____ m. | Flat/Lowland/Field_____ Dune_____ Inlet/Channel____ Delta____ Lagoon____ Marsh/Wetland____
Sloped: > (5°) (15°) (30°) | Man-Made____:________________________Other:__________________ Wooded / Vegetated?

4c. RIVER VALLEY CHARACTER : *Circle or select as appropriate.*

Channel Width: < 10 m 10-100 m >100 m estimate ________ m | Shoal(s) Present: Y / N Point Bar Present: Y / N
Water Depth: < 1 m 1-5 m >5 m estimate ________ m | Bar-Shoal substrate: silt /sand/mixed/cobble/boulder/bedrock/debris

CHANNEL FORM: Cascade ____ Rapids ____ Pool ____ Riffle ____ Glide ____ Jam ____ Other:________________
RIVER FORM: Straight ____ Meander ______ Anastamosed ______ Braided ______ Other: ________________
VALLEY FORM: Canyon _____ Confined or Leveed Channel _____ Flood Plain Valley ____ Other: ________________

5. OPERATIONAL FEATURES	Oiled Debris? Yes / No	Type:	Amount: (bags/trucks)
Direct backshore access? Yes / No	Alongshore access from next segment? Yes / No	Suitable for backshore staging? Yes / No	
Access Description / Restrictions:		Current Dominated Channel? Yes / No	

6. OILING DESCRIPTION: *Indicate 100% overlapping oil zones in different river bank zones by numbering them (e.g. A1, A2)*

Zone ID	WP # Start	WP # End	Substrate Type(s) or ESI Code	River Bank Zone				Oil Cover						Oil Thickness					Oil Character							
								Area		Distribution		Size														
				MS	LB	UB	OB	Length (m)	Width (m)	Dist % (> 1) or	Number per unit area	Avg Size (cm)	Large Size (cm)	TO	CV	CT	ST	FL	FR	MS	TB	PT	TC	SR	AP	NO

7. SUBSURFACE OILING CONDITIONS: *Format: Indicate Zone ID in Pit #, e.g., A-1, B-2, B-3, (use only number if not in zone e.g. 4 , 5)*

Pit #	WP #	Substrate Type Surface/Subsurface	River Bank Zone				Pit Depth (cm)	Oiled Interval (cm-cm)	Subsurface Oil Character								Water Table (cm)	Sheen Color B,R,S,N	Clean Below Yes / No
			MS	LB	UB	OB			AP	OP	PP	OR	OF	TR	NO	%			
		/						-											
		/						-											
		/						-											
		/						-											

8. COMMENTS: Cleanup Recommendations; Ecological/Recreational/Cultural/Economic Issues; Wildlife Observations; Other Descriptions

Sketch / Map: Yes / No Photos/Video: Yes / No Numbers: (-) Photographer Name:

Figure 14: SCAT River Bank Summary Form[23]

[23] NOAA 2013. (Note that in some cases, digitized versions of these types of forms are being implemented with GIS-capable applications on cell phones and digital devices.)

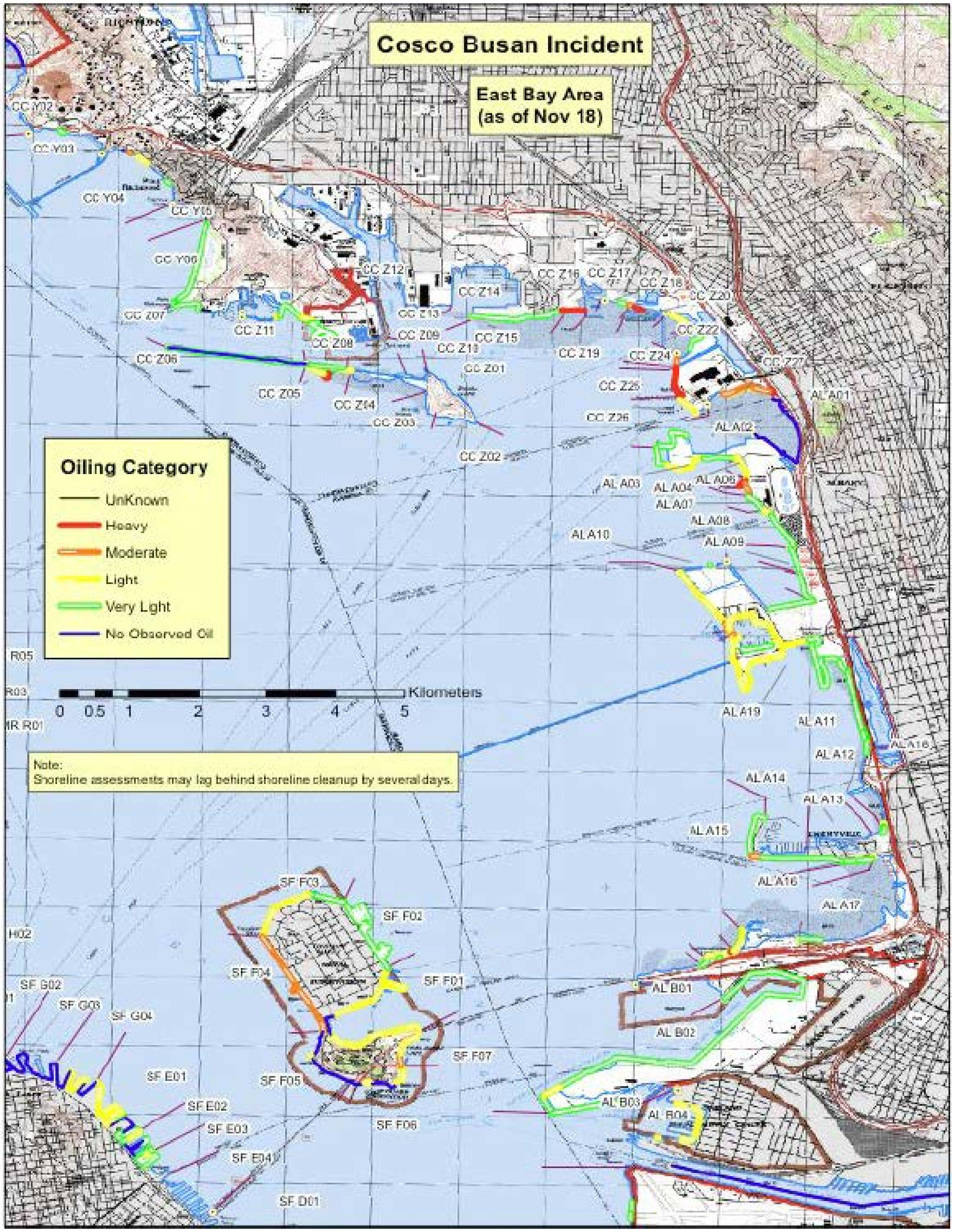

Figure 15: Example of SCAT Shoreline Mapping Survey[24]

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[24] NOAA 2013.

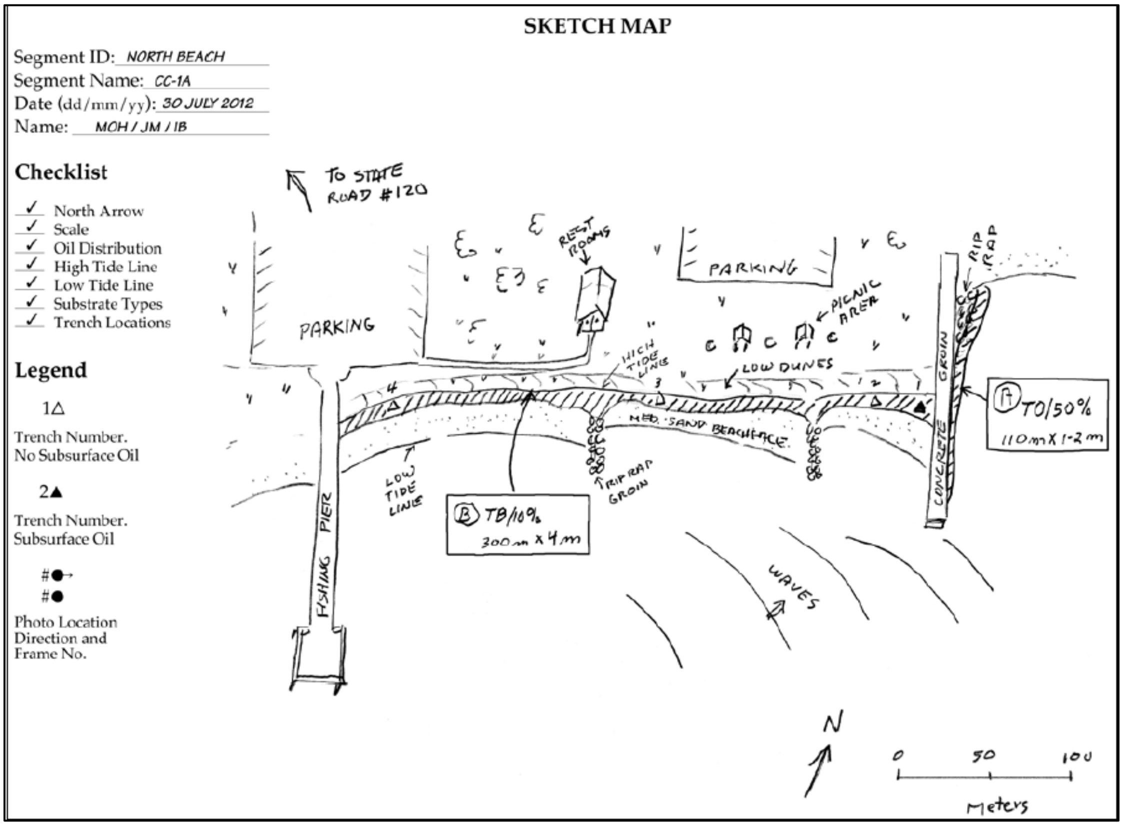


Figure 16: Example of Completed SCAT Beach Sketch[25]

Trade-Offs in Response and Net Environmental Benefit

During nearly all phases of spill response, "trade-off" issues needs to be considered. These issues require on-scene coordinators, responders, and certain stakeholders to make important, but often difficult, decisions particularly regarding:[26]

- Protection of certain particularly sensitive and highly-valued shoreline resources by deflecting oil away from those areas towards areas that would be less affected by oiling; and
- Shoreline cleanup options that pit the desire to remove all oil against the potential impacts associated with intensive treatments.

Both of these trade-off issues are ones that should best be discussed well in advance of any spills in Area Committees and Harbor Safety Committees as part of contingency planning. For sensitive resource protection, geographic response strategies (GRSs) and geographic response plans (GRPs) lay out protective booming strategies for identified resources based on local inputs. This requires extensive local involvement in the contingency planning process so that in the event of a spill the appropriate strategies can be carried out in a timely and mutually agreed-upon manner. Local stakeholders should participate in this process so that prioritization of response resources are allocated based on local values. However,

[25] NOAA 2013.

[26] In offshore oil spills, there are additional trade-off issues regarding use of chemical dispersants and in situ burning that are not relevant for the Hudson River. These two strategies are not likely options for a spill response in the river.

federal and state on-scene coordinators, scientific support coordinators (SSCs), and experienced spill responders will have knowledge of the way in which response decisions may affect shoreline features and resources in different ways. This may include determinations about "sacrificial" beaches that may be selected for receiving deflected oil because it is known that eventual oil removal and cleanup of these areas will be more successful than other more sensitive locations, such as wetlands.

Decisions to employ "natural recovery" or to limit intrusive cleanup methods in some areas, such as wetlands, may cause public concern. Leaving oiled areas to naturally recover has the appearance of "doing nothing," when in some cases it is the most effective option that provides for the best long-term recovery of oiled sites. Response officials need to effectively communicate about the drawbacks and potential damage of intrusive removal tactics and the benefits of this approach. Again, this is best accomplished as part of contingency planning and community outreach as part of Area Committee and Harbor Safety Committee processes well in advance of any spills.

In the end, the concept of "net environmental benefit" should be the over-riding strategy for spill response operations.

Contingency Planning: National Contingency Plan (NCP)

Advance strategizing and building the network of response is a vital part of preparedness for potential oi spills. There are various levels of oil spill contingency planning. In the US, the over-arching federal blueprint for spill response is the National Oil and Hazardous Substances Pollution Contingency Plan, which is more commonly called the National Contingency Plan (NCP).[27] The NCP, first developed in 1968 in response to the massive oil Torrey Canyon tanker spill off England, develops the national response capability and promotes the coordination among the hierarchy of responders and contingency plans.

Key provisions of the National Contingency Plan are:[28]

- §300.110: Establishes the National Response Team and its roles and responsibilities in the National Response system. This includes planning and coordinating responses, providing guidance to Regional Response Teams, coordinating a national program of preparedness planning and response, and facilitating research to improve response activities. EPA serves as the lead agency within the National Response Team (NRT).
- §300.115: Establishes the Regional Response Teams and their roles and responsibilities in the National Response System, including coordinating preparedness, planning, and response at the regional level. The RRT consists of a standing team made up of representatives of each federal agency that is a member of the NRT, as well as state and local government representatives. It also consists of an incident-specific team made up of members of the standing team that are activated for a response. The RRT also provides oversight and consistency review for area plans within a given region.
- §300.120: Establishes general responsibilities of federal On-Scene Coordinators (FOSCs).

[27] 40 CFR § 300.
[28] https://www.epa.gov/emergency-response/national-oil-and-hazardous-substances-pollution-contingency-plan-ncp-overview#NCP%20Related%20Federal%20Register%20Notices

- §300.125(a): Requires notification of any discharge or release to the National Response Center through a toll-free telephone number. The National Response Center (NRC) acts as the central clearinghouse for all pollution incident reporting.
- §300.135(a): Authorizes the predesignated On-Scene Coordinator to direct all federal, state, and private response activities at the site of a discharge.
- §300.135(d): Establishes the unified command structure for managing responses to discharges through coordinated personnel and resources of the federal government, the state government, and the responsible party.
- §300.165: Requires the On-Scene Coordinator to submit to the RRT or NRT a report on all removal actions taken at a site.
- §300.170: Identifies the responsibilities for federal agencies that may be called upon during response planning and implementation to provide assistance in their respective areas of expertise consistent with the agencies' capabilities and authorities.
- §300.175: Lists the federal agencies that have duties associated with responding to releases.
- §300.210: Defines the objectives, authority, and scope of Federal Contingency Plans, including the National Contingency Plan (NCP), Regional Contingency Plans (RCPs), and Area Contingency Plans (ACPs).
- §300.317: Establishes national priorities for responding to a release.
- §300.320: Establishes the general pattern of response to be executed by the On-Scene Coordinator (OSC), including determination of threat, classification of the size and type of the release, notification of the RRT and the NRC, and supervision of thorough removal actions.
- §300.322: Authorizes the OSC to determine whether a release poses a substantial threat to the public health based on the size and character of the discharge, and its proximity to human populations and sensitive environments. In such cases, the OSC is authorized to direct all federal, state, or private response and recovery actions. The OSC may enlist the support of other federal agencies or special teams.
- §300.323: Provides special consideration to discharges which have been classified as a spill of national significance. In such cases, senior federal officials direct nationally-coordinated response efforts.
- §300.324: Requires the OSC to notify the National Strike Force Coordination Center (NSFCC) in the event of a worst case discharge. The NSFCC coordinates the acquisition of needed response personnel and equipment. The OSC also must require implementation of the worst case portion of the tank vessel and Facility Response Plans and the Area Contingency Plan.
- §300.355: Provides funding for responses to oil releases under the Oil Spill Liability Trust Fund, provided certain criteria are met. The responsible party is liable for federal removal costs and damages as detailed in section 1002 of the Oil Pollution Act. Federal agencies assisting in a response action may be reimbursed. Other federal agencies may provide financial support for removal actions.
- Subpart J: Establishes the NCP Product Schedule, which contains dispersants and other chemical or biological products that may be used in carrying out the NCP. Authorization for the use of these products is conducted by Regional Response Teams and Area Committees, or by the OSC in consultation with EPA representatives.

- §300.415(b): Authorizes the lead agency to initiate appropriate removal action in the event of a hazardous substance release. Decisions of action will be based on:
    - Threats to human or animal populations;
    - Contamination of drinking water supplies or sensitive ecosystems;
    - High levels of hazardous substances in soils;
    - Weather conditions that may cause migration or release of hazardous substances;
    - Threat of fire or explosion; or
    - Other significant factors effecting public health or the environment.
- §300.415(c): Authorizes the OSC to direct appropriate actions to mitigate or remove the release of hazardous substances.

Contingency Planning: Area Contingency Plan (ACP)[29]

An Area Contingency Plan (ACP) is a reference document prepared for the use of all agencies engaged in responding to environmental emergencies within a defined geographic area. An ACP is a mechanism to ensure that all responders have access to essential area-specific information and promotes inter-agency of coordination to improve the effectiveness of responses.

The USCG is designated the lead agency for planning and response in coastal zones and certain major inland water bodies (including the Hudson River). The EPA is the designated the lead for inland zones.

Under the Clean Water Act (CWA) 311(j)(4), an ACP is to include:

- A description of the area covered by the plan, including areas of special economic or environmental importance that might be damaged by a discharge.
- A description of the responsibilities of owners, operators and federal, state and local agencies in removing a discharge. Also to be included, descriptions on how to mitigate or prevent a substantial threat of discharge to ensure optimum communication and coordination during a response;
- A list of resources (personnel, equipment and supplies) available for response to discharges;
- A list of local scientists, both inside and outside federal government service, with expertise in the environmental effects of spills of the types of oil typically transported in the area. This list may be used to provide information or participate in meetings of the scientific support team. It may also be used to describe the procedures to be followed for obtaining an expedited decision regarding the use of dispersants; and
- A description of how the plan is integrated with other plans.

When implemented in conjunction with the NCP, the ACP must be adequate to remove a worst case discharge and mitigate or prevent a substantial threat of such discharge.

An ACP may also contain Sub-Area and Geographic Response Plans (GRPs), which may have more limited scope than the ACP itself. The development and application of GRPs differ regionally and in different states.

[29] https://www.epa.gov/oil-spills-prevention-and-preparedness-regulations/area-contingency-planning

For the Hudson River in New York, there are GRPs developed under the auspices of NYSDEC that deal more specifically with responses to railroad-related spills and GRPs within Geographic Response Strategies (GRSs) that deal with protective and response strategies for spills in the Hudson River.

Contingency Planning: Railroad Geographic Response Plans (GRPs)

The GRPs for New York State were developed by county with draft versions made available between 2015 and 2017. These GRPs deal specifically with railroad-related spills of hazardous substances and were developed largely in response to concerns about CBR transport through local communities. The plans include maps (for example, Figure 17) that indicate:

- Railroad features (e.g., tracks, at-grade and above-grade street crossings, mile markers, junctions);
- 1,000-foot *Emergency Response Guidebook* (ERG) response distances for spills;
- 0.5-mile ERG evacuation distance for fires;
- Environmental features (e.g., conservation areas, booming opportunity locations, water features, river mile markers); and
- Human features (e.g., access points, ambulance, fire department, boat launches, hospitals, utilities, residential areas, public water intakes, schools, major oil storage facilities.

In addition, for each map the GRP includes information on contact numbers, resources, notifications for evacuation, and other considerations specific to the geographic location (for example, Figure 18).

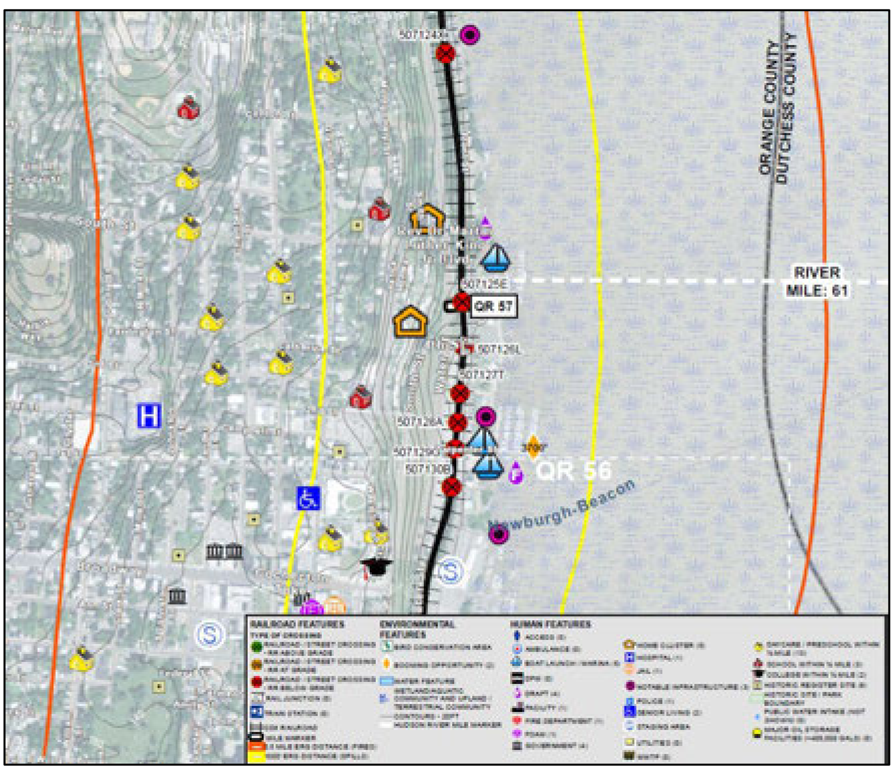
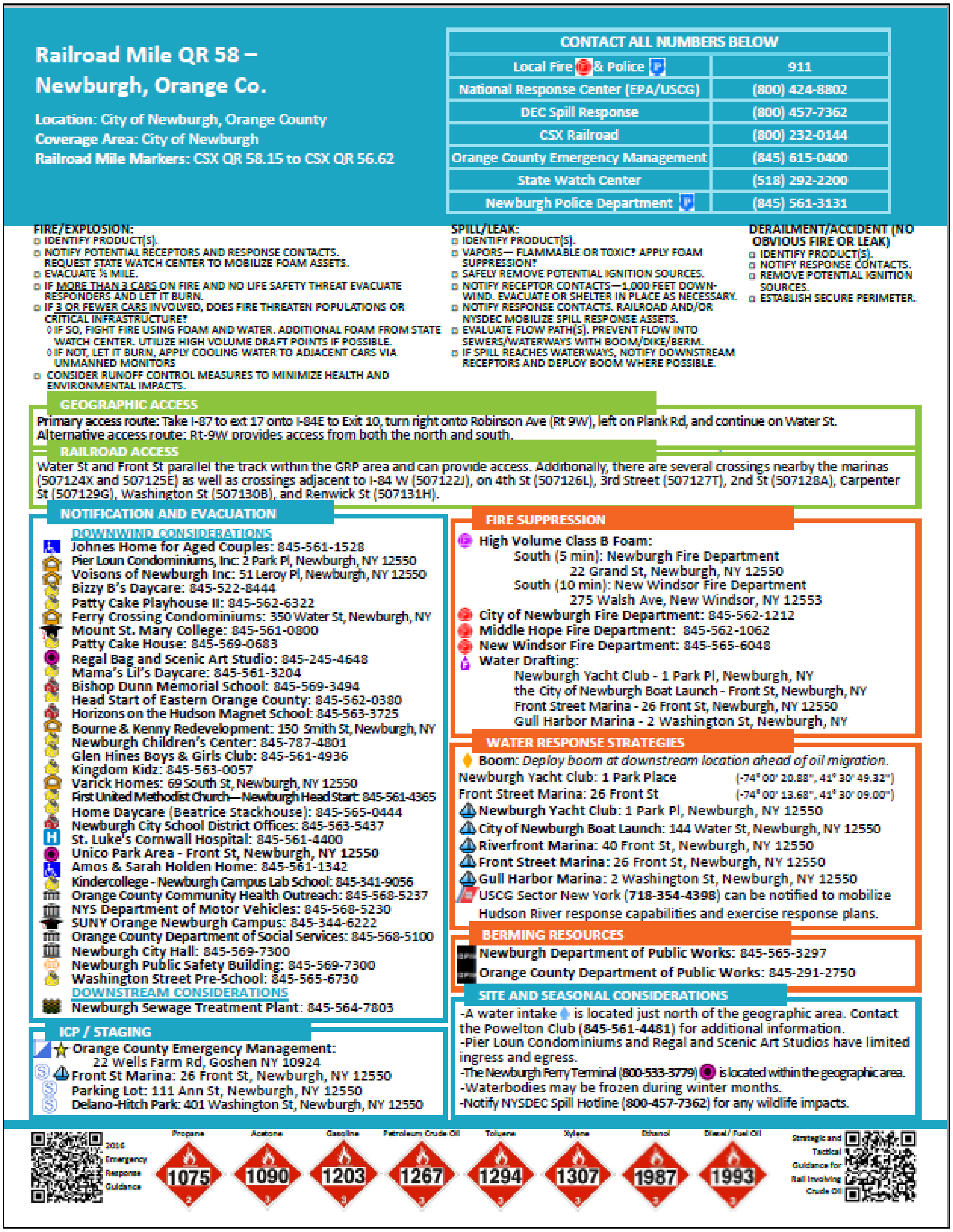


Figure 17: Example of GRP Map with Features



Railroad Mile QR 58 – Newburgh, Orange Co.

Location: City of Newburgh, Orange County
Coverage Area: City of Newburgh
Railroad Mile Markers: CSX QR 58.15 to CSX QR 56.62

CONTACT ALL NUMBERS BELOW	
Local Fire & Police	911
National Response Center (EPA/USCG)	(800) 424-8802
DEC Spill Response	(800) 457-7362
CSX Railroad	(800) 232-0144
Orange County Emergency Management	(845) 615-0400
State Watch Center	(518) 292-2200
Newburgh Police Department	(845) 561-3131

FIRE/EXPLOSION:
- IDENTIFY PRODUCT(S).
- NOTIFY POTENTIAL RECEPTORS AND RESPONSE CONTACTS. REQUEST STATE WATCH CENTER TO MOBILIZE FOAM ASSETS.
- EVACUATE ½ MILE.
- IF MORE THAN 3 CARS ON FIRE AND NO LIFE SAFETY THREAT EVACUATE RESPONDERS AND LET IT BURN.
- IF 3 OR FEWER CARS INVOLVED, DOES FIRE THREATEN POPULATIONS OR CRITICAL INFRASTRUCTURE?
  - IF SO, FIGHT FIRE USING FOAM AND WATER. ADDITIONAL FOAM FROM STATE WATCH CENTER. UTILIZE HIGH VOLUME DRAFT POINTS IF POSSIBLE.
  - IF NOT, LET IT BURN, APPLY COOLING WATER TO ADJACENT CARS VIA UNMANNED MONITORS
- CONSIDER RUNOFF CONTROL MEASURES TO MINIMIZE HEALTH AND ENVIRONMENTAL IMPACTS.

SPILL/LEAK:
- IDENTIFY PRODUCT(S).
- VAPORS— FLAMMABLE OR TOXIC? APPLY FOAM SUPPRESSION?
- SAFELY REMOVE POTENTIAL IGNITION SOURCES.
- NOTIFY RECEPTOR CONTACTS—1,000 FEET DOWN-WIND. EVACUATE OR SHELTER IN PLACE AS NECESSARY.
- NOTIFY RESPONSE CONTACTS. RAILROAD AND/OR NYSDEC MOBILIZE SPILL RESPONSE ASSETS.
- EVALUATE FLOW PATH(S). PREVENT FLOW INTO SEWERS/WATERWAYS WITH BOOM/DIKE/BERM.
- IF SPILL REACHES WATERWAYS, NOTIFY DOWNSTREAM RECEPTORS AND DEPLOY BOOM WHERE POSSIBLE.

DERAILMENT/ACCIDENT (NO OBVIOUS FIRE OR LEAK)
- IDENTIFY PRODUCT(S).
- NOTIFY RESPONSE CONTACTS.
- REMOVE POTENTIAL IGNITION SOURCES.
- ESTABLISH SECURE PERIMETER.

GEOGRAPHIC ACCESS

Primary access route: Take I-87 to ext 17 onto I-84E to Exit 10, turn right onto Robinson Ave (Rt 9W), left on Plank Rd, and continue on Water St.
Alternative access route: Rt-9W provides access from both the north and south.

RAILROAD ACCESS

Water St and Front St parallel the track within the GRP area and can provide access. Additionally, there are several crossings nearby the marinas (507124X and 507125E) as well as crossings adjacent to I-84 W (507122J), on 4th St (507126L), 3rd Street (507127T), 2nd St (507128A), Carpenter St (507129G), Washington St (507130B), and Renwick St (507131H).

NOTIFICATION AND EVACUATION

DOWNWIND CONSIDERATIONS
- Johnes Home for Aged Couples: 845-561-1528
- Pier Loun Condominiums, Inc: 2 Park Pl, Newburgh, NY 12550
- Voisons of Newburgh Inc: 51 Leroy Pl, Newburgh, NY 12550
- Bizzy B's Daycare: 845-522-8444
- Patty Cake Playhouse II: 845-562-6322
- Ferry Crossing Condominiums: 350 Water St, Newburgh, NY
- Mount St. Mary College: 845-561-0800
- Patty Cake House: 845-569-0683
- Regal Bag and Scenic Art Studio: 845-245-4648
- Mama's Lil's Daycare: 845-561-3204
- Bishop Dunn Memorial School: 845-569-3494
- Head Start of Eastern Orange County: 845-562-0380
- Horizons on the Hudson Magnet School: 845-563-3725
- Bourne & Kenny Redevelopment: 150 Smith St, Newburgh, NY
- Newburgh Children's Center: 845-787-4801
- Glen Hines Boys & Girls Club: 845-561-4936
- Kingdom Kidz: 845-563-0057
- Varick Homes: 69 South St, Newburgh, NY 12550
- First United Methodist Church—Newburgh Head Start: 845-561-4365
- Home Daycare (Beatrice Stackhouse): 845-565-0444
- Newburgh City School District Offices: 845-563-5437
- St. Luke's Cornwall Hospital: 845-561-4400
- Unico Park Area - Front St, Newburgh, NY 12550
- Amos & Sarah Holden Home: 845-561-1342
- Kindercollege - Newburgh Campus Lab School: 845-341-9056
- Orange County Community Health Outreach: 845-568-5237
- NYS Department of Motor Vehicles: 845-568-5230
- SUNY Orange Newburgh Campus: 845-344-6222
- Orange County Department of Social Services: 845-568-5100
- Newburgh City Hall: 845-569-7300
- Newburgh Public Safety Building: 845-569-7300
- Washington Street Pre-School: 845-565-6730

DOWNSTREAM CONSIDERATIONS
- Newburgh Sewage Treatment Plant: 845-564-7803

ICP / STAGING

- Orange County Emergency Management: 22 Wells Farm Rd, Goshen NY 10924
- Front St Marina: 26 Front St, Newburgh, NY 12550
- Parking Lot: 111 Ann St, Newburgh, NY 12550
- Delano-Hitch Park: 401 Washington St, Newburgh, NY 12550

FIRE SUPPRESSION

- High Volume Class B Foam:
  - South (5 min): Newburgh Fire Department, 22 Grand St, Newburgh, NY 12550
  - South (10 min): New Windsor Fire Department, 275 Walsh Ave, New Windsor, NY 12553
- City of Newburgh Fire Department: 845-562-1212
- Middle Hope Fire Department: 845-562-1062
- New Windsor Fire Department: 845-565-6048
- Water Drafting:
  - Newburgh Yacht Club - 1 Park Pl, Newburgh, NY
  - the City of Newburgh Boat Launch - Front St, Newburgh, NY
  - Front Street Marina - 26 Front St, Newburgh, NY 12550
  - Gull Harbor Marina - 2 Washington St, Newburgh, NY

WATER RESPONSE STRATEGIES

Boom: *Deploy boom at downstream location ahead of oil migration.*

Newburgh Yacht Club: 1 Park Place	(-74° 00' 20.88", 41° 30' 49.32")
Front Street Marina: 26 Front St	(-74° 00' 13.68", 41° 30' 09.00")

- Newburgh Yacht Club: 1 Park Pl, Newburgh, NY 12550
- City of Newburgh Boat Launch: 144 Water St, Newburgh, NY 12550
- Riverfront Marina: 40 Front St, Newburgh, NY 12550
- Front Street Marina: 26 Front St, Newburgh, NY 12550
- Gull Harbor Marina: 2 Washington St, Newburgh, NY 12550
- USCG Sector New York (718-354-4398) can be notified to mobilize Hudson River response capabilities and exercise response plans.

BERMING RESOURCES

- Newburgh Department of Public Works: 845-565-3297
- Orange County Department of Public Works: 845-291-2750

SITE AND SEASONAL CONSIDERATIONS

-A water intake is located just north of the geographic area. Contact the Powelton Club (845-561-4481) for additional information.
-Pier Loun Condominiums and Regal and Scenic Art Studios have limited ingress and egress.
-The Newburgh Ferry Terminal (800-533-3779) is located within the geographic area.
-Waterbodies may be frozen during winter months.
-Notify NYSDEC Spill Hotline (800-457-7362) for any wildlife impacts.

2016 Emergency Response Guidance

Propane	Acetone	Gasoline	Petroleum Crude Oil	Toluene	Xylene	Ethanol	Diesel/ Fuel Oil
1075	1090	1203	1267	1294	1307	1987	1993

Strategic and Tactical Guidance for Rail Involving Crude Oil

Figure 18: Example of Geographic-Specific Information in GRP

Contingency Planning: Geographic Response Strategies (GRSs)

The Hudson River geographic response strategies (GRSs) contain GRPs for specific locations. These GRPs contain maps (e.g., Figure 19), generally for two-mile sections of the river (1 inch = 2,000 feet), and detailed markings for:

- Socioeconomic features (e.g., boat ramps, parks, marinas, water intakes); and
- Environment features designated by priority; and
- Booming strategies for deflection, protection, recovery, and secondary.

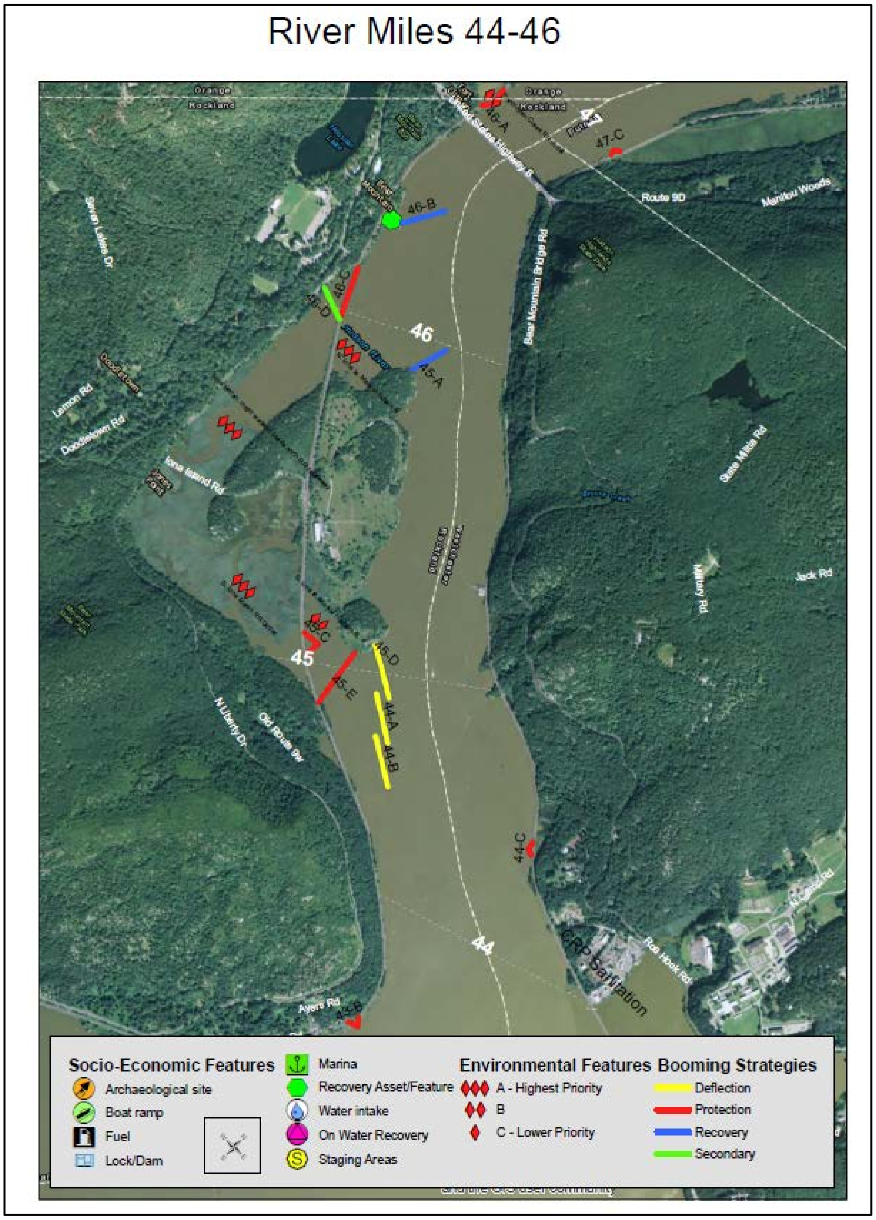


Figure 19: Example of Hudson River GRP

Each map refers to a second page ("back sheet") that describes the socioeconomic and environmental features, as well as booming specifications (e.g., Figure 20).

Socio Economic Features

CRP Sanitation –

Phone: 914-592-4129

Environmental Features

Popolopen Creek – This creek is protected by a railroad, but does have a small outlet into the Hudson. The habitat is mainly comprised of sandy beaches and tidal flats.

Iona Marsh - Iona Island Marsh includes a sizeable tidal freshwater marsh within the Hudson estuary. The site has been designated one of four component sites of the Hudson River National Estuarine Research Reserve and is also registered as a National Natural Landmark with the U.S. Department of the Interior. The area is recognized as a Bald Eagle Wintering Sanctuary and Important Bird Area. Shallow bay areas and creek channels in Iona Island Marsh provide spawning and nursery habitats for a variety of coastal migratory and resident freshwater fishes. Species found in the area include American eel, alewife, blueback herring, white perch, and striped bass

Name	Anchor Up	Anchor Down	Type	Actual Length	Boom Length	Phone Number	Notes	Boom-ID
S. Manitou Marsh Outlet Protection	N. of Outlet	S. of outlet	Protection	220.5	250			47-C
Popolopen Creek Protection	N. of Creek, R/R track	S of Creek, R/R track	Protection	459.1	500			46-A
Bear Mountain Recovery	Middle of River	Dock near Bear Mountain	Recovery	731	750			46-B
Iona Marsh Protection	N. R/R tracks	S. R/R tracks	Protection	876.3	900			46-C
Iona Marsh Secondary	W. bank of river	railroad bridge	Secondary	563	600			46-D
Iona Island Recovery	Middle of River	N. tip of Iona Island	Recovery	628.6	700			45-A
Iona Marsh S. Protection	S. Point of Iona Marsh	R/R tracks, S. of outlet	Protection	977.4	1000			45-B
S. Iona Marsh Secondary	N. of outlet	S. of outlet	Protection	523.7	600			45-C
Iona Marsh Deflection A	Island E. of marsh	Middle of river	Deflection	870.9	900			45-D
Iona Marsh Deflection B	Middle of river	middle of river	Deflection	839.7	850			44-A
Iona Marsh Deflection C	Middle of river	Middle of river	Deflection	828.1	850			44-B
Unnamed Marsh Outlet	N. of outlet	S. of outlet	Protection	231.3	250			44-C
Unnamed Culvert	N. of culvert	S. of culvert	Protection	302.6	300			43-B

Figure 20: Example of Back Sheet for Hudson River GRP

Application of Geographic Response Strategies in Spill Situations

Geographic Response Strategies (GRS) are planning and response tools that are intended to guide local responders in the first 24 to 48 hours of an oil spill until additional resources supplied by Unified Command can arrive. As a response tool, the GRS allows quick decisions to be made by providing detailed geographic information on shoreline types, sensitive natural and cultural resources, boom deployment strategies, estimated resource needs, e.g., amounts of boom, staging areas/boat launching ramps, water intakes, etc. A GRS is usually part of the ACP that each USCG Sector is required to maintain to enhance preparedness and prevention activities for all coastal areas of the United States.

GRSs are site-specific response plans tailored to protect sensitive areas threatened by an oil spill. GRSs are map-based strategies that can save time during the critical first few hours of an oil spill response. They show responders where sensitive areas are located and where to place oil spill protection resources. This is especially important for responders who are often local to area and may not be familiar with the resources at risk.

The strategies serve as guidelines for the federal and state on-scene coordinators during an oil spill in the area covered by the GRSs. The GRSs are a great help in preplanning for a spill response and can provide excellent guidance during a spill response, but are not a mandate for specific action at the time of a spill.

Implementation of GRSs is the third phase of an oil spill response (Figure 21).

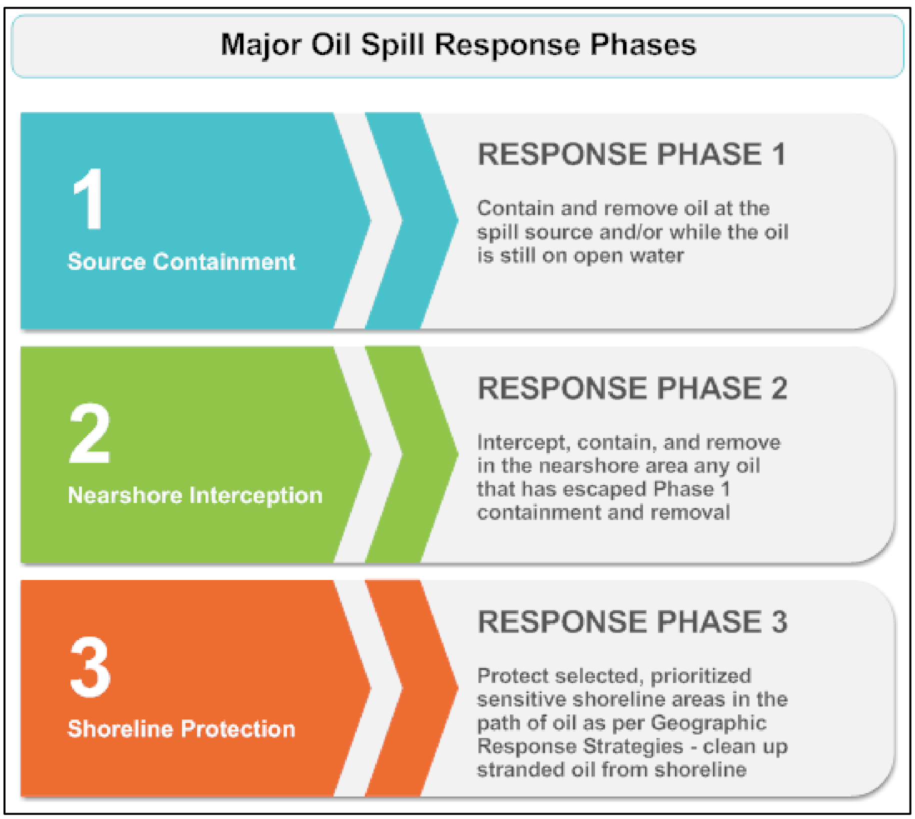


Figure 21: Major Oil Spill Response Phases

The first and primary phase of the response is to contain and remove the oil at the scene of the spill or while it is still on the open water, thereby reducing or eliminating stranding on shorelines or effects on sensitive habitats. If some of the spilled oil escapes this tactic, the second, but no less important, phase is to intercept, contain and remove the oil in the nearshore area. The intent of Phase 2 is the same as Phase 1 –remove the spilled oil before it affects sensitive environments. If phases one and two are not fully successful, Phase 3 is to protect sensitive areas in the path of the oil. The purpose of Phase 3 is to protect the selected sensitive areas from the effects of a spill or to minimize that effect to the maximum extent practical. (Any oil that does strand on shorelines will need to be cleaned up during shoreline operations.)

GRSs are intended to be flexible, to allow the spill responders to modify them, as necessary, to fit the prevailing conditions at the time of a spill. Seasonal constraints, such as ice or weather, may preclude implementation of some of the strategies in the winter months. It is not intended that all the sites be automatically protected at the beginning of a spill, but rather those that are in the projected path of the spill. In the initial hours and days of a spill, sites selected for equipment deployment should be prioritized due to the initial lack of sufficient resources to deploy. The strategies developed for the selected sites should be completed with a focus on minimizing environmental damage, utilizing as small a footprint as possible to support the response operations, and selecting sites for equipment deployment that will not cause more damage than the spilled oil.

Initially booming strategies shown in the GRSs are chosen by evaluation of the waterbody, its shoreline contours, potential currents and tides and sensitive areas. Since the GRS is a map-based strategy, ideally, each site should be visited and equipment deployed according to the strategy, to ensure that the strategy is the most effective in protecting the resources at risk at the site. Eventually revisions should be made to the strategies if changes are indicated by site visits, exercises or actual use during spills.

Predicting Effectiveness of GRS Boom Strategies

The actual effectiveness of protection or deflection booming in keeping oil out of specific locations under various conditions is often only realized after a spill event. The effectiveness of booming strategies depends on:

- Timing of the boom deployment relative to the location and path of the oil slick(s);
- The continuously changing wind, wave, and current conditions during the course of the response;
- The condition of the boom; and
- The skill of the response crews in anchoring, angling, maintaining, and shifting locations/angles of the boom over the course of the response operations.

The potential effectiveness of specific boom configurations can be modeled using SIMAP, as has been done for a number of studies.[30] The angles of the boom relative to the current vectors (velocity and direction) can be modeled to determine the degree to which oil may entrain (e.g., Figure 22).[31] Assuming that the boom is properly anchored, maintained, and angled relative to continuously changing current direction, it is possible to estimate the degree to which oil should be contained or deflected.

[30] For example: Etkin et al. 2006 (in Patuxent River, Maryland); Etkin et al. 2008 (in San Francisco Bay, California).
[31] The issue of boom angle relative to current velocity is shown in Figure 3.

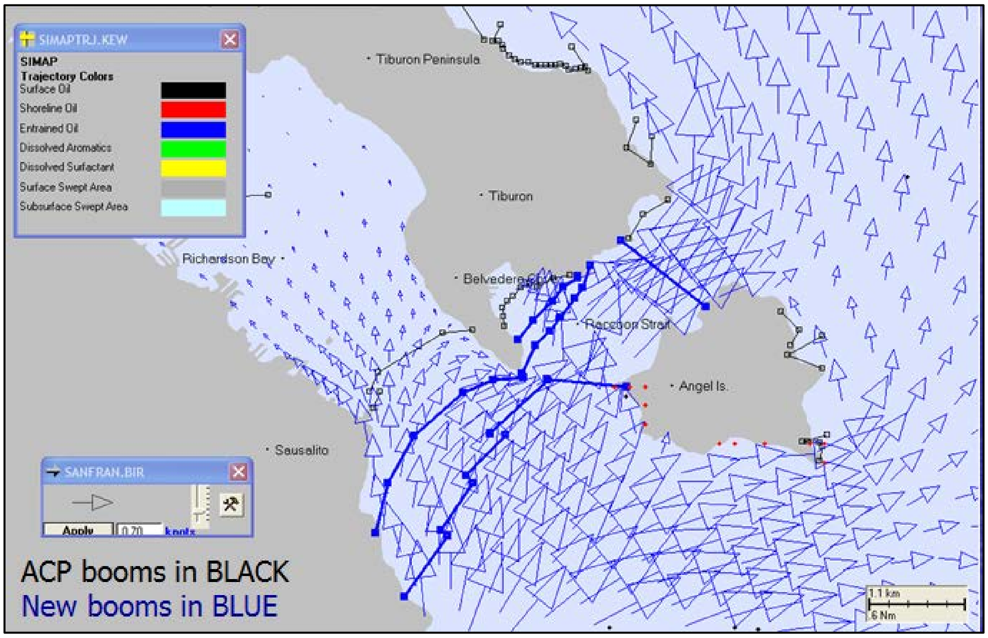


Figure 22: Example of Boom Evaluation with Current Vectors (San Francisco Bay)[32]

Note that for the HROSRA, boom deployment (as per the GRSs) was not specifically incorporated into the SIMAP simulations for the various modeled spill scenarios.[33] For this reason it was not possible to predict the effectiveness of the boom strategies. However, it was possible to observe that due to the fact that current velocity exceeded boom capacity at many points in time at most locations, there would be boom effectiveness issues for many spills (Figure 4). Testing of booming strategies via modeling would be a means to evaluate some of the GRS booming configurations during different spill situations and by tidal cycles and seasons.

Vessel Response Plans (VRPs) and Facility Response Plans (FRPs)

Another level of contingency planning comes from the owners and operators of the potential major sources of spillage, specifically the vessels and facilities, that need to prepare vessel response plans (VRPs) and facility response plans (FRPs), respectively.

The requirements for VRPs are very specific for both tank vessels and non-tank vessels.[34] The VRP program is overseen by the USCG. VRPs require that vessel owners and operators develop a contingency plan for each vessel that describes the procedures that would be carried out in the event of a spill, including a worst-case discharge (WCD). This includes the designation of a qualified individual (QI) that has the responsibility and authority to make decisions and expenditures and act as a liaison with the

[32] From Etkin et al. 2008; French McCay et al. 2008.

[33] Incorporation of booming configurations into SIMAP requires marking the specific locations, including angling, at each tidal cycle during the simulation.

[34] USCG oil spill response regulations are contained in 33 CFR Part 155 (Non-tank & Tank Vessels) and 33 CFR Part 154 Marine Transportation Related Facilities. US EPA oil spill response regulations are contained in 40 CFR Part 112 for Non-Marine Transportation Related Facilities. Pipeline regulations are within the jurisdiction of the Department of Transportation/Pipeline and Hazardous Materials Safety Administration (PHMSA) 49 CFR Part 194 and railcar regulations 49 CFR 130.

FOSC on behalf of the vessel owner, as well as to designate oil spill removal organizations (OSROs) that would have the appropriate resources to respond to spills in every location that the vessel transits. VRPs also require training and exercises to be undertaken, as well as inspection and maintenance of response resources.

Similarly, FRPs are required of certain larger facilities that storage and use oil. FRPs are overseen by the US EPA. FRPs must:

- Be consistent with the National Contingency Plan and applicable Area Contingency Plans;
- Identify a qualified individual (QI) having full authority to implement removal actions, and require immediate communication between that person and the appropriate federal authorities and responders;
- Identify and ensure availability of resources to remove, to the maximum extent practicable, a worst-case discharge;
- Describe training, testing, unannounced drills, and response actions of persons on the vessel or at the facility;
- Be updated periodically; and
- Be resubmitted to an EPA Regional Office for approval of each significant change.

Key elements of an FRP include:

- Emergency Response Action Plan, which serves as both a planning and action document, should be maintained as an easily accessible, stand-alone section of the overall plan;
- Facility information, including its name, type, location, owner, operator information;
- Emergency notification, equipment, personnel, and evacuation information;
- Identification and analysis of potential spill hazards and previous spills;
- Discussion of small, medium, and worst-case discharge scenarios and response actions;
- Description of discharge detection procedures and equipment;
- Detailed implementation plan for response, containment, and disposal;
- Description and records of self-inspections, drills and exercises, and response training;
- Diagrams of facility site plan, drainage, and evacuation plan;
- Security (e.g., fences, lighting, alarms, guards, emergency cut-off valves and locks, etc.); and
- Response plan coversheet.

Oil Spill Response Organizations (OSROs)

US Coast Guard and US Environmental Protection Agency regulations require Responsible Parties (RPs) to have available by contract or other approved means, oil spill response contractors with the appropriate equipment resources meeting required capability levels to respond to various levels of oil spills. Oil spill regulatory compliance levels are based on discharge volume category.

Average Most Probable Discharge (AMPD)

AMPD is defined as the Average Most Probable Discharge. This is the lesser of 50 bbl of oil or 1% of the cargo from the vessel during cargo oil transfer operations to or from the vessel. For a facility, it is the discharge of the lesser of 50 bbl of oil or 1% of the volume of the facility's worst case discharge. OPA90 requires that a containment boom equal to twice the length of the largest vessel involved in the transfer be deployed at the site of the operation within one hour of detection of a spill; additionally skimmers and temporary storage must be on site within 2 hours.

Maximum Most Probable Discharge (MMPD)
Maximum most probable discharge or MMPD means a discharge of –

- For a vessel, two thousand five hundred (2,500) bbl of oil, for vessels with a fuel and cargo capacity equal to or greater than 25,000 bbl; or
- For a vessel, ten% of the vessel's fuel and cargo capacity, for vessels with a fuel and cargo capacity of less than 25,000 bbl.
- For a facility, this will require response resources capable of containing and collecting up to 1,200 bbl of oil or 10% of the worst case discharge, whichever is less.

The RP must have response resources that must include sufficient containment boom, oil recovery devices, and storage capacity for any recovery of up to the MMPD planning volume.

Worst Case Discharge (WCD)
For a vessel, worst case discharge means a discharge in adverse weather conditions of a vessel's entire oil cargo. For a non-Marine Transportation Related Facility, the worst case discharge planning volume would be based on the capacity of the largest oil storage tank within a common secondary containment area or the largest oil storage tank within a single secondary containment area, whichever is greater. For permanently manifolded tanks that function as one oil storage unit, the worst case discharge planning volume would be based on the combined oil storage capacity of all manifolded tanks or the capacity of the largest single oil storage tank within a secondary containment area, whichever is greater.

As defined by 33 USC. Section 2735(b)(2), means, "in the case of a vessel, a discharge in adverse weather conditions of its entire cargo" and, "in the case of an onshore facility, the largest foreseeable discharge in adverse weather conditions."

It should be noted that the response regulatory requirements for railcars do not, at this time, require any RP contracted resources nor any response resource levels of capability or on time arrival time limits for any railcar incident of railcars having less than 42,000 gallons of capacity, most railcars in service today are less than 42,000 gallons thus do not rise to the level to have a Comprehensive Response Plan which would include contracted resources.

Section 311(j) of the Federal Water Pollution Control Act (FWPCA), amended by section 4202 of the Oil Pollution Act of 1990 (OPA90), requires the preparation and submission of response plans by the owners or operators of certain oil-handling facilities and for all vessels defined as "tank and non-tank vessels" (hereafter referred to as plan holders). Plan holders, through their response plans, must address the extremely complex system for assembling, mobilizing and controlling response resources to maintain statutory compliance as well as being prepared to respond to oil spills within their area of operation. Plan holders are required to submit a response plan to the Coast Guard that identifies and ensures, by contract or other approved means, the availability of response resources (personnel and equipment) necessary to remove, to the maximum extent practicable, a worst case discharge (WCD), including a discharge resulting from fire or explosion, and to mitigate or prevent a substantial threat of such a discharge.

To relieve the burden upon the plan holders to provide extensive detailed lists of response resources, the Coast Guard created the Oil Spill Removal Organization (OSRO) classification program, administered by the National Strike Force Coordination Center (NSFCC), so that plan holders would only be required to identify the OSROs by name in their response plans. If the OSRO is classified by the Coast Guard, it means its capacity has been determined to equal or exceed the response capability needed by the plan holder for regulatory compliance, see Title 33 Code of Federal Regulations (CFR) § 154.1035 and § 155.1035. In addition, the classified OSRO's detailed lists of response resources would be required to be listed in the Response Resource Inventory (RRI), which is also administered by the NSFCC.

The RRI is the backbone of the classification system and its capabilities are two-fold, an inventory element and a classification element. The inventory element provides Federal On-Scene Coordinators (FOSCs) and contingency planners the ability to query available spill response equipment and its proximity to Coast Guard Captain of the Port (COTP) zones. The classification element, largely considered an incentive for OSROs to enter their inventories into the RRI, complements facility and vessel response plan development and review processes by systematically classifying OSRO response capability.[35]

Historically, the Coast Guard based OSRO classification levels upon three categories: (1) feet of containment boom; (2) temporary storage capacity (TSC); and (3) skimmer capacity, which translated into an estimated daily recovery capacity (EDRC) measured in bbl per 24-hour period. In December 1995, the guidelines added classification based upon COTPs zones and specific operating environments.

In June 2002, the Coast Guard modified the guidelines to include classifying OSROs in six operating areas versus four, eliminating Average Most Probable Discharge (AMPD) classifications, and incorporating Maximum Most Probable Discharge (MMPD) through WCD Tier 3. In addition, the guidelines introduced Alternate Classification Cities (ACCs) within COTP zones to stimulate increases in classified OSRO coverage. Further, the guidelines added time delivery parameters to programmatically calculate response times based on whether or not companies had personnel on-site 24 hours a day, capable of mobilizing and deploying equipment upon notification, and whether or not the equipment being used was owned, contracted or obtained for company use by other approved means.

The OSRO classifications are as follows (Table 6 and Table 7):

- MMPD and WCD Tier 1 Classification: Only resources located at equipment sites capable of being mobilized and in route to the scene of a spill within two hours of notification are counted toward MMPD and WCD1 classifications. Because of the potential for non-dedicated resources to be committed to other functions, only dedicated resources are presumed to be able to mobilize within these time requirements.

[35] USCG 2016.

- WCD Tier 2 and WCD Tier 3 Classifications: Owned, contracted, dedicated and non-dedicated equipment is allowed for WCD2 and WCD3 classification.[36]

Tiers 1, 2 and 3 means the combination of response resources and the times within which the resources must be capable of arriving on-scene to meet WCD resource requirements as defined in 33 CFR Section 154.1020 and 33 CFR Section 155.1025.

Table 6: OSRO Classification Requirements[37]

Protective Boom (feet)	Containment Boom (feet)	Oil Recovery Equipment (bbl/day EDRC)	Recovered Oil Storage (bbl TSC)	Facility Response Times (hours)	Vessel Response Times (hours)
MMPD (1,200 bbl/day recovery)					
4,000	1,000 plus 300 per skimming system	1,200	2,400	6 for higher-volume ports	12 for higher-volume ports
				12 for all other locations	24 for all other locations
WCD1 (1,875 bbl/day recovery)					
25,000	1,000 plus 300 per skimming system	1,875	3,750	6 for higher-volume ports	12 for higher-volume ports
				12 for all other locations	24 for all other locations
WCD2 (3,750 bbl/day recovery)					
25,000	1,000 plus 300 per skimming system	3,750	7,500	30 for higher-volume ports	36for higher-volume ports
				36 for all other locations	48 for all other locations
WCD3 (7,500 bbl/day recovery)					
25,000	1,000 plus 300 per skimming system	7,500	15,000	54 for higher-volume ports	60 for higher-volume ports
				60 for all other locations	72 for all other locations

Table 7: Response Times for Containment Boom, Mechanical Recovery & Storage[38]

Area	Facility or Vessel[39]	MMPD	WCD1	WCD2	WCD3
Rivers/Canals	**Facility**	12	1	36	60
	Vessel	24	2	48	72
	Facility HVPAs	6	6	30	54
	Vessel HVPAs	12	12	36	60

Management of an Oil Spill Using Incident Command/Unified Command

A significant activity during a spill response is how the incident is managed. Without an organizational structure that manages all aspects of the response, containing individuals that have been trained in the

[36] The classified OSROs in Sector New York/New Jersey are detailed in Appendix B.
[37] USCG OSRO Classification Guidelines
[38] USCG OSRO Classification Guidelines
[39] HVPA = high volume port area

functionality of that management structure, no matter how much equipment or how many field responders, it is doubtful that the response to that incident will be successful.

The regulations require: a vessel/facility owner or operator to be responsible for ensuring that sufficient numbers of trained personnel, boats, aerial spotting aircraft, sorbent materials, boom anchoring materials, and other resources are available to sustain response operations to completion. All such equipment must be suitable for use with the primary equipment identified in the response plan. A vessel/facility owner or operator is not required to list these resources in the response plan, but shall certify their availability. The regulations require that the response organization have trained personnel necessary to continue operation of the equipment and staff of the oil spill removal organization and spill management team for the first seven days of the response.

The Incident Command System (ICS) is the on-site management system used by the USCG, EPA, State Agencies and Responsible Parties to manage an oil spill. The National Contingency Plan (NCP) requires all oil spill Incident Command Organizations to be managed by Unified Command. One part establishes the unified command structure for managing responses to discharges through coordinated personnel and resources of the federal government, the state government, and the RP.

The primary reference for oil spill responders is the *USCG Incident Management Handbook* (IMH).[40] The IMH is designed to assist Coast Guard personnel in the use of the National Incident Management System (NIMS) Incident Command System (ICS) during response operations and planned events. The IMH is an easy reference job aid for responders. It is not a policy document, but rather guidance for response personnel. The IMH provides the blueprint for managing all coastal responses. The EPA also has their IMH, 2016 edition.[41]

The ICS is a standardized emergency management system specifically designed to provide for an integrated organizational structure that reflects the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries. ICS is the combination of facilities, equipment, personnel, communications, and procedures operating within a common organizational structure to manage incidents.

Although a single Incident Commander normally handles the command function, an ICS organization may be expanded into a Unified Command (UC). The UC is a structure that brings together the "Incident Commanders" of all major organizations involved in the incident in order to coordinate an effective response while at the same time carrying out their own jurisdictional responsibilities. The UC links the organizations responding to the incident and provides a forum for these entities to make consensus decisions. Under the UC, the various jurisdictions and/or agencies and non-government responders may blend together throughout the organization to create an integrated response team. The EPA UC/ICS organization for Inland River Spills is depicted in the EPA IMH as shown in Figure 23.

[40] USCG 2014.

[41] US EPA 2016.

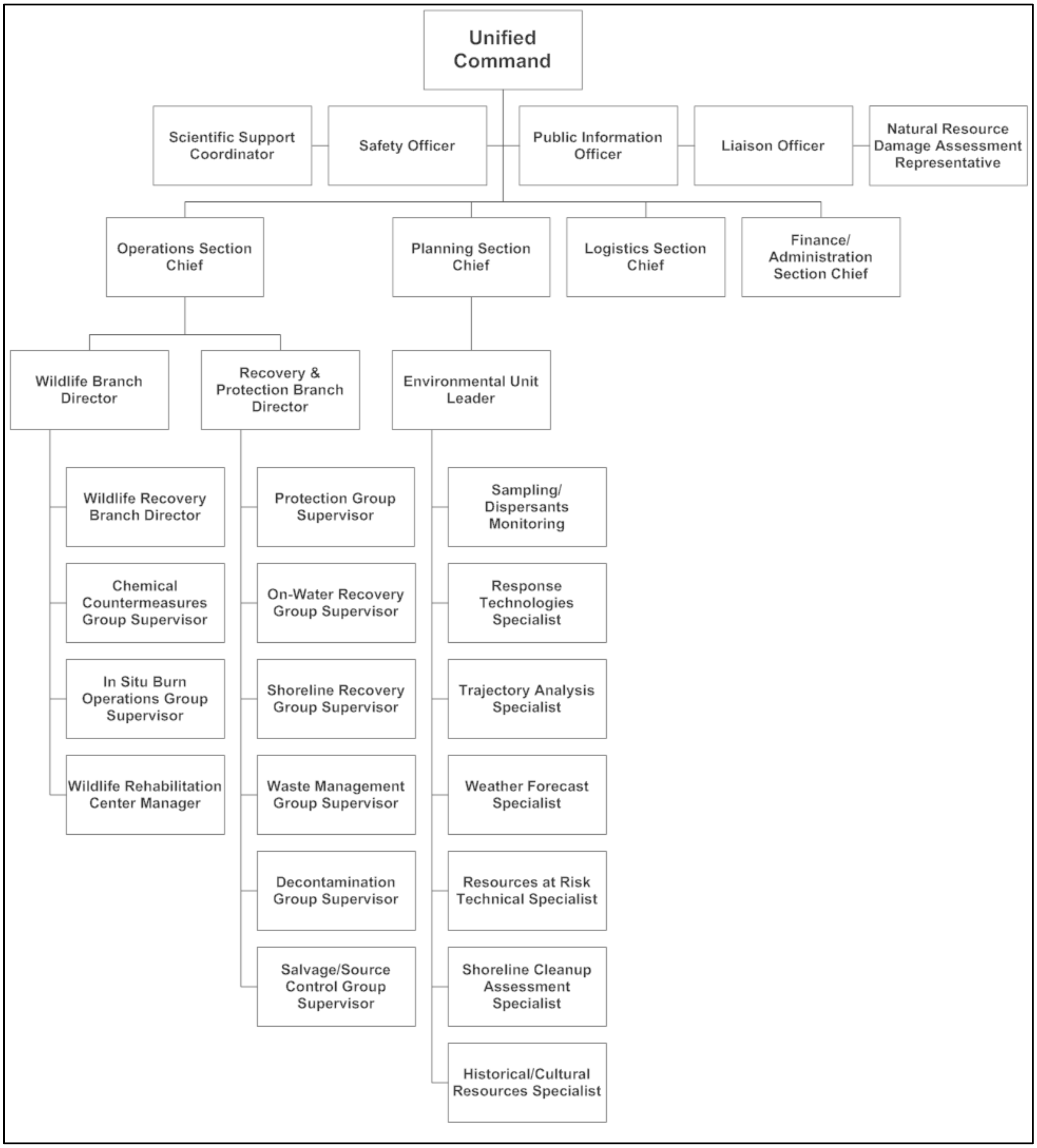


Figure 23: EPA UC/ICS Organization for Inland River Spills

The UC is responsible for overall management of the incident. The UC directs incident activities, including development and implementation of overall objectives and strategies, and approves ordering and releasing of resources. Members of the UC work together to develop a common set of incident objectives and strategies, share information, maximize the use of available resources, and enhance the efficiency of the individual response organizations. Unified Command is typically formed and composed of the FOSC (USCG or EPA), State On-Scene Coordinator (SOSC), and the RP Incident Commander. Other local jurisdictions, including a Fire Chief if there is a potential for fire, may also be requested to participate in the UC. Typically the rule is, in general terms, an organization may be included in the UC if:

- The organization has jurisdictional authority or functional responsibility under law for oil spill response
- The organization is specifically charged with commanding, coordinating or managing a major aspect of the oil spill response
- The organization has resources to support the oil spill response
- The organization's area of responsibility is affected by the oil spill or the response operation

The objective of the ICS organization is to maximize team efficiency by defining lines of communications, delegating responsibilities, expanding with new people and duties to ensure no one exceeds their capabilities, mentally or physically. The ICS organization builds from the ground up, with the management of all major functions initially being the responsibility of just a few people. Functional units are designed to handle the most important incident activities, and as the incident grows, additional individuals are assigned to perform those functions.

UC sets the objectives for the Incident Management Team (IMT). Top priorities are to protect public health, the safety of both responders and communities in this region, and limit the environmental impacts as we contain and clean up the spill as quickly and efficiently as possible. Spill specific objectives usually follow and whereas the general priorities rarely change as the spill response continues, the spill specific objectives may change periodically if not daily.

Participation of Volunteers and Non-Governmental Organizations

In an oil spill, there are often opportunities for volunteers and non-government organizations to participate. There are potentially at least three paths that may be taken.

Individuals may become trained in the appropriate level of Hazardous Waste Operations and Emergency Services (HAZWOPER) regulations, 29 CFR 1910.120. HAZWOPER is a set of guidelines produced and maintained by the Occupational Safety and Health Administration (OSHA), which regulates hazardous waste operations and emergency services in the United States and its territories.[42] With these guidelines, the US government regulates hazardous wastes and dangerous goods from inception to disposal.

Once trained HAZWOPER, individuals can:

- Become employed by an OSRO during a response
- Participate as a volunteer in various capacities during the response
- Participate in wildlife rehabilitation activities, usually under the supervision of an organization such as Tri-State Bird and Rescue, Inc.[43]

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[42] An excellent reference document is the *Training Marine Oil Spill Response Workers under OSHA's Hazardous Waste Operations and Emergency Response Standard*, published by the Department of Labor, OSHA; Available at: https://www.osha.gov/Publications/3172/3172.html

[43] Tri-State Bird and Rescue, Inc., is headquartered in Newark, DE, https://tristatebird.org/

Non-governmental organizations can also work through the UC/IC organization via the Liaison Officer (LO) as shown in Figure 23. The LO works directly with the UC. His/her primary duties are to provide the point of contact for representatives of assisting and cooperating agency and to respond to requests or concerns from stakeholder groups. The LO address inter-organizational issues and bring issues and concerns to the attention of the Incident Commander with a recommended course-of-action. Key goals include:

- Developing rosters of participating agencies and stakeholders;
- Facilitating information exchange within the UC organization; and
- Exchanging information with agency reps/stakeholders.

The National Response Team (NRT) has released the *NRT Use of Volunteers Guidelines for Oil Spills*, which may be very helpful in defining the roles and preparing potential volunteers to maximize their effectiveness in working with the overall response operations.[44]

Effectiveness of Spill Response for Risk Mitigation

For oil spill risk mitigation, spill prevention will always be the most essential approach, followed by spill control or reduction in release volume. Spill response operations will never be completely effective in removing oil from the environment, though with strategic planning and the right conditions, they can help to lessen impacts and consequences.

After spill prevention, for most oil spill situations in rivers, the priorities for response in order of precedence are:

- **Source Control**: Keeping as much additional oil as possible from being released into the environment;
- **Site Containment:** Corralling oil in the near vicinity of the spill site by secondary containment berms (storage tank spills) and/or booming (on water);
- **Monitoring and Tracking:** Following and predicting the most likely path (trajectory) of floating and entraining oil with weather and current/tidal information, modeling, and remote sensing;
- **Protection:** Proactively shielding previously-identified sensitive sites in local geographic response plans or strategies from oil incursion with deflection or exclusionary booming;
- **Deflection:** Altering the trajectory of floating oil away from sensitive and difficult-to-clean areas towards locations that are less sensitive to oil and more amenable to effective oil removal;
- **On-Water Containment:** Corralling and amassing floating oil with booms to assure greater efficiency and effectiveness of mechanical removal operations;
- **On-Water Recovery:** Skimming and vacuuming of contained floating oil;
- **Shoreline Removal:** Cleanup of stranded oil on shorelines and coastal structures with manual and mechanical methods; and

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[44] The Guidelines can be found on the NRT Website (www.nrt.org; *Guidance, Technical Assistance & Planning; Use of Volunteers Guidelines for Oil Spills*) https://nrt.org/Main/Resources.aspx?ResourceType=Use%20of%20Volunteers%20for%20Oil%20Spill%20Guidelines%20and%20MOU&ResourceSection=2

- **Disposal:** Gathering and transport of collected oily debris and recovered oil-water mixtures to hazardous waste disposal sites.

In real spill situations, environmental conditions will interfere and complicate even the best planned and executed response operations, particularly those related to on-water containment and recovery or removal. Currents, tides, winds, and waves will move the oil on the water surface and into the water column and sediments. Swift currents will reduce the effectiveness of booms by entrainment.

The nature of the oil itself changes with weathering as it evaporates, dissolves, disperses, and comes in contact with sediment and debris. Darkness and fog will hinder visibility and interfere with oil removal and tracking. At some times of year, ice will also interfere with response operations.

In addition to hindrance of actual response operations, environmental conditions and other factors can affect logistics, which in turn delay or alter the effectiveness of response. Weather conditions and traffic can delay the arrival of essential response equipment or preclude certain operations for safety reasons.

In some cases, there are system "bottlenecks" that hinder the effectiveness and efficiency. For example, when unusually large amounts of oily water are collected by skimming or vacuuming, which occurs when oil is very thin on the water surface, there may be a lack of sufficient storage capacity due to a backlog of decanting operations or transport for disposal.

Given all of these factors, despite the best planning and skills of operators, the expectation for the effectiveness of spill response as mitigation should be realistic or "cautiously-optimistic" at best. Most mechanical removal operations, for example, do not collect more than 5 – 10% of spilled oil, often much less. There are conditions that make mechanical recovery considerably more effective, such as very low currents and low wind in a sheltered place in which a spill occurs from a pre-boomed vessel with response equipment already on site.

In cases in which a highly-flammable and volatile product, such as gasoline, is spilled skimming operations are likely to be ineffective due to the high evaporation rate. These operations may also be dangerous for responders due to gas vapor concentrations. Unified Command may opt to forgo attempts at skimming or vacuuming in these incidents for public and worker safety.

In an extensive study conducted for the Bureau of Safety and Environmental Enforcement (BSEE),[45] the potential effectiveness of existing spill response capabilities in offshore worst-case discharge scenarios was analyzed.[46] Two key findings were:

- Source control is of paramount importance in reducing the impact of spills; and
- Skimmers are likely to achieve only <1% to 20% of their potential hypothetical effectiveness in field conditions due to environmental factors.[47]

[45] Buchholz et al. 2016a, 2016b, 2016c.

[46] Since the study involved offshore well blowouts, in situ burning, and surface and sub-surface dispersants were also evaluated. Since these methods are inappropriate for the Hudson River, the results are not presented.

[47] Based on Estimated Recovery System Potential (ERSP), which is less than Effective Daily Recovery Capacity (EDRC), which is, in turn, 20% of "nameplate capacity" (manufacturer's claimed recovery rate in tank testing).

Factors with Potential to Reduce Response Effectiveness in Hudson River

In the Hudson River, there are a number of factors that would tend to preclude high effectiveness in oil removal by these means:

- **Currents (>0.7kts) often exceeding boom capability;**
- **Geography of river and tides spreading oil across a large area;**
- **Ice conditions that may impede mechanical removal equipment, booms, and boat access; and**
- **High degree of sediment in some locations that may lead to oil submergence.**

In addition, the extensive wetland areas along the river will require particularly careful cleaning operations. High levels of foot traffic and incursion with equipment can often cause more harm than oil. This means that some areas will have to be left to natural recovery.

The extensive length of the river and the degree to which oil would move back and forth with the tides, especially in larger-volume spills will mean that resources will need to be spread across large areas, which will create logistical challenges.

Another significant limitation is that the most effective spill response strategies (see Table 8) – chemical dispersants and in situ burning, which were applied effectively in the response to the 2010 Deepwater Horizon spill in the Gulf of Mexico, as well as other spill incidents around the world, are not viable options for the Hudson River.

Table 8: Chemical Dispersants and In Situ Burning for Oil Spill Response[48]

Factor	Chemical Dispersants (Surface)[49]	In Situ Burning
How it Works	The chemical dispersants act like detergents to break the oil physically and chemically into smaller droplets that are more bio-available to naturally-occurring microbes that can metabolize and break down the oil into harmless components. The chemicals are applied by sprays from airplanes or from boats in a concentration of about 1 - 2 parts dispersant to 20 parts oil.	The oil is corralled with fire-proof boom into a relatively thick layer on the surface and ignited with gels (usually from helicopters) to burn off the oil.
When Appropriate	This is a highly-effective strategy when the oil is threatening sensitive shorelines and near-shore resources, and is not too thinly spread and not too highly weathered (chemically and physically broken down by exposure to air and sunlight).	This is an excellent strategy in offshore areas where the spilled oil is relatively fresh or continuously being released over a longer time period.
Effectiveness	50 – 98% breakup of the oil.	As much as 98% of the oil will be burned, leaving some residue on the surface.

[48] Neither of these is an appropriate option for spills in the Hudson River.
[49] Sub-surface application of dispersants may be used for sub-surface releases, especially from offshore wells.

Table 8: Chemical Dispersants and In Situ Burning for Oil Spill Response[48]		
Factor	**Chemical Dispersants (Surface)**[49]	**In Situ Burning**
Benefits	This is a highly effective way to keep oil off sensitive shorelines and near-shore areas. The chemically-dispersed oil is one-tenth to one-hundredth as toxic as the fresh oil that has spilled. If the oil is broken up offshore there is significantly less shoreline cleanup required (which can have its own negative effects). Near-shore effects are reduced protecting many bird species and other wildlife in wetlands. This methodology has been used extensively and successfully around the world.	The oil is kept off of the shoreline and out of sensitive near-shore areas.
Challenges	Dispersants work best when the oil is not too highly weathered. This means that there is a "window of effectiveness" that is hours to a couple of days at most since the oil spilled. With continuous spillage (e.g., Deepwater Horizon) there is fresh oil continuously appearing so the window is extended for the duration of the outflow. It is best to make decisions about the appropriateness of dispersant use in a particular area before a spill occurs so as not to delay the response. The dispersants also require some mechanical action (waves) to work. They do not work well in very calm waters. Conditions need to be suitable for airplane sorties. Dispersant caches are often far from the spill site.	Containing the oil within booms into a thickness that is amenable to ignition can be difficult especially if the current velocity is making booms ineffective. The ignition can be difficult if the oil is too weathered or spread too thin.
Drawbacks	Dispersants do drive oil components into the water column (below the surface). This may cause some toxic effects to fish and invertebrates in the water. Near-shore use is restricted in most areas because the dispersed oil has less area in which to dilute and disperse. Because of potential toxic effects, dispersant use is generally not permitted near coral reefs and mangroves.	The oil burns creating black plumes of smoke that may cause temporary human health problems from high particulate matter. Burns cannot be conducted downwind or near to populated areas. There are often permitting issues due to air pollution concerns. The particulates that are released in a burn are not unlike what would be released if that oil were burned as a fuel.

Additional Response Considerations for the Hudson River

Source Control

Another extremely important part of a response operation is controlling the source of the spill – i.e., shutting off the release of oil or preventing additional oil from being discharged. While spill response operations are essential and will begin immediately or within short order after a spill is reported, source control may even be more important. Source control's importance is analogous to turning off the faucet in an overflowing bathtub before running for a mop.

The method of source control depends on the actual spill source and accident cause. For a pipeline, source control would clearly entail shutting off the appropriate valves to stem the flow of oil. A similar opportunity may exist when a spill occurs during oil transfer operations or due to a leaking pipe on a vessel.

If the oil spill originates from a vessel that has a breached cargo or fuel tank, the approach to source control is more complex. Salvage professionals[50] that are designated in a vessel response plan (VRP) will arrive on scene to conduct necessary operations that stem the flow of oil, lighter (remove) remaining oil from the vessel, and stabilize the vessel.

These actions can have a highly significant effect on mitigating the consequences of an oil spill. Reducing the amount of oil that is released from a vessel involved in a casualty can mean the difference between a maximum most-probable discharge (MMPD) and a worst-case discharge (WCD) scenario.

Water Intakes

One major issue of concern during an inland river spill is the potential for shutdown of potable water and industrial cooling water intakes. Shutting down freshwater intakes can cause widespread economic and political impacts, not normally associated with a spill in the marine environment. Emergency shut downs of water intakes providing industrial water and potable water to local businesses and residential areas can cost millions of dollars for the city and state, not to mention the inconveniences and potential health impacts to the population. The Hudson River has a number of water intakes providing potable drinking water, recreational and industrial supplies as shown in Table 9.

Potential shutdown of water intakes is a very real and unique concern for spills in freshwater environments. The density of freshwater can make spills in the more challenging as well. Oil usually floats because it is less dense than the water it is floating on. Density is the mass, or weight, of a substance divided by its volume. The density of freshwater is usually about 1 gram per cubic centimeter (g/ml). Ocean saltwater is denser (usually around 1.02 to 1.03 g/ml) because it contains more salt. The higher the salinity of water, the denser it is. Densities of oils generally range from 0.85 g/ml for a very light oil, like gasoline, to 1.04 g/ml for a very heavy oil. Most types of oils have densities between about 0.90 and 0.98 g/ml. These oils will float in either fresh or salt water. Oils that are heavier than the receiving water will sink below the surface, but often are submerged in the water column by turbulence.

[50] See also section in the volume on Firefighting and Vessel Salvage Regulations.

Table 9: Water Intakes in Hudson River Study Area

Facility	Town	Intake Type			
		Public	Agriculture	Industrial/ Commercial	Recreational
Domino Sugar Refinery	Yonkers			●	
Montefiore Hospital	Tarrytown			●	
Tallman Mountain State Park	Orangetown				●
Sleepy Hollow Country Club	Briarcliff				●
Rockland Lake Golf Course	Orangetown				●
Tilcon Stone Quarry	Haverstraw			●	
Haverstraw Power Plant	Haverstraw			●	
Indian Point Energy Center	Cortlandt			●	
Camp Smith Military	Cortlandt			●	
Town of Fort Montgomery	Fort Montgomery	●			
Town of Cold Spring	Philipstown	●			
Town of Beacon	Beacon	●			
Southern Dutchess Country Club	Beacon				●
VA Hudson Valley Castle Point	Wappinger	●			
Marlboro Quarry	Marlboro			●	
Agricultural Area	Milton		●		
IBM	Poughkeepsie			●	
Dutchess Golf Club	Poughkeepsie				●
Marist College	Poughkeepsie	●			
Town of Hyde Park	Hyde Park	●			
Town of Port Ewen	Esopus	●			
Town of Catskill	Catskill	●			
Town of Athens	Athens	●			
Town of Coxsackie	Coxsackie	●			
Town of Castleton-on-Hudson	Schodack	●			
Epcor Utilities	Schodack			●	
PSEG Power New York	Bethlehem			●	
Pfizer/AMRI	Rensselaer			●	
City of Albany	Albany	●			
Agricultural Area	Menands		●		
Town of Watervliet	Watervliet	●			
Town of Green Island	Green Island	●			
Town of Troy	Troy	●			

Oils that are lighter than the receiving water can initially float and then sink after mixing with sand, either by stranding onshore or mixing with suspended sand by wave action. In both the cases, oil is still buoyant and, if separated from the sediment, will refloat. Only heavy crude oils and refined products (generally with an API gravity, or °API, less than 20)[51] exhibited this behavior. Diluted bitumen products also initially float, but can approach the density of fresh water after evaporation of the diluent and become entrained in the water column where the oil droplets can interact with suspended particles and sink.

In estuaries, such as the Hudson River, the salt front and accompanying estuarine circulation extend inland for many miles. The landward intrusion of salt is carefully monitored by engineers because of the potential consequences to water supplies if the salt intrusion extends too far. For instance, the city of Poughkeepsie, N.Y., 60 miles north of the mouth of the Hudson River, depends on the river for its drinking water. Roughly once per decade, drought conditions cause the salt intrusion to approach the Poughkeepsie freshwater intake.

When an oil spill occurs, one of the primary actions that the RP should take is to notify downstream water intakes of the spill, and if it is a tidal waterway, upstream water intakes should be notified as well. Exclusion booms should be promptly deployed on the surface around the water intakes.

However, the fate of certain oils that are spilled into the environment in certain circumstances will have a tendency to have a portion of the oil become entrained in the water column. Dissolution is the chemical stabilization of oil components in water. Dissolution accounts for only a small portion of oil loss, but it is still considered an important behavior parameter because the soluble components of oil, particularly the smaller aromatic compounds, are more toxic to aquatic species than the aliphatic components.

Natural dispersion is the removal of oil from the water surface by its incorporation, in the form of small droplets, into the water column by wave action. The rate of dispersion depends on the amount of wave energy at the sea surface. For low-energy wave conditions, the rate of dispersion is low. For high sea states, dispersion may dominate with the result that most of the oil is removed from the water surface in a few hours.

The more viscous the oil, the slower the rate of dispersion. In the water column, dispersed oil is present as small droplets and, thus, has a much higher surface area in contact with the water. This increases the rate of dissolution and the rate of natural biodegradation. The rates of both evaporation and dispersion increase with increasing wind and decreasing viscosity. They are thus competing processes in the oil mass balance.

For the HROSRA modeled spill scenarios, it can be seen that certain oil types in some of the scenario with a high percentage of oil emulsified in the water column as shown in Table 10.

[51] API gravity or °API is an inverse measure of petroleum density relative to water. As density (or specific gravity) increases, °API decreases. °API = (141.5/specific gravity) - 131.5.

Table 10: Water Column Percentages for HROSRA Spill Scenarios[52]		
Scenario	**Mass Balance Percentage of Oil in Water Column**	
	Average Summer	**Average Winter**
Albany 155,000 bbl Bakken Crude Tanker	34%	10%
Coxsackie 25,000 bbl Home Heating Oil	7 – 32%	<1%
Kingston 155,000 bbl Home Heating Oil	25%	<9%
Kingston 150,000 bbl Diluted Bitumen	<1%	<1%
Rondout 75,421bbl Bakken Crude	30%	11%
Rondout 14,000 bbl Heavy Fuel Oil	0%	0%
Newburgh 11,000 bbl Bakken Crude	8 – 26%	12%
Bear Mountain 2,500 bbl Home Heating Oil	<5%	<5%
Iona Island 11,000 bbl Bakken Crude	7 – 32%	>26%
Tappan Zee 2,500 bbl Home Heating Oil	8%	5%
Tappan Zee 50 bbl Heavy Fuel Oil	0%	0%
Yonkers 155,000 bbl Gasoline	<1%	<1%

Since most water intakes have their intake well below the surface of the water, it is the percentage of oil in the water column that would cause the municipal water system to shut down the water intake when the pollution percentage reaches a certain level. At that time, alternative sources of water for drinking, cooking, and bathing needs to be made available. Planning for these alternate supplies, especially for potable water, is a preparedness activity that can be conducted long before a spill occurs that may shut off the usually drinking water supply for days or weeks to a community.

An oil spill, especially on the upper Hudson River, could potentially have negative consequences for potable and commercial water intakes with shutdowns that could last for a long period until river monitoring determines that the pollution has passed the water intake by and reopening of water supply could recommence.

Preparing for this eventuality of water intakes being shut down can be addressed in preparedness activities with river stakeholders working with municipal and commercial water intakes on action plans that would ensure alternate supply especially for potable water residents have sufficient safe water sources for cooking, drinking and bathing.

Water intakes that would be affected in the event of spills like hypothetical incidents that were modeled are shown in Table 11. Note that water intakes may be shut off in a precautionary manner even if the actual concentration of oil in the water column is not high enough to cause health effects for drinking water or to present safety or operational issues for commercial or industrial intakes.

[52] See HROSRA Volumes 4 and 7.

Table 11: Water Intakes Potentially Affected in HROSRA Spill Scenarios

Facility	Town	Spill Scenarios with Potential Water Intake Impacts by Season[53]																																			
		Albany Bakken			Coxsackie HHO			Kingston HHO			Kingston Dilbit			Rondout Bakken			Rondout HFO			Newburgh Bakken			Bear Mtn HHO			Iona Bakken			Tappan Zee HHO			Tappan Zee HFO			Yonkers Gasoline		
		Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter
Domino Sugar Refinery	**Yonkers**																																				
Montefiore Hospital	**Tarrytown**																																				
Tallman Mountain SP	**Orangetown**																																				
Sleepy Hollow CC	**Briarcliff**																																				
Rockland Lake Golf	**Orangetown**																																				
Tilcon Stone Quarry	**Haverstraw**																			●	●		●	●	●	●	●	●									
Haverstraw Power	**Haverstraw**																			●	●		●	●	●	●	●	●									
Indian Point Energy	**Cortlandt**																			●	●		●	●	●	●	●	●									
Camp Smith Military	**Cortlandt**																			●	●		●	●	●	●	●	●									
Charles Point Resource	**Peekskill**																			●	●		●	●	●	●	●	●									
Fort Montgomery	**Ft Montgomery**																																				
Cold Spring	**Philipstown**																																				
Beacon	**Beacon**																																				
Southern Dutchess CC	**Beacon**																																				
Danskammer Power	**Newburgh**							●		●	●		●	●		●	●			●	●	●	●														
Roseton Power	**Newburgh**							●			●		●	●		●	●			●	●	●	●														
Town of Chelsea	**Wappinger**							●		●	●		●	●		●	●			●	●	●	●														
VA Hudson Valley	**Wappinger**																																				
Marlboro Quarry	**Marlboro**																																				

[53] Intakes for drinking water and agriculture are marked in red. These intakes would be of greatest concern for public health and safety.

Table 11: Water Intakes Potentially Affected in HROSRA Spill Scenarios

Facility	Town	Spill Scenarios with Potential Water Intake Impacts by Season[53]																																			
		Albany Bakken			Coxsackie HHO			Kingston HHO			Kingston Dilbit			Rondout Bakken			Rondout HFO			Newburgh Bakken			Bear Mtn HHO			Iona Bakken			Tappan Zee HHO			Tappan Zee HFO			Yonkers Gasoline		
		Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter
Agricultural Area	**Milton**																																				
Highland	**Highland**				●																		●														
IBM	**Poughkeepsie**				●			●	●	●	●	●	●	●	●	●	●	●	●				●														
Dutchess Golf Club	**Poughkeepsie**				●			●	●	●	●	●	●	●	●	●	●	●	●				●														
Marist College	**Poughkeepsie**				●			●	●	●	●	●	●	●	●	●	●	●	●				●														
Highland	**Highland**				●			●	●	●	●	●	●	●	●	●	●	●	●																		
Hyde Park	**Hyde Park**				●			●	●	●	●	●	●	●	●	●	●	●	●																		
Rhinebeck	**Rhinebeck**	●			●		●	●	●	●	●	●	●	●	●	●	●	●	●																		
Port Ewen/Rondout	**Esopus**	●			●		●	●	●	●	●	●	●	●	●	●	●	●	●																		
Catskill	**Catskill**	●			●		●					●	●		●	●		●	●																		
Ulster	**Ulster**	●			●		●					●	●		●	●		●	●																		
Athens	**Athens**	●																																			
Coxsackie	**Coxsackie**	●																																			
Castleton-on-Hudson	**Schodack**	●		●		●																															
Epcor Utilities	**Schodack**	●		●		●																															
PSEG Power NY	**Bethlehem**	●	●	●		●																															
Pfizer/AMRI	**Rensselaer**	●	●	●		●																															
OGS	**Albany**	●	●	●		●																															
City of Albany	**Albany**																																				
Agricultural Area	**Menands**																																				

Table 11: Water Intakes Potentially Affected in HROSRA Spill Scenarios

Facility	Town	Spill Scenarios with Potential Water Intake Impacts by Season[53]																																	
		Albany Bakken			Coxsackie HHO			Kingston HHO			Kingston Dilbit			Rondout Bakken			Rondout HFO			Newburgh Bakken			Bear Mtn HHO			Iona Bakken			Tappan Zee HHO			Tappan Zee HFO			Yonkers Gasoline		
		Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter
Watervliet	**Watervliet**																																				
Green Island	**Green Island**																																				
Troy	**Troy**																																				

Responding to Oil Spills in Ice[54]

Ice season on the Hudson River generally runs from about 12 December through 31 March, though it varies somewhat each year. Vessel transits continue for the most part during ice season aided by ice-cutting operations. Spills can occur from vessels under ice conditions in the Hudson River[55] and there is always a possibility of a train, pipeline, or facility spill in ice conditions.

Oil spill response under ice conditions have occurred for decades in Arctic areas and other ice-laden locations. A large body of research on the behavior of oil in ice (Figure 24) and the effectiveness of various response strategies exists.[56] While some of the challenges for spill response under ice conditions also are relevant for all spill response situations, there are specific issues that occur during ice conditions.

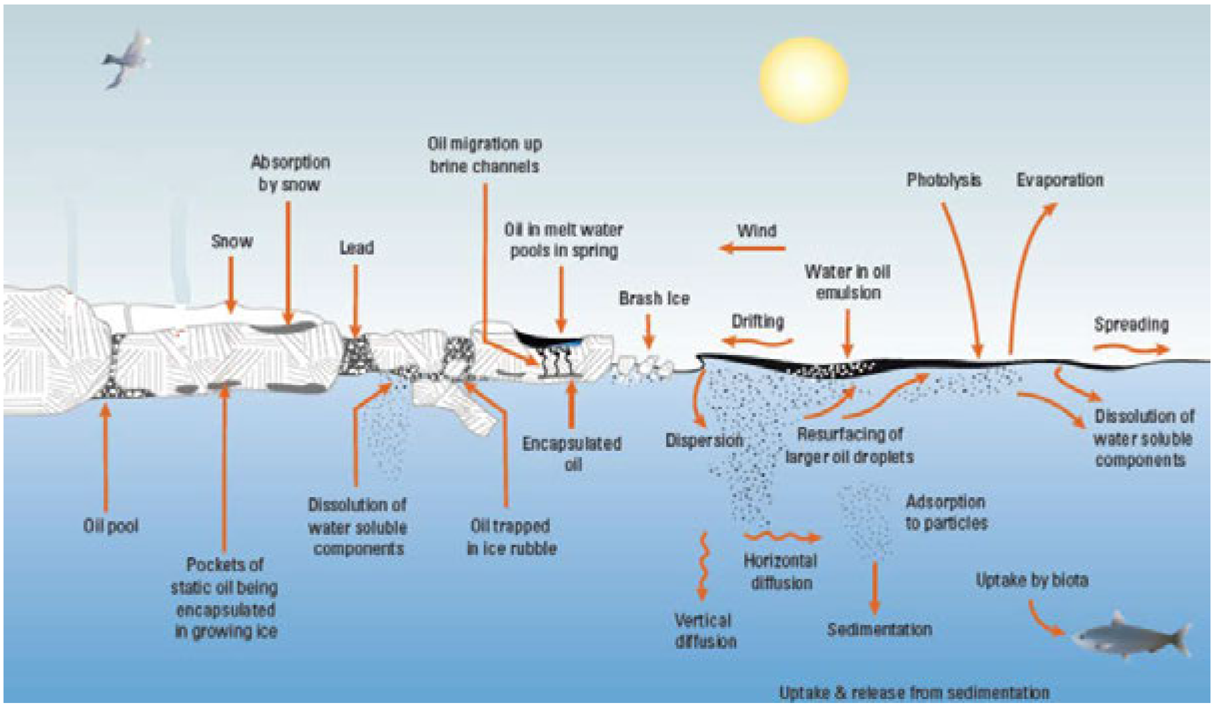

Figure 24: Environmental Processes that Affect Oil Behavior and Weathering in Ice[57]

Among the "lessons learned" in some of the most recent training and demonstration exercises conducted by the USCG Research & Development Center are:[58]

- Different recovery systems and tactics are necessary for different ice and weather conditions.
- Icebreakers may be necessary to assist other vessels to make way through ice and to the oil.
- Environmentally-sound equipment de-icing methods are necessary.
- Frequent crew rotations for work on deck are necessary in cold weather.

[54] For more detail on ice conditions in the Hudson River, see HROSRA Volume 2.
[55] For example, see the section on the 1977 Ethel H spill in the Hudson River in this volume.
[56] Research on oil in ice was reviewed in Etkin 1990, and more recently in Hansen 2014.
[57] Modified from Daling et al. 1990 and A. Allen.
[58] Hansen 2014.

- Shipping and loading equipment in cold climates is performed more easily if everything is containerized.
- Ice radar can enhance performance during navigation and to identify ice types.
- Low temperatures and turbulence can have a high impact on operations for the remote sensing equipment, so a dedicated or maneuverable platform is preferred.
- Booms and any lines attached to equipment should never be deployed over ice.
- Some types of skimmers needs to be ruggedized to protect cables, hoses and fittings from ice.
- Barge use and tending procedures need to be developed:
    - Use of barge in ice;
    - Emergency response; and
    - Need to document tactics and guidance for FOSC during ice conditions.
- At this time, there are few vessels that are built to handle ice; so responders need to understand what equipment and vessels are available so that they can adapt. In some cases, the ice-strengthened vessels can perform surveillance missions and be available to ensure the safety of all response vessels.

Response operations under ice conditions present health and safety challenges for responders. With the potential for very low temperatures and high wind conditions in the Hudson River during winter months, these challenges must be considered in contingency planning. High air temperatures during winter in the Albany area, the furthest north part of the HROSRA study area, generally average at about freezing (32°F) during the day and 15°F at night. However, it is not unusual to have temperatures in the single digits or below 0°F during the day. Air temperatures tend to be somewhat warmer in the southern part of the Hudson River. These types of conditions cause challenges for both response personnel and equipment.

PCBs and Other Contaminants in Substrate[59]

The potential presence of PCBs and other contaminants[60] in some sediment in the Hudson River could conceivably complicate some spill responses that involved extensive dredging or shoreline substrate removal.[61] There may also be PAHs and benzene that are present in substrate (prior to an oil spill). In 2002, New York Sea Grant in partnership with NYSDEC conducted a study to determine the concentrations in the sediment at various marinas and other locations located along the Hudson River. A sample of the study's findings is summarized in Table 12.

The guidance for marina dredging might also be applicable for any more extensive dredging that might occur during an oil spill for the detection and/or removal of submerged oil, or for removal of heavily-oiled shoreline substrate.

[59] The PCB contamination issue in the Hudson River is discussed in HROSRA Volume 2.
[60] Lead, mercury, copper, cadmium, dichlorodiphenyltrichloroethane (DDT) and its breakdown products – dichlorodiphenyldichloroethylene (DDE) and 1,1dichloro-2,2-bis(p-chlorophenyl) ethane (DDD).
[61] Holochuck 2005.

Table 12: Sample Ambient Contaminant Levels along Locations in Lower Hudson Valley[62]

Location	Maximum Concentrations[63] (in ppm – except for PCBs in ppb)[64]									
	Copper	Cadmium	Lead	Mercury	PCBs	Benzo(a) anthracene	Anthracene	Chrysene	PAHs	Benzene
Nyack Marina (Mile 28)	87.5	2.8	96	0.51	12	-	-	-	-	-
Shattemuc YC (Mile 32)	7.8	1.0	6.9	nd <0.04	43	-	-	-	-	-
Cortlandt YC (Mile 40)	15.6	0.4	2.48	0.52	-	-	0.39	-	1.67	-
Cornwall YC (Mile 57)	89.5	0.011	0.11	0.005	-	-	0.39	-	1.67	-
Chelsea Pump Sta. (Mile 65)	21.7	1.2	16.4	0.071	-	-	-	-	-	-
Hyde Park Marina (Mile 78)	86	0.4	0.78	nd <0.04	-	-	-	-	-	-
Norrie Point Marina (Mile 78)	86	0.4	0.78	nd <0.04	-	0.017	-	-	-	-
Anchorage Marina (Mile 91)	6.2	0.62	2.5	nd <0.004	-	-	-	-	-	-
Athens Ferry Slip (Mile 118)	120	2.52	212	1.74	1.25	2	-	2.39	-	2
Ravena-Coeymans YC (Mile 133)	46.8	1.11	45.6	-	4.96	-	-	-	-	-
National Gypsum (Mile 143)	46.8	1.11	45.6	nd (<0.25)	-	-	-	-	-	-

The issue of PCB- and other contaminated-sediment with respect to oil spill cleanup operations does not appear in the ACP at this time and there is no known guidance on this. However, it is conceivably an issue that might need to be addressed during the response to a large spill with extensive oiling. In this case, NYSDEC and USACE permits would be required. As part of that, chemical sampling protocols developed by NYSDEC may have to be implemented. There may also be a permitting process involved (Figure 25).

According to NYSDEC, in cases where sediments to be dredged consist primarily of sand and gravel, requirements for chemical testing may be waived. In such cases, applicants should submit results of testing for particle size analysis and total organic carbon. In general, chemical analysis will not be required for samples which contain less than 10% of particles passing the number 200 sieve and less than 0.5% total organic carbon.[65]

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[62] Holochuck 2005.
[63] Different sampling programs have yielded differing results. The maximum values are presented here (Holochuck 2005).
[64] nd = not detected.
[65] Holochuck 2005.

Figure 25: Dredging Permit Process in New York State[66]

[66] From Holochuck 2005 (Adapted from information presented by the American Heritage Rivers Initiative program in November 2004).

Filing Oil Spill Claims

When an oil spill occurs, there will inevitably be claims filed by various entities that have experienced damages caused by the spill. The National Pollution Funds Center (NPFC), managed by the US Coast Guard,[67] provides information for potential claimants. The types of claims authorized by OPA90 that would potentially be eligible for filing on the NPFC website are shown below in Table 13**.**

Table 13: Types of Claims Authorized by OPA90[68]

Claim Type	Description	Who Can Submit
Natural Resource Damages (NRD)	Costs for: • Assessing area's natural resource damages, • Restoring natural resources, and • Compensating public for lost use of the affected resources.	Only specially designated natural resource trustees
Removal Costs	Costs to prevent, minimize, mitigate, or clean up oil spill. (Costs of cleaning up property fall under the category of property damage, not removal costs.)	Cleanup contractors or OSROs; Federal, State, and local government entities; RP; anyone who helped clean up the spill
Property Damage	Injury to or economic loss resulting from destruction of real property (land or buildings) or other personal property. Does not include personal injury.	People or entities who own or lease the damaged property
Responsible Party: Affirmative Defense or Limit of Liability Defense	• Affirmative Defense is assertion that RP is not cause of incident due to one of three factors: Act of God, Act of War, or Sole cause of Third Party • Limit of Liability Defense is asserting RP has exceeded their Limit of Liability as defined on their COFR.	Owner or Operator responsible for the pollution incident
Loss of Profits & Earning Capacity	Damages equal to loss of profits or impairment of earning capacity due to injury, destruction, or loss of property or natural resources	Anyone with loss of profits or income. (One does not have to own damaged property or resources to submit claim under this category.)
Loss of Subsistence Use of Natural Resources	Loss of subsistence use claim if natural resources parties depend on for subsistence use purposes have been injured, destroyed, or lost by oil spill incident.	Anyone who, for subsistence use, depends on natural resources that have been injured, destroyed, or lost (One does not have to own damaged property or resources to submit claim under this category.)
Loss of Government Revenue	Net loss of taxes, royalties, rents, fees, or net profit shares due to the injury, destruction, or loss of real property, personal property, or natural resources	Federal agencies; States; local governments
Increased Public Services	Net costs of providing increased or additional public services during or after removal activities, including protection from fire, safety, or health hazards, caused by discharge of oil or directly attributable to response to oil spill incident	States; local governments

The National Pollution Fund Center, which administers the Oil Spill Liability Trust Fund (OSLTF), receives its revenues from:[69]

67 https://www.uscg.mil/Mariners/National-Pollution-Funds-Center/Claims/
68 Source: National Pollution Funds Center (https://www.uscg.mil/Mariners/National-Pollution-Funds-Center/)

- **Barrel Tax:** The largest source of revenue has been a per-barrel excise tax, collected from the oil industry on petroleum produced in or imported to the United States. The original 5-cent-per-barrel tax expired at the end of 1994 because of the sunset provision in the law. The 2005 Energy Policy Act again reinstated the tax (effective April 2006). The Energy Improvement and Extension Act of 2008 extended the per-barrel excise tax through December 2017 and increased the per-barrel excise tax from 5 cents to 8 cents from 2009-2016 and to 9 cents in 2017.
- **Transfers:** A second major source of revenue has been transfers from other existing pollution funds listed above. Total transfers into the Fund since 1990 have exceeded $550 million. No additional funds remain to be transferred to the OSLTF.
- **Interest:** A recurring source of OSLTF revenue is the interest on the Fund principal from US Treasury investments. As a result of historically low interest rates, interest income declined in 2003 and 2004, but has rebounded in recent years as Treasury rates have risen with the economic recovery. The Department of the Treasury serves as the OSLTF's investment manager.
- **Cost Recoveries:** Another source is cost recoveries from responsible parties (RPs); those responsible for oil incidents are liable for costs and damages. NPFC bills RPs to recover costs expended by the Fund. As these monies are recovered, they are deposited into the Fund.
- **Penalties:** In addition to paying for cleanup costs, RPs may incur fines and civil penalties under OPA, the Federal Water Pollution Control Act, the Deepwater Port Act, and the Trans-Alaska Pipeline Authorization Act. Penalty deposits into the OSLTF are generally between $4 million and $7 million per year.

New York State also has an oil spill fund, the New York Environmental Protection and Spill Compensation Fund,[70] the purpose of which is to:

- Pay for the cleanup of petroleum spills;
- Pay damage claims to parties injured by a spill;
- Recover costs from parties responsible for spills; and
- Partner with municipalities to protect the environmental and revitalized communities.

The fund is financed by storage tank registration fees and license fees imposed on bbl of petroleum imported for use in New York. The Fund also obtains reimbursement of cleanup costs and damage claim payments from response parties. Most oil spills in New York are remediated, to some extent, by the party responsible for the spill. For many spills, however, the RP is unknown, or unwilling or unable to handle a cleanup. When this happens, the Fund must assume responsibility for the spill. This means that NYSDEC, as the Fund's technical arm, must undertake the cleanup at the Fund's expense. This mechanism allows for rapid, expert response that protects public health and environmental resources.

The New York State Oil Spill Fund:

- Finances cleanup and removal of petroleum contamination when a RP fails to do so;
- Reimburses eligible claims for losses suffered by victims of oil spills;

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[69] https://www.uscg.mil/Mariners/National-Pollution-Funds-Center/About_NPFC/OSLTF/
[70] www.osc.state.ny.us

- Works closely with DEC to clean up oil spills;
- Works closely with the Office of the Attorney General to recover monies spent on oil spills;
- Accounts for the State's oil-spill-related revenues and expenditures;
- Acts as liaison among program stakeholders, including the regulated community, responsible parties, municipalities, environmental groups, members of the Legislature, spill victims, and other governmental agencies;
- Places liens on properties that are sites of oil spills when the owners are responsible parties and fail to pay for cleanup;
- Assures equitable settlement of cost recovery cases and consistent prosecution of all cases;
- Safeguards petroleum registration and license fees and surcharges, and assures that they are used appropriately;
- Assures the independence of judgment and obligation to protect public monies inherent in the Office of the State Comptroller;
- Requires thorough investigations and cleanups based on factual, technical information from DEC program staff, thus protecting victims of spills, public health and the environment;
- Maintains the financial integrity and independence of the Oil Spill Fund; and
- Reviews brownfield applications for spill sites under redevelopment.

Oil Types in Modeled HROSRA Scenarios: Bakken Crude[71]

Bakken oil has been transported by tank vessel on the Hudson River and railcar along the river. This oil type is applied in the HROSRA modeled hypothetical spill scenarios from tank vessels at the Port of Albany and off Rondout Creek, as well as crude-by-rail (CBR) scenarios at the Newburgh Waterfront and Iona Island. The volatility of this type of oil creates specific challenges for spill response. *Additional information on the propensity for fires and explosions are presented in HROSRA Volume 5.*

Properties of Bakken Crude Oil[72]

In general, Bakken crude oil presents the same physical properties as light Group II oils or other fuels. It will float on water, as its specific gravity is less than 1, and it is considered moderately volatile. This type of crude oil will contain higher concentrations of light end petroleum hydrocarbons (such as methane, ethane, propane, and butane). These dissolved gases and lighter ends will:

- Increase the vapor pressure;
- Lower the flashpoint; and
- Lower the initial boiling point.

While Bakken oil is generally considered to be a type of "sweet" crude,[73] there may be instances where hydrogen sulfide (H_2S) may be present in higher concentrations than may be expected.

Emergency responders should remember that light sweet crude oil, such as that coming from the Bakken region, is typically assigned a packing group (PG) I or II.

The PGs mean that the material's flashpoint is below 73° F and, for PG I materials, the boiling point is below 95° F. This means the materials pose significant fire risk if released from the package in an accident.

Typical Bakken crude oil properties (@ 60° F) are:

- Specific Gravity 0.7 – 0.8: floats on water
- Vapor Density 2.5 – 5.0: heavier than air
- Vapor Pressure, 280-360 mmHg: moderate volatility

Bakken flammability characteristics are:

- NFPA Flammability = 3-4
- Sensitive to static discharge
- Explosive Limits variable: LEL 0.4%; UEL 15.0%
- Flash point: - 40° to 212° F (- 74° to 122°F: AFPM data)

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[71] Source: much of the information contained in this section has been derived from MASSDEP 2015, NW Area Committee, 2015, and DOT 2016.
[72] Bakken crude is a type of shale oil. Another type of shale oil is light tight oil.
[73] "Sweet" crude oil is a type of petroleum that contains mall amounts of hydrogen sulfide (less than 0.42%) and carbon dioxide. When crude oil contains more than 0.5% sulfur, it is considered to be "sour."

Emergency personnel need to be aware of the chemical and physical characteristics as well as the health and safety issues associated with a Bakken oil spill/fire explosion response, are more volatile than other crude oils because of dissolved gases and other petroleum hydrocarbon light ends and may contain hydrogen sulfide in high concentrations.

Because of the presence of up to 30% (by volume) light volatiles in Bakken crude oil, the potential for fire and explosion is the single largest risk to responder and public health regarding this type of oil. Accordingly, extreme caution should be exercised during the initial stages of response.

Responders should refer to the general response guidelines in the most recent edition of the Emergency Response Guidebook prepared by the United States Department of Transportation –Pipeline and Hazardous Materials Safety Administration and Transport Canada.

Fate and Effect of Bakken Crude Oils

Crude oil is not a single chemical; rather it is a complex combination of hydrocarbons and other compounds, with the composition varying significantly between crude oil produced from different geographic regions. Even within individual regions or geological formations, the composition can vary with location and over time. Hydrocarbons are the most abundant compounds found in crude oil. Similar hydrocarbons and other constituents such as hydrogen sulfide are present in all crude oil although their proportions vary depending on the crude source. As a result, the physical and chemical properties of crude oil can also vary. The fate and transport of crude oil components through the environment is reflective of the variation in the crude oil composition and physical/chemical properties, which are directly related to the carbon range (number of carbon atoms) and therefore the molecular weight of the various components. The carbon range and the molecular weight affect the volatility, water solubility and viscosity of various crude oil components which in turn control the fate and transport of crude oil in the environment.[74]

In evaluating the potential effect of a crude oil release to the environment following an accident, it is essential to take into account the pathways that crude could travel from the point of release. The major migration pathways include the following:

- Evaporation, volatilization and dispersion into air;
- Infiltration into soil in immediate vicinity of the release;
- Direct surface release or overland runoff from release location to streams, rivers, lakes, coastal water areas, outer harbors, open water, ditches, wetlands and storm/ sanitary sewers;
- Transport in groundwater, after leaching through soil saturated with crude oil; and
- Natural dispersion and dissolution into the water column of waterbodies.

Crude oil mass and concentrations of its individual components are expected to reduce over time and with distance from the release location at rates that depend upon the migration pathway, as well as the environmental characteristics such as temperature, soil type and flow rate. In some circumstances, especially where large volume releases create pools of crude oil on soil surface, components of crude oil may leach into the underlying groundwater over a time period of several days to months. A plume of

[74] American Petroleum Institute 2011.

water soluble crude oil components will then be generated in the groundwater near the release site and will migrate in the direction of groundwater flow.

If large volume releases occur into water, crude oils will typically float to the water surface as their specific gravity is less than 1. After floating on the water surface for some of time, some components of crude oil will evaporate, dissolve, photo-oxidize, biodegrade and eventually some components may naturally disperse into the water column and descend to the bottom of the water body and become adsorbed into sediments. The migration pathways for crude oil depend to a large extent on the physical properties of the crude oil components, primarily molecular weight.

On-Water Spills of Bakken Crude

In general, crude oil floats on water until oil densities change through weathering and/or sediment uptake. Crude oil may gradually over-wash, become suspended in the water column, or sink depending on the degree of weathering and formation of oil-mineral aggregates.

The strategy for cleaning up a spill in water bodies begins with localizing the spill, using a variety of boom strategies. Booms can be used in several ways: a containment strategy keeps the oil from spreading; collection holds the oil near the source; deflection steers the oil towards collection areas and away from sensitive areas; and protection creates barriers that keep oil from affecting sensitive areas. Booms work best in calm waters and this effectiveness decreases as wave heights and currents increase.

Cleanup tools include skimmers, sorbents, and chemical dispersants. Skimmers are mechanical devices that physically remove the oil from the surface of the water. Sorbents, available as pads, pillows, or booms, remove oil sheens and thin slicks that are too scattered for skimming.

Barriers are commonly used to mechanically impede oil spreading and movement. Booms, dams, and weirs are used to contain and concentrate oil on water. Containment challenges with booms include flow relative to the boom (current or towing speeds), turbulence, wave action, oil load in boom, and oil density relative to water.

An underflow dam of gravel and earth or traditional materials for adjustable underflow dams should be considered for use in shallow waters, narrow waterways, calm waters, or low-flow conditions. Contained oil can be recovered with vacuum trucks, skimmers, dredging and other traditional oil recovery techniques.

As oil becomes entrained into the water column, either through turbulence or combination of flow and densities near those of the receiving water body, conventional surface booming becomes less effective. Conventional booms may be effective in containing oil that has only slightly submerged below the immediate surface, but other methods such as trawl nets specifically designed to recover heavy oil may become necessary.

Responders need to prepare for both a light, floating oil and the potential for a heavy, submerged or sinking oil. In addition, material that initially floats will lose light hydrocarbons to evaporation and mix with fine sediments and may eventually move into the water column and sink to the bottom at natural collection points. The ability to detect, monitor, contain, and recover submerged or sunken oil is limited.

Research and development is ongoing to design equipment for responding to sinking or submerged oil spills.

In fast moving water, recovering oil is more difficult as oil tends to entrain in the water column. Oil will flow under containment booms and reduce the efficiencies of most conventional oil recovery equipment. Installing underflow dams, overflow dams, sorbent barriers, or a combination of these techniques will often increase recovery efficiencies.

High wind or turbulent conditions also present challenges so sufficient length and size of containment booms should be fully considered to contain the oil. Bakken crude oil has a low viscosity, and will quickly spread and evaporate. It will also adhere to suspended solids in the water column. Recoverable product may persist for only 4 to 8 hours, depending on size of spill. Its lighter components volatilize, posing human health hazard near spill location, and the low molecular weight PAHs dissolve in the water column potentially causing toxic aquatic effects.

Shoreline Effects from Bakken Crude

Oil spill cleanup operations may cause more harm to a fragile coastal marsh environment than the oil itself. One of the major fates of spilled petroleum in the coastal environment is its incorporation into the sediments.

Treatment options for shoreline cleanup vary for shoreline types and as a function of oil type. For example, low pressure flushing may be an applicable treatment technique for medium oil on coarse and sand-mixed substrate; however, the technique may be ineffective for heavy oil. Treatment tactics for shoreline cleanup include natural recovery, washing recovery, manual removal, mechanical removal, in-situ mixing relocation, in-situ burning, and bio-remediation. Shoreline effects are less likely where current or flow transport the material away from the shoreline. Effects are more likely in calm waters. Chemical shoreline cleaners are available to treat oil that has adhered to the shoreline. Appropriate regulatory approval is necessary prior to application of these techniques.

Bakken Spill Event Response Actions

Response actions First Responders should consider implementing during the initial phase of the emergency response should include the following:

- Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Isolate the area and consider evacuation, if necessary.
- All equipment used when handling the product must be grounded.
- Determine the concentrations of any flammable or toxic vapors using air monitoring instruments.
- Evaluate the need for continuous air monitoring with technical specialists.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- Prevent entry into waterways, sewers, basements or confined areas.
- A vapor suppressing foam may be used to reduce vapors. Determine if adequate foam supplies and equipment available for vapor suppression.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.

- Use clean non-sparking tools to collect absorbed material.
- Large Spill: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor; but may not prevent ignition in closed spaces.

Bakken Fire-Explosion Event Actions

Flammability is the greatest hazard associated with crude oil in a spill incident, particularly in a rail incident. The flash point of crude oil is variable, but generally ranges from -59° C to 50° C for Bakken crude. Because of its flammable nature, the crude may ignite resulting in explosions, fireballs, and pool fires. Long duration fires involving crude stored in tanks may result in a boil over, in which the contents of the tank may be expelled beyond the container or containment area

Bakken crude floats on water and can be reignited on surface water. Explosion may occur following a major tank rupture, spilling fuel which vaporizes, contacts an ignition source, and explodes and also rapidly burns in a fireball. The pressure safety valve may or may not be able to vent the increase in pressure fast enough, resulting in tank failure, fireball, and a partial explosion.

Due to the flammability of Bakken crude, the elimination of sources of ignition (e.g., static electricity, pilot lights, mechanical/electrical equipment, and electronic devices) and the use of explosion-proof electrical equipment is recommended and may be required depending on the relevant fire codes. Explosive hazards can occur in tanks in a spill situation. In addition, spilled material entering low-lying areas, sewers, storm drains, or other confined areas have the potential for the creation of explosive conditions.

Summary of Bakken Crude Issues of Concern[75]

- HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames.
- Vapors may form explosive mixtures with air.
- Vapors may travel to source of ignition and flash back.
- Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Vapor explosion hazard indoors, outdoors or in sewers.
- Those substances designated with a (P) may polymerize explosively when heated or involved in a fire.
- Runoff to sewer may create fire or explosion hazard.
- Containers may explode when heated.
- Many liquids are lighter than water.
- Substance may be transported hot.

Fire Emergency Response

The Emergency Response Guidebook is primarily a guide to aid first responders in quickly identifying the specific or generic hazards of the material(s) involved in the incident, and protecting themselves and the general public during the initial response phase of the incident. It is published by the Department of Transportation (DOT).

[75] Source: DOT 2016.

For crude oil assigned to NA 1267 Petroleum crude oil, irrespective of Packing Group, Guide No. 128 of the most recent edition of the Emergency Response Guidebook (ERG) provides a first responder with instructions on what steps to take upon arrival at the scene of an accident or incident:

- CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient.
- CAUTION: For mixtures containing alcohol or polar solvent, alcohol-resistant foam may be more effective.
- Small Fire
    - Dry chemical, CO2, water spray or regular firefighting foam.
- Large Fire
    - Water spray, fog or regular firefighting foam.
    - Do not use straight streams.
    - Move containers from fire area if you can do it without risk.
- Fire involving Tanks or Car/Trailer Loads
    - Withdraw from the area and let fire burn if proper equipment is not available
    - Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Utilize water spray, fog, or regular foam. Do not use straight streams. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
    - Cool containers with flooding quantities of water until well after fire is out to prevent re-ignition and explosion of heated containers.
    - Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
    - ALWAYS stay away from tanks engulfed in fire.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

In the event of a derailment scenario with a spill and fire, confinement and containment operations (i.e., spill control) are a priority. Traditional firefighting strategies and tactics may not be effective in these situations. If fire suppression operations are initiated, responders need sufficient foam concentrate supplies, adequate water supply, foam appliances, equipment, and properly trained personnel to effectively implement and sustain fire suppression and post-fire suppression operations. The strategy that provides the highest level of safety to responders is defensive to protect exposures or non-intervention tactics which allow the fires to burn out. The decision to protect exposures and let the product burn must be considered. Major fires may require withdrawal, allowing the tank to burn.

Burning railcars containing crude oil and adjacent cars should be cooled at the vapor space with unmanned hose lines to prevent heat induced tears and further minimize personnel exposure. Use water fog spray to cool containers, control vapors, and to protect personnel from exposures. There is potential that containers of liquid that are not properly cooled may rupture violently if exposed to fire or excessive heat. Isolate the ends of tank(s) involved in fire, but realize that shrapnel from exploding containers may travel in any direction and the tank may rupture at any point in the structure.

Apply Class B firefighting foam as you would on fires involving other hydrocarbons. Alcohol Resistant AFFF, as well as regular AFFF will effectively extinguish a fire. Class B foam blankets prevent vapor production and ignition of flammable and combustible liquids. Foam is most effective on static fires that are contained in some manner. Firefighting foam is not effective on hydrocarbon fuels in motion (i.e., three dimensional fires) that include product leaking or spraying from manways, valves, fractures in the tank shell (e.g., rips, tears, etc.) or spills on sloping terrain.

As a general rule, do not flush crude oil spills with water. Most crude oil spills are not water soluble and will have a tendency to float on water. Some crude oil will sink and some fractions of crude oil are water soluble. For those fractions that float on water, burning crude oil may be carried on flowing water from the immediate area and may reignite away from the immediate source area.

New York State Homeland Security and Emergency Services guidance on fire prevention and control of rail car fires involving crude oil dated April 22, 2015, contains the following advisement:

If SPILL but NO fire:

- SMALL Spill: Isolate 150 ft. in all directions.
- LARGE Spill: Also evacuate 1,000 ft. downwind.

Secure potential ignition sources; use air monitoring; apply foam for vapor suppression; and begin spill confinement operations (diking, damming and boom deployment) to limit spread of spilled product. (See FIRE SUPPRESSION for foam and air monitoring guidance).

If FIRE: Isolate ½ MILE in all directions and shelter downwind.

EXTINGUISH vs. LET IT BURN: Do you need to extinguish the fire?

- Evaluate life hazard, property/critical infrastructure at risk and environmental effect (in that order).
- If a life hazard exists: Focus available foam operations or use water fog patterns on oil fires to protect rescue operations. Conduct structural firefighting as necessary and from uphill and upwind if possible. Beware of any running spill or spill fed fire which may cut off routes to safe zones. Consider defensive operations once life hazard is addressed.
- If NO life hazard and more than 3 tank cars are involved in fire OFPC recommends LETTING THE FIRE BURN unless the foam and water supply required to control is available (See FIRE SUPPRESSION). Withdraw and protect exposures, including cooling exposed tank cars with unmanned monitors if possible (See FIRE SUPPRESSION).
- If 3 tank cars or fewer are involved, do you need to extinguish the fire? (Evaluate hazard to property and environment.)
- If YES, are foam and water resources available to extinguish the fire? (See FIRE SUPPRESSION)

Fire Suppression

Estimate the foam and water requirements for vapor suppression, extinguishment and post fire security. OFPC estimates for crude oil rail scenarios are listed below. These estimates are based upon applying Class B foam at 3% concentration and can be adjusted as needed. Polar solvents such as Ethanol may require greater amounts of foam and water and higher application rates (0.2gpm/ft²).

- 1 tank car on fire = 600 gallons of foam concentrate; apply solution at a target rate of 660 gallons per minute (gpm) for 15 minutes; and reapply as necessary to maintain foam blanket;

  Total water supply required = (+/-) 38,000 gallons for foam and cooling water.

  NOTE: Stream reach for single 600 gpm foam nozzle = 150 feet max

- 3 tank cars on fire = 1,500 gallons of foam concentrate; apply solution at a target rate of 1,680 gpm for 15 minutes; and reapply as necessary to maintain foam blanket;

  Total water supply required = (+/-) 80,000 gallons for foam and cooling water.

  NOTE: Stream reach for single 1000 gpm foam nozzle= 200 feet max

- Use cooling water on exposed and involved cars; minimum rate = 200 gpm applied to the exterior of the vapor space of each car during extinguishment and maintain for 30 minutes thereafter. Note water application may interfere with the foam blanket. Continue to re-apply foam as needed to maintain post-fire security (vapor suppression).
- ALL RESOURCES MUST BE AVAILABLE PRIOR TO BEGINNING SUPPRESSION (FOAM OPS)
- USE AIR MONITORING. Withdraw at 10% LEL (Combustible Gas Indicator).

The following information is provided to assist with determining pump discharge pressures needed to provide required inlet pressure at foam master stream appliances:

- Friction loss for 4" LDH at flows noted above: 7 psi/100' at 600 gpm; 19 psi/100' at 1000 gpm.
- Friction loss for 5" LDH at flows noted above: 3 psi/100' at 600 gpm; 7 psi/100' at 1000 gpm.

To determine Foam requirements for a specific crude oil surface spill use the following formula:

Spill Area (ft²) X Application Rate (0.10 gpm/ft²)= GPM Foam Solution x 15 mins.

NOTE: Large storage tank fires require higher application rates for longer duration.

Air Monitoring[76]

- All personnel inside exclusion zone should wear structural PPE and SCBA.

[76] Note: These action levels are intended to provide basic, quick reference guidance for the initial phase of emergency operations. As any crude oil release will likely include other hazards detailed guidance should be obtained and a complete air monitoring plan implemented.

- Air monitoring should be conducted to protect personnel operating within the exclusion zone and to verify isolation and protective action distances established are effective.
- Lower Explosive Limit (LEL) at or above 10% = WITHDRAW FROM AREA.

For unprotected personnel:

- Photoionization Detector (PID) reading above 10ppm = withdraw or don SCBA and PPE.
- Hydrogen Sulfide (H2S) reading above 10ppm = withdraw or don SCBA and PPE.
- Oxygen (O2) reading below 20.8% = withdraw or don SCBA and PPE.
- Colorimetric tube for benzene (if available): any color change = withdraw or don SCBA and PPE.

In addition to the half-mile isolation distance, evacuate the public downwind in areas affected by smoke and particulates.

Health & Safety Issues with Bakken Crude

The potential human exposure pathways during spill situations depend on the nature of the spill. In general, given the volatile nature of Bakken crude and other light crudes, inhalation exposures are the most likely exposure scenarios for both first responders and nearby workers or residents.

Skin contact (dermal exposure) is possible, but unlikely, since responders should be wearing appropriate protective clothing. If a fire occurs following a spill or release, burning can result in inhalation exposures to smoke particles and VOCs in the immediate proximity of the spill, but also at some distance. Ingestion exposure is also unlikely, although if the spill reaches surface water, components of crude oil will dissolve, and could affect a drinking water source. Water supply intakes have been shut down during several incidents. In addition, contact could occur as a result of other uses of surface water, such as swimming or boating, or use for cooling or production water.

Crude oil has been found to have a relatively low acute toxicity. Fresh or weathered crude can cause skin irritation and other irritant reactions in response workers, although these effects may be a result of repeat exposure.

Crude oil ingestion in small quantities may result in nausea, vomiting, and diarrhea. Vomiting and subsequent aspiration of hydrocarbons can result in significant lung injury.

Acute effects in exposure related to oil spill effects include respiratory, eye, and skin symptoms, headache, nausea, dizziness, and fatigue

Exposed residents in proximity to an oil spill may show acute symptoms such as headache, throat irritation and itchy eyes.

In summary, for Bakken crude:

- Inhalation or contact with material may irritate or burn skin and eyes.
- Fire may produce irritating, corrosive and/or toxic gases.
- Vapors may cause dizziness or suffocation.
- Runoff from fire control or dilution water may cause pollution.

- CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.
- As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate closed spaces before entering.

Protective Clothing

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.

Evacuation

- Large Spill: Consider initial downwind evacuation for at least 300 meters (1000 feet).
- Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

Response Considerations-Monitoring Equipment

For Spill:

- 4 or 5 gas monitors for O2, LEL, H_2S
- PID/FID for VOCs (FIDs may be more sensitive)
- Chemical -specific monitors for benzene
- Colorimetric tubes
- PID with benzene tube

Additionally, for fire:

- Particulate monitors for Polynuclear Aromatic Hydrocarbons (PAHs)[77] sampling
- Monitors or sampling equipment for particulates (smoke)

Response Considerations-Safety

- Air monitoring – Spill: O_2, Explosive Levels – LEL/UEL, H_2S, benzene, and organic vapors (VOCs)
- Air monitoring – Fire: O_2, CO, Explosive Levels – LEL/UEL, benzene, and organic vapors (VOCs),
- Sulfur and nitrogen oxides and particulates – smoke

[77] PAHs are also referred to as: polycyclic aromatic hydrocarbons.

Example of Bakken Crude Spill: Barge E2MS 303 (Mississippi River 2014)

This incident was the result of a boat-barge collision on the Mississippi River at River Mile Marker 154, on February 22, 2014 (Figure 26 and Figure 27). The collision resulted in a gash in one of the barge tanks at the waterline and 750 – 800 bbl (31,500-33,600 gallons) of Bakken crude was released. This incident was the first known instance of large-scale release of Bakken crude in a navigable waterway.

Figure 26: Barge E2MS 303 Leaking 750 bbl Bakken Crude into Lower Mississippi River[78]

The final USCG report on the Barge E2MS 303 stated that Unified Command stood down on Day 8. The total oil recovered was 95 gallons/2.3 bbl out of an estimated 750-800 bbl/31,500-333,600 gallons lost. There were no reports of oiled wildlife or fish kills, no shoreline clean up measures required other than in immediate vicinity of spill, reports of high concentrations of benzene vapors during lightering operations and 65 mile closure of the Lower Mississippi River for two days.

According to NOAA,[79] it was determined that this Bakken crude oil had a low viscosity, and quickly spread and evaporated. The oil quickly adhered to suspended solids in the water column, forming unstable emulsions and the oil contained a high level of alkanes in the nC-10 to nC-18 range (which volatilize), and high levels of PAHs in naphthalene to phenanthrene range (which can dissolve in the water column). NOAA stated that the product spread and evaporated quickly, thus recoverable product persisted for only 4-8 hours, though this would depend upon the size of the spill. High evaporation rate and low LEL pose hazards for source control responders and the public near spill location which means that air monitoring and ignition source control are critical. Low molecular weight PAH may dissolve in water column, causing toxic effects and the absence of shoreline effect in this spill related to river flow, shoreline effects would be more likely in calm waters.

[78] Source: US Coast Guard.

[79] Doelling et al. 2014.

Figure 27: Sheen Visible at Water's Edge (Barge E2MS 303 Spill)[80]

Example of Bakken Crude Spill: Aliceville, Alabama Train Derailment

On November 08, 2013, after a crude-by-rail train derailment near Aliceville, Alabama, several oil tank cars burst into flames and burned for many hours. Twenty-five of the train's 90 cars derailed near a 60-foot-long wooden trestle, and a number were still on fire 18 hours later, operator Genesee & Wyoming Inc. said. They were sending flames hundreds of feet high that could be seen from over ten miles away. A local official said the crude oil had originated in North Dakota, home of the booming Bakken shale patch. If so, it may have been carrying the same type of light crude oil that was on a Canadian train that derailed in the Quebec town of Lac-Mégantic this summer, killing 47 people. The train was hauling 90 DOT-108 tank cars, a different model than the DOT-111s that had been cited before. Each carried 30,000 gallons (114,000 liters) of crude, or 64,000 bbl in all.

Figure 28: Oil-Soaked Wetlands in Aliceville, Alabama Bakken Crude Spill[81]

[80] Note contaminated debris. Source: US Coast Guard.

[81] Photo by John Wathen, Hurricane Creekkeeper

Example of Bakken Crude Spill: Lynchburg, Virginia Train Derailment

The CSX train that derailed and erupted in flames in Lynchburg, Virginia, in April 2014, was carrying crude oil from the Bakken shale in North Dakota, the kind of oil involved in several other fiery derailments in the months prior to this accident. Some 15 cars derailed, several of which erupted in flames. Three tumbled down an embankment into the James River. No one was hurt in the accident. State emergency managers estimated that a total of 30,000 gallons of crude oil had leaked into the river, creating a sheen up to 9 miles long, according to the Virginia Department of Environmental Quality. Most of the slick has been contained by booms and some of the oil has burned off, he said. Drinking water was not affected.[82]

Federal investigators came to a different conclusion in Operation Classification,[83] a Pipeline and Hazardous Materials Safety Administration (PHMSA) and Federal Railroad Administration (FRA) report issued with the proposed rule-making, which would create a new program for sampling, testing and classifying the oil. Bakken crude oil is classified properly under the current system, the report said. It stated that Bakken crude "has a higher gas content, higher vapor pressure, lower flash point and boiling point and thus a higher degree of volatility than most other crudes in the US, which correlates to increased ignitability and flammability."

The 2014 report was based on a joint investigation by the PHMSA and FRA that took 135 samples of oil in the Bakken region from August 2013 through May, including four from a Plains facility in Ross, North Dakota. The four Plains samples, including the one taken the day of the Lynchburg accident, met the classification for Packing Group 1, the most hazardous of three categories of Class 3 flammable liquids, federal regulators said. The sample taken in April 2014 contained 4.4% butane and smaller amounts of other volatile gases.

Federal tests showed the North Dakota oil was highly flammable and belonged in the most hazardous category of flammable liquids under federal regulations. The crude oil shipments travel through some of the most highly populated, historic and environmentally sensitive areas of Virginia, including the heart of downtown Richmond along the James River.

The oil trains pose a significant challenge to local fire and emergency professionals who would respond to a wreck potentially involving multiple tanker cars along a 400-mile route through Virginia that passes directly through Richmond, as well as Covington, Clifton Forge, Lynchburg and Williamsburg.

According to the Assistant Chesterfield County Chief of Fire and Emergency Services, "It's either going to be a really big spill or a really big fire." The flammability of the oil is magnified by the sheer volume passing by rail through central Virginia four to six times a week on its way from the Bakken shale fields of North Dakota to a Yorktown terminal owned by Plains on the York River. The terminal ultimately could handle 800 trains a year, or two a day, with each "unit train" carrying more than 100 rail cars of oil.

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[82] Martz 2014.
[83] https://www.phmsa.dot.gov/safe-transportation-energy-products/operator-classification ; https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/07_23_14_Operation_Safe_Delivery_Report_final_clean.pdf

Figure 29: Burning Cars from Train Derailment Lynchburg, Virginia (James River)[84]

Figure 30: Removal of Damaged Tanker Cars in Lynchburg, Virginia (James River)[85]

[84] Photo by Paula Mays.

[85] Photo: Steve Helber/AP

Oil Types in Modeled HROSRA Scenarios: Home Heating Oil & Diesel

The Army Corps of Engineers Waterborne Commerce Statistics combines heating oil and diesel oil as Distillate Fuel Oil. In 2016, the Corps data shows that 1,223,000 tons of distillate fuel oil was transported on the Hudson River by tank vessel. In the HROSRA, hypothetical scenarios involving home heating oil spills from tank vessels were modeled for Coxsackie, the proposed Kingston Anchorage, Bear Mountain Bridge, and Tappan Zee.

Properties of Home Heating Oil and Diesel

Heating oil and diesel are distillates and have similar characteristics.[86] There are two significant distinctions between these types of oils. No. 2 oil is stained with a reddish dye and No. 2 diesel has road taxes tacked onto its price. Diesel fuel is structurally comparable to oils commonly used in heating buildings, which includes No. 2 oil. These fuels all share similar molecular structures and they are made up of elaborate combinations of aromatic and aliphatic hydrocarbon molecules. As much as 90% of these molecules consist of hydrogen-soaked paraffins and naphthenes, while 10 to 20% are aromatics and 1% are alkenes. While they are used for two completely different purposes, home heating fuel oil No. 2 and diesel No. 2 are very similar and, in some cases, can be interchanged. But while diesel fuel is relatively consistent, home heating fuel can vary from region to region and from winter to summer.

Diesel oil has a very low viscosity and is readily dispersed into the water column when winds reach 10 knots or with breaking waves. Diesel oil is much lighter than water (specific gravity is between 0.83 and 0.88, compared to 1.03 for seawater). It is not possible for this oil to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment. However, it is possible for the diesel oil that is dispersed by wave action to form droplets that are small enough be kept in suspension and moved by the currents.

Oil dispersed in the water column can adhere to fine-grained suspended sediments (adsorption) which then settle out and get deposited on the seafloor. This process is more likely to occur in rivers such as the Hudson with high sediment loads and near river mouths where fine-grained sediments are carried in by rivers. It is less likely to occur in open marine settings. This process is not likely to result in measurable sediment contamination for small spills.

Diesel oil is not very sticky or viscous, compared to black oils. When small spills do strand on the shoreline, the oil tends to penetrate porous sediments quickly but also tend to be washed off quickly by waves and tidal flushing. Thus, shoreline cleanup is usually not needed. Diesel oil is readily and completely degraded by naturally occurring microbes, under time frames of one to two months.

Short-term hazards of the some of the lighter, more volatile and water soluble compounds (such as toluene, ethylbenzene, xylenes, and particularly PAHs) in heating oil no. 2 include potential acute toxicity to aquatic life in the water column (especially in relatively confined areas) as well as potential inhalation hazards. Heating oil no. 2 has moderate volatility and moderate solubility.

Heating oil no. 2 is a middle distillate petroleum hydrocarbon product of intermediate volatility and mobility. As an intermediate product, heating oil no. 2 has a combination of lighter, less persistent and

[86] These oils are also sometimes referred to as No. 2 fuel.

more mobile compounds as well as some heavier, more persistent and less mobile compounds. The relatively lighter, more volatile, mobile, and water soluble compounds in heating oil no. 2 will tend to evaporate fairly quickly into the atmosphere. When exposed to oxygen and sunlight, most of these compounds will tend to break down relatively quickly.[87]

Example of Heating Oil Spill: Barge North Cape 1999, Rhode Island

At 1430 Eastern Standard Time (EST) on January 19, 1996, MSO Providence received a call from Station Castle Hill that the tug Scandia was on fire. The tug Scandia was located some three miles south and west of Point Judith, Rhode Island towing the barge North Cape, which was carrying 94,000 bbl of #2 home heating fuel Weather was severe with sustained winds of more than 40 knots from the south-southeast and forecast to increase. The tug Scandia was abandoned and USCG Search and Rescue teams were dispatched to assist the crew. At approximately 2000 EST, a USCG helicopter reported that the barge North Cape was aground on Nebraska Shoals, directly adjacent to the Trustom Pond National Wildlife Refuge, owned and operated by the US Fish and Wildlife Service (USFWS). The helicopter further reported that the barge was releasing oil (Figure 31).

Figure 31: Barge North Cape and Tug Scandia[88]

The barge North Cape spilled oil in two separate releases. The first, released during the height of the initial storm, was 700,000 gallons and the second, less than a day later, was 125,000 gallons. The

[87] Irwin 2997.
[88] Photo Source: NOAA.

combination of the type of oil released and the energy of the storm caused great dispersion into the water column. As a result, in the days following the spill, great numbers of shellfish (mostly bivalves and juvenile lobsters) washed ashore.[89] Subsequently, the Rhode Island Department of Health closed more than 200 square miles of commercial fishery in the area of the spill. This closure was coordinated with the EPA Region One and with NOAA's National Marine Fisheries Service (NMFS), which closed federal fishing grounds using the Magnuson Act. This is the first time federal fisheries have been closed due to oil contamination.

The emergency phase of the response lasted seven days and the on-scene command post was demobilized following the removal of the barge North Cape from the beach. Active USCG spill response and assessment continued from the MSO, including re-survey of key impacted recreational and endangered piping plover nesting beaches. The full re-opening of the Rhode Island fishery was not complete until the middle of June. Organoleptic panels were established to certify that seafood, lobsters, and clams, in particular, were marketable.[90]

Example of Heating Oil Spill: Ashland Oil Tank 1999

On January 2, 1988, a tank containing 3.9 million gallons of diesel fuel instantaneously collapsed and discharged three quarters of a million gallons into the Monongahela River in Floreffe, Pennsylvania (Figure 32). The spill resulted in severe short-term environmental damage, the closing of a major inland port, and threatened the drinking water supplies of 500,000 people in Pennsylvania. With the deployment of over 20,000 feet of containment boom, eleven vacuum trucks, three cranes, and over 150 people, about 30% of the product which entered the river through a 24-inch pipe was collected. The Ashland tank failure would become one of the worst inland oil spills in the nation’s history.

Figure 32: Aerial Photo of Collapsed Ashland Oil Tank

The spill’s pollution of the Monongahela and Ohio rivers created an acute public safety emergency. Public water systems were shuttered and more than one million people in some 80 communities downstream in Pennsylvania, Ohio, and West Virginia were affected. Some towns were without regular water services for up to eight days. Thousands of birds and fish were killed.

[89] French McCay 2003.
[90] NOAA Incident News.

On the Monongahela, meanwhile, a giant oil slick soon moved down river, washing over two dam locks and dispersing throughout the width and depth of the river. The spill not only killed birds and fish and contaminated drinking water, but also damaged private property and adversely affected area businesses. The Coast Guard closed the Monongahela River to vessel traffic between the Ashland facility in West Elizabeth and Pittsburgh. The smell of diesel fuel could be detected as far south as Pittsburgh. Rail and motor vehicle traffic was halted along some routes near the river due to concerns about human health and fire hazards. As the diesel fuel entered the Monongahela River above Pittsburgh, at least five municipal water suppliers serving tens of thousands of residents were affected, closing their water intakes. Water conservation measures were put in place to conserve supplies; classes in some Pittsburgh schools were suspended, for example, to help conserve water. Still, some Pittsburgh residents went without normal water service from January 4 until January 12th. When the oil slick reached the junction of the Monongahela and Allegheny rivers – which together form the Ohio River which continues west and southwest – concentrations of diesel fuel remained high enough to warrant continuing concern for downriver users in the states of West Virginia and Ohio. In Steubenville, Ohio, for example, all nonessential businesses were closed with water service interrupted for three days.[91]

Figure 33: Cleanup Workers at Ashland Storage Yard in Aftermath of Tank Collapse [92]

By January 8, 1988, although icy water and stiff winds had slowed the flow of the slick, it reached Wheeling, West Virginia. In the days thereafter, it would continue flowing south-southwest down the Ohio River – though in more diluted form – to other large cities, including Louisville, Kentucky, Cincinnati, Ohio, and Evansville, Indiana (792 river miles downriver from Pittsburgh). Coast Guard and Oil Company cleanup of the spilled diesel fuel was hampered by the wintry weather, though some 2.98 million gallons were reported recovered. An estimated 510,000 gallons to 860,000 gallons of the diesel fuel were not recovered and remained in the rivers.[93]

[91] *Pittsburgh-Post Gazette* article.
[92] Photo: Darrell Sapp/*Pittsburgh Post-Gazette*.
[93] *Pittsburgh-Post Gazette* article.

Oil Types in Modeled HROSRA Scenarios: Heavy Fuel Oil/Bunkers

Heavy fuel oil is used in many cargo vessels as bunker fuel.[94] Heavy fuel oil is also burned at many facilities that generate power. For the HROSRA, one hypothetical scenario involving a heavy fuel oil spill was modeled off Rondout Creek. This scenario was part of a worst-case discharge scenario described in the Area Contingency Plan (ACP).

Properties of Heavy Fuel Oil

Heavy fuel oils are characterized by high specific gravity, typically in the range 0.92 - 1.02 g/cm≥, and by relatively high kinematic viscosities, in the range of 5,000 to 30,000 mPas @ 15° C. Some viscosities are higher still, which coupled with high pour points can render the oils solid at ambient sea temperature (10 - 25° C). These gross characteristics common to most heavy fuel oils belie their complexity and diversity.[95]

However, residual fuel oils such as intermediate (medium) and heavy fuel oils are more diverse. This is because such oils often consist of the viscous and tarry residues of crude oil refining with complex mixtures of heavy aliphatic and aromatic compounds, bitumens, and asphaltenes. Waxy residues from crude oil storage tank cleaning may also be added to the residues from crude refining. Such residues are then blended with light fuels or products to meet a viscosity specification suitable for the engines or burners for which the fuel is destined. Thus, the characteristics of a certain intermediate or heavy fuel oil will depend on the properties of the crude oil(s) from which the residue is derived, as well as the nature of any oils or other products blended in to allow the fuel to meet a particular specification for viscosity and flash point.

Unfortunately, the nomenclature used to describe fuel oils in different countries and within different parts of the oil and shipping industry can cause confusion. Fuel oils can be called variously: Bunker A, B, C; Fuel Oil No. 2, 4, 6; Intermediate Fuel Oil (IFO 180); or Heavy Fuel Oil (IFO 380). The relationship between different classifications is not always clear.

No. 6 fuel oil is a dense, viscous oil produced by blending heavy residual oils with a lighter oil (often No. 2 fuel oil) to meet specifications for viscosity and pour point. When spilled on water, No. 6 fuel usually spreads into thick, dark-colored slicks, which can contain large amounts of oil. The most viscous no. 6 oils will often break up into discrete patches and tarballs when spilled instead of forming slicks. Oil recovery by skimmers and vacuum pumps can be very effective when early in the spill. Very little of this viscous oil is likely to disperse into the water column.

Heavy fuel oils are generally less toxic than crude oils and many refined products, but pose a greater threat of physically contaminating marine life, including birds and marine mammals reliant on fur or feathers for insulation. It may be no coincidence that some of the greatest havoc in bird populations has been caused by spills of heavy fuel oil. The strong adhesive properties and the high persistence of heavy fuel oils are key factors. The cleanup and rehabilitation of oiled animals can present enormous logistic

[94] Regulations regarding air emissions in certain port areas restrict the burning of heavy fuel oils in favor of diesel fuel. However, most ocean-going vessels will burn heavy fuel oil at sea and will contain this type of fuel in their bunker tanks. This oil may spill in the event of an accident.

[95] Ansell et al. 2001.

problems, the successful resolution of which also depend on the resilience of the animals when held in captivity.

Fate and Effect

The characteristics of this product have important implications for the behavior of spilled heavy fuel oil in the marine environment. Because of their high viscosity and pour point, they are very viscous liquids or solids at low ambient temperatures, and difficult to pump. Their high specific gravity confers little buoyancy and heavy fuel oils are easily swamped by waves, especially in rough sea conditions when the oil is tumbling with the orbital motion of the waves rather than floating on the surface. Often there is little or no sheen emanating from the oil to act as a tell-tale sign for aerial observers.

It is difficult to assess the quantity of heavy fuel oil floating on or just below the water surface, because viscous heavy fuel oils tend not to spread into thin layers as much as crude oils (especially in cold climates) but instead remain in sharply-edged patches, the thickness of which is impossible to assess from the air.

No. 6 fuel oil is a persistent oil; only 5-10% is expected to evaporate within the first hours of a spill. Consequently, the oil can be carried hundreds of miles in the form of scattered tarballs by winds and currents. The tarballs will vary in diameter from several yards to a few inches and may be very difficult to detect visually or with remote sensing techniques.

The specific gravity of a particular No. 6 fuel oil can vary from 0.95 to greater than 1.03. Thus, spilled oil can float, suspend in the water column, or sink. Small changes in water density may dictate whether the oil will sink or float. Floating oil in a high sediment environment (rivers, beaches) could potentially sink once it picks up sediment, resulting in subsurface tarballs or tarmats. These oils can occasionally form an emulsion, but usually only slowly and after a period of days.

Shoreline Effect

Because of its high viscosity, beached oil tends to remain on the surface rather than penetrate sediments. Light accumulations usually form a "bathtub ring" at the high-tide line; heavy accumulations can pool on the beach. Shoreline cleanup can be very effective before the oil weathers and becomes very sticky and viscous.

The most important factors determining the effects of No. 6 fuel oil contamination on marshes are the extent of oiling on the vegetation and the degree of sediment contamination from the spill or disturbance from the cleanup. Many plants can survive partial oiling; fewer survive when all or most of the above-ground vegetation is coated with heavy oil. However, unless the substrate is heavily oiled, the roots often survive and the plants can re-grow.

When heavy fuel oil comes ashore there is a tendency for it to become firmly attached to any solid surfaces and to resist all but the most aggressive cleanup efforts. However, in cases where the oil has emulsified it has also been observed that the oil does not adhere to surfaces, particularly if they were wet beforehand. The cleanup techniques for heavy fuel oils on shorelines are generally the same as for other types of oil, especially when manual methods are used. Removal of heavy fuel oil from hard-packed sand beaches using non-specialized equipment and manual labor is normally straightforward. As with other types of oil, care needs to be taken so that excessive amounts of clean material are not removed and oil is not mixed into the beach substrate. One advantage of viscous heavy fuel oil is that penetration into sandy beaches is likely to be minimal and it is easily separated from the underlying sand using hand tools.[96]

Example of Heavy Fuel Oil Spill: Cosco Busan, San Francisco 2007

On November 7, 2007, the freighter Cosco Busan struck the Bay Bridge as it attempted to depart San Francisco Bay. The accident created a gash in the hull of the vessel, causing it to spill 53,569 gallons of heavy fuel oil into the Bay. Wind and currents took some of the oil outside of the Bay, where it affected the outer coast from approximately Half Moon Bay to Point Reyes. Inside the Bay, the oil primarily impacted waters and shoreline within the central portion of the Bay, from Tiburon to San Francisco on the west side and from Richmond to Alameda on the east side (Figure 34).

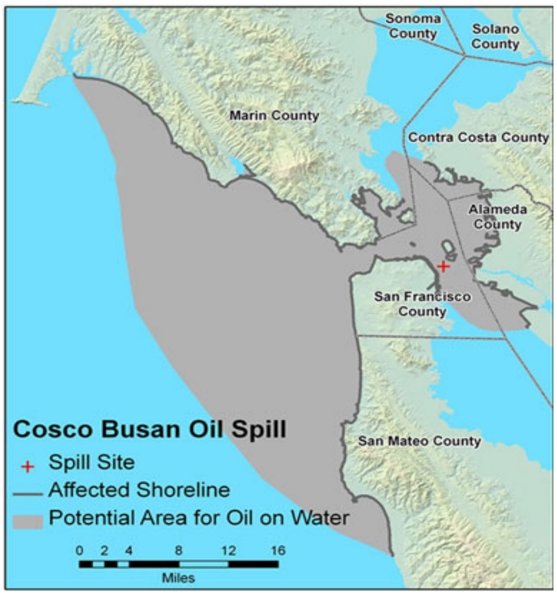

Figure 34: Map of Cosco Busan Oil Spill Site[97]

The Cosco Busan spill precipitated widespread beach closures, fishery closures (both commercial and recreational), and the cancellation of many activities associated with boating or use of the Bay waters. A large-scale response ensued, with cleanup crews active for several weeks. The response was organized through a Unified Command, which was made up of several federal and state agencies as well as the responsible parties. Portions of the response were completed as beaches were inspected and determined to have met cleanup criteria.

The USCG officially declared the response to be complete on November 9, 2008, one year and two days after the spill. Most of the active response ended less than two months after the spill. Some cleanup

[96] Ansell et al. 2001.
[97] Source: California Department of Fish and Wildlife.

continued at several beaches into summer 2008, as they continued to have oiling episodes as buried or sunken oil was uncovered or washed up by wave action.[98]

Miles of beaches were closed; fishing and crabbing were suspended.[99]

Example of Heavy Fuel Oil Spill: Barge DM 932 (Mississippi River)

The inland river tank barge DM 932, a 200-foot tank barge carrying #6 fuel oil being pushed by the Towboat Mel Oliver, was struck by the 600ft Liberian flagged M/V Tintomara loaded with bio-diesel/styrene at MM 98 on the Mississippi River. The barge DM-932 split in half, which released 500,000 gallons of No. 6 Heavy Fuel Oil into the Mississippi River.

The response had over 2,300 responders, 1,185 contaminated vessels were cleaned, 26 miles of oil spill containment boom was deployed, 200 response vessels, 3,250 bbl were lightered to avoid loss to the environment and 3,000 bbl of oil were recovered (Figure 35).

The economic impact was estimated to be 275 million dollars per day due to closure of the Mississippi River from New Orleans to the Gulf of Mexico. Water supply intakes were closed in four (4) Louisiana Parishes. This was an inland Riverine oil spill which involved recovery operations in a fast current, with water level changes and the river bank providing limited access to the river.

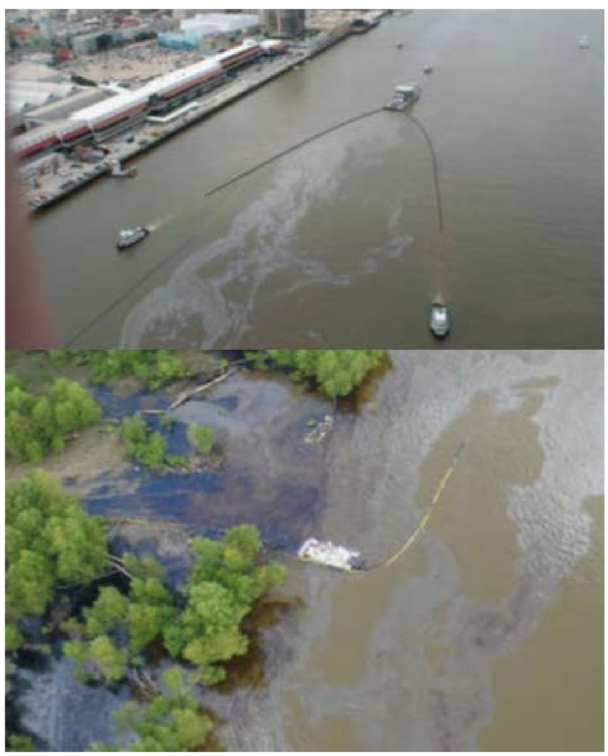

Figure 35: Response Operations for Barge DM 932 Spill[100]

[98] Source: Cosco Busan Oil Spill Trustees. 2012.
[99] NOAA OR&R, "Remembering Cosco Busan: An Overview of the 2007 Oil Spill."
[100] Photo Source: NOAA & Hanzalik, USCG 8th District Presentation, 2009.

Example of Heavy Fuel Oil Spill: Ethel H (II) in Hudson River

On 4 February 1977, the barge Ethel H (II) carrying nearly 60,000 bbl of No. 6 fuel oil grounded just south of West Point in the Hudson River. Over the next several days a total of about 12,000 bbl spilled into the river. Tugs helped to prevent the barge from sinking. The lightering or pumping of oil from submerged tanks prevented additional oil from entering the river, significantly reducing the magnitude of the spill.[101] Nevertheless oil flowed downstream to the New York Harbor.

At the time of the incident the river was covered by ice. Most of the spilled oil mixed with the ice and moved downstream. The presence of about 12-20 inches of shorefast ice protected most of the shore. Two days after the spill, oil was reported two miles north and three miles south of the grounding site. Four days after the spill, oil-soaked ice was observed extending north to Worlds End and south to the George Washington Bridge. Pockets of oil-coated ice were observed at Peekskill Bay, Verplanck Point, and from Croton Point to East Haverstraw. Overflights six days after the spill, revealed 80% brash ice coverage with 75% being oil stained. Brown ice and stained shores were observed at the Harlem River, Gravesend Bay, and 79th Street Marina. A light sheen appeared in the middle of the river while the heaviest concentrations stayed close to the shoreline. The following day, oil entered the marsh at Bowling Point.

Shoreline types affected included: extensive wetlands, marshes, exposed rocky shores, and sand/gravel beaches. Heavy black oil was reported coming ashore on Fire Island beaches 1-2 months after the spill. Personnel on a Cedar Island beach survey conducted on April 7 reported moderate to heavy coverage of oil soaked debris, tarballs, and sludge from the eastern tip of the island extending two miles to the west.

Major cleanup efforts continued through about mid-April (for just over two months). Oiled birds were treated at a rehabilitation center set up by US Fish and Wildlife. Multiple marinas reported oil effects. Five months after the spill, the Philipse Manor Beach Club (Sleepy Hollow) alerted the Captain of the Port, New York, of the presence of oil on their beaches. Concentrations of black tar balls were found approximately two to four inches deep in the sand. Fingerprinting confirmed the oil to be from the Ethel H (II). The oil soaked sand was then removed.

Figure 36: Boom Deployment in Ice for Ethel H Spill[102]

[101] NOAA Incident News. https://incidentnews.noaa.gov/incident/6235#!

[102] Photo by Erich Gundlach.

Oil Types in Modeled HROSRA Scenarios: Gasoline

Spills of gasoline and other flammable liquids, including many crude oils, pose significant response challenges as well as serious health and safety concerns for responders and communities downstream and downwind from the release. Gasoline is regularly transported on the Hudson River in tank vessels and is widely used as a fuel for recreational boating. In the HROSRA, one hypothetical scenario of a worst-case discharge spill from a gasoline tanker at the Yonkers Anchorage was modeled. The volatility of gasoline creates specific challenges for spill response. *Additional information on the propensity for fires and explosions are presented in HROSRA Volume 5.*

Properties of Gasoline

Gasoline range products are finished gasolines and volatile hydrocarbon fractions used for blending into finished gasoline, including straight-run naphtha, alkylate, reformate, benzene, toluene, xylene, and other refined petroleum products with a flash point below 100° F (37.8° C).

Response Considerations

When these types of products are spilled into the environment, it is imperative to take immediate steps to control the source of the release (where safe), to eliminate all possible ignition sources, to quickly establish isolation distances, to notify regulatory and local response agencies, and to initiate a preliminary site safety plan prior to any response activities. However, it is essential that no personnel enter a potentially unsafe environment prior to an initial safety assessment, including vapor monitoring for flammable materials, reduced oxygen, and toxic substance levels.

In many cases, highly flammable liquids should not be contained as part of spill response. Containing gasoline and other highly flammable liquids increases the risk of fire by delaying dispersion of vapors into the atmosphere. The risks posed by response techniques such as booming and applying foam to spilled gasoline and other flammable liquids are warranted only under very limited circumstances.

However, in some cases and as judged by the FOSC, Incident Command, or Unified Command, containment and the use of foam may be appropriate and necessary in response to an imminent threat to public health and safety and the environment. Deflection and protection booming can be used to move flammable liquids away from sensitive areas but must be conducted in a safe manner, within safe atmospheric levels In unaffected downstream or down current areas at risk, a boom should be deployed prior to arrival of the product. Though mechanical recovery of flammable liquids on water can be an effective practice under some circumstances, often the more prudent response option is to allow flammable liquids to evaporate and dissipate.[103]

Given the inherent danger of booming flammable liquids on water, as well as the products' rapid rates of evaporation and dissipation, the following guidelines for responding to gasoline and other flammable liquid releases on water might be considered by first responders. However, it should be noted that these are only guidelines. Each release must be evaluated based on its particular circumstances. Safe work practices and professional judgment should always prevail. Due to the extreme fire, explosion, and inhalation hazards presented by gasoline spills, initial response techniques typically involve evacuation to

[103] Responders should use DOT 2016.

a safe distance and allowing the product to spread to enhance evaporation. Defensive techniques (exclusion or deflection booming, trenching) can be implemented at a safe distance downstream or downslope of a spill.

- Control the source of flammable liquids as quickly as possible, when safe to do so.
- Ensure that proper safety precautions are taken to prevent accidental ignition and risk to responding personnel and the general public.
- An evacuation may be warranted under some circumstances. In many cases, the best response option may be to allow the spilled product to spread and evaporate.
- Notify emergency and regulatory response agencies
- Involve local fire jurisdictions immediately.
- Ensure that proper site hazard analysis and risk assessment are conducted to determine the scope of the release and initiate the development of a Site Safety Plan.
- Establish control zones as soon as possible
- Track and predict liquid and vapor movements; re-establish control zones as appropriate.
- Eliminate all potential ignition sources within appropriate control zones.
- Prevent entry of the spilled product into waterways, sewers, or confined areas
- Conduct air monitoring throughout the response;[104]
- Coordinate response efforts with all agencies; work within a Unified Command.
- Identify and prioritize environmental concerns. Conduct exclusion, deflection, and protective booming downstream or down current as appropriate, outside of hazardous atmospheres and prior to the arrival of the released product.
- Workers should avoid touching, walking, or boating through the spilled product.
- Avoid prolonged inhalation exposure to fumes.
- Allow evaporation and dissipation unless there is an imminent threat to public health and safety.
- When appropriate, use fire monitors/water fog spray to move product out from under docks and other collection areas where the product concentrates. Stage firefighting foam (appropriate to the type of flammable liquid released) and application equipment, if appropriate.
- All equipment used when handling the product must be grounded.

Example of Gasoline Spill with Fire: Tanker Jupiter, Bay City, Michigan

On the morning of September 16, 1990, the tank vessel Jupiter caught fire and exploded during offloading operations at the Total Oil Company refinery on the Saginaw River near Bay City, Michigan. A wake from a passing bulk carrier apparently caused the parting of the Jupiter's transfer hose, grounding cable, and all but one of its mooring lines. Residual gasoline in the broken transfer hose was believed to have been ignited by a spark on the dock. The Jupiter's stern swung around into the Saginaw River and

[104] Note: Air monitoring must be conducted with the greatest of care. Air monitoring both increases the exposure danger to responders and introduces possible accidental ignition sources. Nearby population centers should be monitored, as should the leading edge of the vapor cloud. However, in open water areas it may make more sense for responders to stay away from the concentrated area around the spilled material. In any area that is being monitored, the monitoring should be conducted continuously, if possible. Also, only direct reading, intrinsically safe, continuously monitoring instruments should be used. Lower explosive levels, oxygen, hydrogen sulfide, and benzene levels should all be monitored.

grounded perpendicular to the direction of the river flow. The grounding resulted in a crack in the vessel's hull from the manifold on the starboard side to 75 feet aft of the manifold on the port side. Area marinas were evacuated and vessel traffic was halted. Bangor County Fire Department and USCG personnel arrived on-scene within 30 minutes of the incident. The pier fire was extinguished in an attempt to save the last mooring line while the fire onboard the vessel remained out of control.

Williams Boots & Coots Company (WB&C) from Houston, Texas, was contracted to fight the fire due to the lack of locally available trained personnel and equipment. On September 17, over 30 hours after the tanker caught fire, WB&C personnel extinguished the blaze by applying foam. Carbon black accumulations falling from the overhead re-ignited the fire ten hours later. This second blaze was cooled with water and extinguished with foam the following day. WB&C personnel also applied foam inside the vessel's cargo tanks to prevent re-ignition of the vessel.[105]

The Jupiter incident eventually involved a declaration of emergency by the Governor of Michigan and the participation of at least three dozen federal, state and local agencies, over 400 responders to the fire, explosion and gasoline spill, and eventually a significant vessel salvage operation. According to one report:

> *"In the blink of an eye, a quiet Sunday morning in Bay City, Michigan turned chaotic. More than a million gallons of unleaded gas went burning out of control at the fuel storage dock. The 18-man crew of the Jupiter were in the river perilously close to the burning tanker. Additionally, all but one of the mooring lines that held the vessel to the dock had parted in the explosion. If the fire had parted the remaining line the Jupiter would have become a potential bomb, floating down the Saginaw River."*[106]

Figure 37: Tanker Jupiter Spill and Fire in Saginaw River[107]

[105] NOAA Incident Report.

[106] *Shipmates*, 9th Coast Guard District publication, January 1992.

[107] Source: http://saginawriverimages.blogspot.com

Figure 38: Scenes from Jupiter Tanker Spill and Fire[108]

[108] Source: http://saginawriverimages.blogspot.com

Oil Types in Modeled HROSRA Scenarios: Diluted Bitumen

To date, the Hudson River has not been a waterway used for the transport of diluted bitumen ("dilbit"). However, there have been proposals to transport this type of oil. Due to its unusual properties and concerns about potential submergence or sinking of this type of oil in an oil spill, one of the HROSRA hypothetical modeled spill scenarios involves diluted bitumen spilled from a tank vessel at the proposed Kingston Anchorage. ***Note that diluted bitumen does not necessarily sink or submerge when spilled into water, though it is possible under certain circumstances that are described below.***

Properties of Oil Sand Products[109]

One should however be cognizant, that oil sand products (OSPs), are classified as a Group 3 oil based upon the oils characteristics prior to a spill into the environment and not on characteristics that might change once the oil is released into the environment, thus the inclusive caveat, *"oils that may exhibit similar qualities when discharged into the environment."*

Crude oil can be categorized into conventional and unconventional crude oil. Conventional oil is a category that includes crude oil, natural gas, and its condensates. It is typically produced by drilling into an oil reservoir to extract the crude oil. Unconventional oil consists of a wider variety of liquid sources, including oil sands, extra heavy oil, gas to liquids, coal to liquids, and kerogen oil.

Non-floating oils refer to heavy oils and Group V oils that exhibit qualities which could, due to the oil characteristics, weathering, interaction with sediment in the water, environmental factors or how they are discharged, potentially cause the oils to submerge or sink. Group V oils, or oils that may exhibit similar qualities, have a specific gravity greater than 1.0.

Since these oils will in the majority of incidents, either whole or in part, initially float on the surface of a waterway if spilled, makes it vital that the RP ensure that communication of the potential that the material spilled may have a tendency for sinking should be brought to the attention of the Unified Command and the response organization at the very earliest opportunity in order for responders to be prepared with strategies, tactics and the appropriate resources to respond to oils that may submerge below the surface.

Key Definitions for Submerged Oil

"Submerged oil" describes any oil that is in the water column, below the water surface, including oil that is in temporary suspension due to turbulence and will refloat or sink in the absence of that turbulence. This includes spilled oil that has neutral or near-neutral buoyancy and that is intermittently submerged below the water surface for a significant proportion of time in the prevailing sea conditions.

"Sunken oil" describes spilled oil that is on the bottom of the water body. The negative buoyancy may be due to the high density of the oil, density increase caused by oil "weathering," or the adherence of sediment or sand to the spilled oil. The sediment or sand may, in some circumstances, come into contact with the spilled oil while it is on the surface or during stranding of spilled oil on a coastline or river bank with subsequent remobilization. In low current conditions, sunken oil in shallow waters may pool in

[109] USCG RDC 2015 provided significant guidance and content for this section.

depressions on the bottom or be moved along the bottom by prevailing currents. At higher current speeds, the spilled oil may be dispersed as relatively large, but still non-buoyant, droplets.

"Non-floating oil" can be used to describe oils that have become either submerged or sunken. The United States Coast Guard defines non-floating oils as "heavy oils and Group V oils that exhibit qualities which could, due to the oil characteristics, weathering, environmental factors or how they are discharged, potentially cause the oils to submerge or sink.

Concerns about Submerged Oil

There is a great deal of concern about the possibility of diluted bitumen (also called "tar sands oil" or "oil sands oil") becoming submerged and unrecoverable if and when it spills into water. Extensive research studies and field observations have indicated that diluted bitumen is not unlike other oils with respect to the propensity for submergence in the water column. Diluted bitumen is lighter than freshwater, salt water, and briny estuarine water. It will float unless it comes in contact with sufficient amounts of sediment and suspended particles to increase the specific gravity (density) of the combination of sediment and oil (oil-particulate aggregates or OPAs) to exceed the specific gravity of the water into which the oil is spilled. When this occurs, some of the oil may become submerged temporarily or permanently in the water column and possibly be deposited on the river bottom. This process may be exacerbated by the weathering of the oil over time (i.e., the evaporation of lighter, more volatile components of the oil) which would somewhat increase the density of the oil itself). These same processes can affect other types of oil, especially crude oils and heavier fuel oils. It is even possible with much lighter oils, such as home heating oil and Bakken crude under the right circumstances.

Bitumen is mostly composed of larger heavy hydrocarbons with density of less than 1.0 g/ml. [Freshwater has a density of 1.0 g/ml and saltwater has a density of 1.03 to 1.05 g/ml]. It will float. Alberta bitumen has a density as high as 1.014 g/ml.

Diluents are composed of light hydrocarbons such as natural gas condensate and naphtha, which decrease the density of the diluted bitumen (or "dilbit") to 0.91 to 0.93, or about 0.92. The resulting dilbit is a highly viscous oil similar in appearance to other heavy crude oils, but with unique properties specific to dilbit. The blend ratio may consist of 25 to 55% diluent by volume, depending on characteristics of the bitumen and diluent, pipeline specifications, operating conditions, and refinery requirements. The dilbit composition used for this modeling study contained about 40% volatile (light) hydrocarbons; the remainder being comprised of very recalcitrant compounds that do not dissolve or easily degrade. Natural gas condensate (a byproduct of natural gas production) is currently the primary type of diluent used for Canadian heavy crude oil and is composed of hydrocarbons such as propane, butane, pentane, and hexane.

However, different diluents may be used at different times of the year or under varying circumstances to change the nature of the resulting blend and to accommodate environmental conditions, particularly ambient temperatures. For example, there are summer and winter blends of Cold Lake Diluted Bitumen that have somewhat different properties, the winter blend being somewhat lighter so it flows more easily at low temperatures. Note that both blends are lighter than fresh water and will float. Oil with density of 1.0 g/ml are less dense than fresh water at 15°C and will typically float.

When a conventional heavy crude oil reaches the aquatic environment, the amount that is typically lost to evaporation will be dependent on the composition of the oil and its vapor pressure. Generally, a smaller fraction of heavier crude oil evaporates than for light crude oil. Dilbit, however, is different than heavier crudes in that it contains more of the lighter components that have been added in the diluent. These lighter components typically evaporate when exposed to air. However, once the lighter components of dilbit evaporate, the remaining heavier fraction may sink if the density of the remaining oil exceeds that of fresh water (1.0 g/ml).

There are two main mechanisms by which any oil, including dilbit, may sink or become submerged (suspended below the water surface in the water column)—through increases in density due to evaporation and by combining with heavier sediment or particles. The possibility of sinking or submergence of oil is a major concern as it can significantly complicate cleanup operations. The nature of dilbit as it weathers has been the subject of considerable debate and research. Some research has indicated that as dilbit weathers, it exhibits bimodal behavior as diluent volatilizes and bitumen dominates the chemistry of the weathered oil.

It is possible that there would be sufficient evaporation of lighter hydrocarbon components that the remaining portions of the oil would have densities greater than that of fresh water. If this occurs, it would generally occur after several days had passed and at least 30% of the oil had evaporated.

Sinking and submergence of oil may occur when it comes in contact with particles and sediment. The formation of OPAs can occur with any type of oil, including dilbit, even when its density is less than that of the water, particularly under turbulent underwater conditions.

Besides potential submergence and sinking, another property of weathered dilbit that is of concern is its adhesion potential. When diluted bitumen weathers, its adhesion increases significantly so that it sticks to substrates and surfaces that it contacts. The adherence of spilled dilbit to shorelines, subsurface features, aquatic vegetation, and other surface complicates the cleanup process, but it also means this portion of the spill does not travel as far downstream. Adherence and coating of organisms, such as turtles, amphibians, insects, birds, and mammals can have a significant effect on organisms.

In general, the toxic properties of both bitumen and diluents are similar to those of other crude oil products, including conventional heavy crude. The components of the diluents are commonly found in other crude oils. Both crude oil and bitumen may contain several potentially toxic metals, stable and persistent resins, and asphaltenes.

Non-Floating Oil Response: Strategy and Tactics

Four significant pipeline spills of dilbit have occurred in the US and Canada.[110] The pipeline incidents include spills from Enbridge pipelines in Michigan and Illinois; a Kinder Morgan Canada pipeline spill in Burnaby, BC; and one spill at a TransCanada-operated Keystone Pipeline pump station in North Dakota. The most recent spill was a pipeline failure in the ExxonMobil Pegasus line in Mayflower, Arkansas, in which released a significant amount of dilbit was released into a suburban residential neighborhood. In the February 16, 2015, derailment and fire of a Canadian National Railway unit train in Ontario, it was

[110] NOAA 2013.

noted that the railroad train carried dilbit, which is generally thought to be less explosive than Bakken crude. It is not clear if the lighter components of the Diluent contributed to the fire.[111]

Effective spill response depends on a good scientific understanding of petroleum product behavior in the environment (e.g., movement and changes in physical properties and chemical composition of the oil). For example, in calm waters, booms can help contain floating oil spills and make skimmer recovery equipment more effective; so it is important to know what fraction of the oil will float or sink and under what conditions. There are 12 to 13 types of OSPs; they differ slightly in how each reacts in the environment based on their specific properties. According to laboratory and mesoscale weathering experiments, dilbit products have physical properties much aligned with a range of intermediate fuel oils and other heavy crude oils. Environment and Climate Change Canada, the US EPA, and others have been performing significant research on the behavior of dilbit.

The four major factors that have a bearing on whether spilled oil, including dilbit, will float, become neutrally buoyant (suspended in the water column), or sink are:

- Density of the oil, which may change with weathering (evaporation);
- Turbidity of the water (stirring up sediment and breaking oil into smaller droplets);
- Salinity of the water (i.e., density of the water relative to the oil); and
- Amount of sediment in the water.

There are specific challenges to be faced where very dense oils sink in fresh and potentially brackish waters, and as have happened in the past. The identification of sunken oil may be difficult as it is likely to be hidden from view. Initial predictions of depositional areas can be made by studying the water body (bathymetry) and its surface water hydrology to determine where natural areas of deposition may occur (for example, the pools of a meander in a river or around the edges of a lake, or depressions in the stream bed). This would be followed by probing or surveying for oil. In some cases changes in temperature or seasonal factors may lead to sheens appearing, which could provide indicators of sunken oil. The use of sorbent snares (pompoms) or sorbent pads fastened to a weight and dragged along the bottom can also be useful in locating the presence of sunken oil. There are significant logistical and operational difficulties in detecting and recovering non-floating oils in the water column or on a river bed. Figure 39 identifies current best practices and alternative technologies possessing the potential to more effectively detect, contain, and recover sunken oil.

Cleanup actions may include agitating or aerating the river or lake bed to encourage the release of oil, with subsequent recovery of released oil as it reaches the surface. Dredging of oiled sediment may also be considered (see Figure 40 and Figure 41). In all cases the treatment of sunken oil is likely to be a long-term project extending far beyond the emergency phase of an incident. For example, in the Enbridge pipeline spill in Michigan in 2010, responders did not complete the submerged oil cleanup for four years.

[111] Thomas 2015.

	Sonar Systems	Camera/ Video	Acoustic Camera	Diver Observations	Towed Sorbents	Stationary Sorbents	Visual Observations	Bottom Sampling	Manual Shovel Pits	Laser Fluorosensor	Water Column Sampling
Water Depth (ft)	10 to 1000	10 to 1000	10 to 1000	5 to 190	5 to 100	5 to 100	0 to 30	0 to 1000	0 to 5	10 to 100	5 to >1000
Water Visibility											
— >30 ft	green	green	green	green	green	green	green	green	red	green	green
— 5 to 30 ft	green	yellow	green	green	green	green	yellow	green	red	yellow	green
— <5 ft	green	red	green	yellow	green	green	red	green	green	red	yellow
Availability	green	green	green	green	green	green	green	green	green	yellow	yellow
Substrate Type											
— Sand	green	green	green	green	green	green	green	green	green	green	green
— Silty sand	green	green	green	green	green	green	green	green	green	green	green
— Mud	green	green	green	green	green	green	yellow	green	yellow	green	green
Bottom Obstruction	green	green	green	yellow	yellow	green	green	green	red	green	green
Oil Patch Size											
— <0.1 ft^2	red	green	yellow	green	yellow	yellow	yellow	red	yellow	green	yellow
— 0.1 to 1 ft^2	red	green	green	green	yellow	yellow	green	red	yellow	green	yellow
— >1 to 10 ft^2	yellow	green	green	green	green	yellow	green	green	green	green	yellow
— >10 ft^2	green	green	green	green	green	yellow	green	green	green	green	yellow
Oil Thickness	yellow	yellow	red	green	yellow	red	yellow	green	green	red	red
Buried Oil	yellow	red	red	yellow	yellow	red	red	green	green	red	yellow
Sensitive Habitat	green	green	green	green	red	green	green	yellow	yellow	green	green
False Positives	yellow	green	green	green	green	green	yellow	green	green	green	green
Coverage Rate	green	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Data Turnaround	green	yellow	yellow	green	yellow	yellow	green	yellow	green	yellow	yellow

NOTE Red = not likely effective; yellow = may be effective; green = most likely effective

Figure 39: Evaluation of Technologies to Detect, Delineate, & Characterize Sunken Oil[112]

[112] API Technical Report 1154-2.

	Suction Dredge	Diver-Directed Vacuuming	Diver-Directed Pumping	Excavator	Grab/Clamshell Dredge	Environmental Clamshell	Sorbents/V-SORS	Trawls and Nets	Manual Removal Shallow Water	Manual Removal with Divers	Agitation/Refloat
Water Depth (ft)											
— <5 ft	Yellow	Red	Red	Green	Green	Green	Yellow	Yellow	Green	Green	Green
— 5 to 40 ft	Green	Green	Green	Yellow	Green	Green	Green	Yellow	Red	Green	Yellow
— 40 to 80 ft	Red	Green	Green	Red	Green	Green	Green	Yellow	Red	Yellow	Red
— >80 ft	Red	Green	Green	Red	Green	Green	Yellow	Yellow	Red	Red	Red
Water Visibility											
— >5 ft	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green
— <5 ft	Green	Yellow	Yellow	Green	Green	Green	Green	Green	Yellow	Green	Green
Water Current											
— <1 (kt)	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green
— 1 to 2 kt	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
— >2 kt	Yellow	Red	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Yellow
Wave Height (ft)											
— <2 ft	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green
— >2 ft	Yellow	Green	Green	Yellow	Green	Green	Green	Green	Red	Green	Yellow
Availability	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green
Oil Pumpability											
— Fluid	Green	Green	Green	Yellow	Yellow	Green	Green	Red	Red	Red	Yellow
— Not fluid	Red	Red	Yellow	Green	Green	Green	Red	Yellow	Green	Green	Red

Red = not likely effective; yellow = may be effective; green = most likely effective

Figure 40: Matrix to Evaluate Technologies for Sunken Oil Recovery (Part 1)[113]

[113] API Technical Report 1154-2.

	Suction Dredge	Diver-Directed Vacuuming	Diver-Directed Pumping	Excavator	Grab/Clamshell Dredge	Environmental Clamshell	Sorbents/V-SORS	Trawls and Nets	Manual Removal Shallow Water	Manual Removal with Divers	Agitation/Refloat
Oil Distribution (%)											
— <10 %	Green	Green	Green	Yellow	Red	Yellow	Green	Yellow	Green	Green	Green
— 10 to 50 %	Yellow	Green	Green	Green	Yellow	Green	Yellow	Red	Yellow	Yellow	Green
— >50 %	Red	Green	Green	Green	Green	Green	Red	Red	Red	Red	Green
Oil Patch Size											
— < 0.1 ft^2	Red	Green	Yellow	Yellow	Yellow	Green	Yellow	Red	Yellow	Yellow	Green
— 0.1 to 1 ft^2	Red	Green	Green	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Green
— > 1 to 10 ft^2	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green
— > 10 ft^2	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green
Substrate Type											
— Sandy	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green
— Muddy	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Red
Bottom Obstructions	Red	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Yellow
Buried Oil	Green	Yellow	Yellow	Green	Green	Green	Red	Red	Yellow	Yellow	Green
Sensitive Habitat	Red	Green	Green	Yellow	Red	Yellow	Yellow	Yellow	Green	Green	Red
Removal Rate*	Green	Yellow	Yellow	Green	Green	Green	Red	Yellow	Yellow	Red	Red
Waste Generation**	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
Environmental Impact**	Red	Green	Green	Red	Red	Yellow	Green	Green	Green	Green	Yellow
Cost **	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Green

* Classified as rapid, medium, or slow.
** Classified as low, medium, or high.

Red = not likely effective; yellow = may be effective; green = most likely effective

Figure 41: Matrix to Evaluate Technologies for Sunken Oil Recovery (Part 2)[114]

[114] API Technical Report 1154-2.

OSROs Classified by USCG for Non-Floating Oil Responses

The United States Coast Guard (USCG) Oil Spill Removal Organization (OSRO) Classification Guidelines for Non-floating Oils requires the OSROs/Spill Response Contractors to have access to the following capabilities in order for USCG to approve their classification as a contractor authorized to be listed in an RP Response Plan as being approved for non-floating oils or oils that exhibit qualities which could cause them to submerge.

Detection Types (Examples):

- Sonar Systems;
- Underwater Visualization Systems;
- Diver Observations;
- Sorbents;
- Laser Fluorosensors;
- Visual Observations by Trained Observers;
- Bottom Sampling; and
- Water-column Sampling
- Induced Polarization

Recovery Types (Examples):

- Suction Dredge;
- Diver-directed Pumping and Vacuuming;
- Mechanical Removal;
- Sorbent/V-SORs;
- Trawls and Nets;
- Manual Removal; and
- Agitation/Refloat

All OSRO equipment will be suited for the area in which it is intended to operate. This will include weather, types of water bottoms, currents and water visibility, logistical challenges, etc. OSROs may choose to keep containment equipment on hand, but it is not a condition of becoming a classified OSRO for non-floating oil.

OSROs will have non-floating oil procedures that connect their inventory, personnel and contractual assets in their ability to respond to an incident. Response times for non-floating oil Facility Response Plans (FRPs) and Vessel Response Plans (VRPs) slightly differ, but the National Strike Force Coordination Center has made the determination that the stricter standard will be utilized when evaluating OSRO's response capability. Classified non-floating oil OSROs must be capable of responding within 24 hours of discovery of a discharge.

The USCG OSRO classification data for the Hudson River area show the following OSROs as being classified to be listed as contracted resources in the USCG COTP NY/Albany for non-floating oil responses. Responsible Parties can list these OSROs as contracted resources in their respective facility and vessel response plans for response to non-floating oil spill incidents. Pursuant to USCG MSIB 13-16 and beginning on July 1st, 2017, Facility and Vessel response plan holders who may handle, store, or transport Group V oils shall only list Non-floating Oil *classified* OSROs or provide the required information within their response plan in accordance with the regulatory Group V Response Plan Development and Evaluation Criteria.

OSROs that are classified by USCG to provide non-floating oil response in the COTP NY/Albany area are:[115]

- Clean Harbors Environmental Services
- National Response Corporation
- Miller Environmental Group
- Marine Spill Response Corporation
- T&T Marine Salvage Inc.
- Moran Environmental Recovery

Example of Non-Floating Oil Spill: Enbridge Pipeline, Kalamazoo River 2010

In 2010, the Enbridge Michigan Pipeline Spill occurred which is still the largest dilbit spill, and one of the largest inland oil spills in US history, occurred on Enbridge's Line 6B pipeline on July 25, 2010 in Marshall, Michigan. Line 6B is a 293-mile section of the Lakehead system, which originates in Edmonton, Alberta (Figure 42). The rupture was not discovered for more than 17 hours.

Figure 42: Aerial View of Enbridge Pipeline Spill Response Operations[116]

Two types of dilbit oil were spilled during the Enbridge pipeline spill into the Kalamazoo River system: Cold Lake and McKay River Heavy. Enbridge did not initially report that the pipeline was carrying dilbit.

[115] See also Appendix B.
[116] Source: *Pittsburgh Post-Gazette*

Disclosure of this information is not required, and thus it took more than a week for federal and local officials to discover they were dealing with a dilbit spill. The release, estimated at 843,000 gallons, entered Talmadge Creek and flowed into the Kalamazoo River, a Lake Michigan tributary. Heavy rains caused the river to overtop existing dams and carry oil 35 miles downstream on the Kalamazoo River.

The dilbit that spilled in Marshall was composed of 70% bitumen and 30% diluents. Although the dilbit initially floated on water, it soon began separating into its different components. Most of the diluents evaporated into the atmosphere, leaving behind the heavy bitumen, which sank under water. According to documents released by the National Transportation Safety Board, it took nine days for most of the diluents to evaporate or dissolve into the water. There are no municipal drinking water intake sites but there were several industrial water intake sites along the Kalamazoo River. A major concern during the spill incident concerned contaminated ground water. Municipal officials noted that drinking water wells were located as close as 200 feet to the contaminated river. EPA reported that the Marshall and Battle Creek municipal water systems were not been affected by the oil spill and no well contamination was detected.

The dilbit initially floated on the fresh water. However, after mixing with sediments and the evaporation of the light hydrocarbons from the diluents, the density of some fractions of the residual oil increased, causing the oil to sink. As a result, there were times during the response when the dilbit was simultaneously floating, submerged in the water column, and on the bottom of the river. Beyond the characteristics of the oil, the water temperature, the presence of sediments, and the velocity of the river affected oil recovery.

Response operations included extensive dredging operations (Figure 43). Enbridge has estimated final cleanup costs to be about $1.21 billion.[117] Cleanup of the 2010 spill was not completed until 2014.

Figure 43: Kalamazoo River Dredging Submerged Oil[118]

[117] Associated Press, 2014

[118] Source: *Dredging Today*-July 31, 2013

Response Considerations for the HROSRA Modeled Scenarios

The general considerations regarding response strategies based on the conditions in the Hudson River and the oil types involved in the modeled scenarios were discussed previously. In this section, some of the specific response considerations for the scenarios are presented.

Note that the oil behavior, trajectory, and fate are presented in greater detail for each scenario in HROSRA Volume 4. Aspects related to potential fires and explosions for the selected scenarios for which these were modeled are presented in HROSRA Volume 5. Tables summarizing all aspects of the scenarios are presented in HROSRA Volume 7.

Port of Albany 155,000-bbl Bakken Crude Tanker Loading Accident

This spill scenario would be considered a WCD from a tanker that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years. The greatest concern about a spill of Bakken crude, particularly in this volume, would be for a fire and/or explosion.[119]

Nearly 50% of the Bakken crude evaporated in the modeled scenarios and the remaining hydrocarbons dissolved and degraded in the water column. Because of oil in the water column, there would likely be concerns about water intakes.

The oil spread very quickly reducing the amount of oil that might be mechanically recovered. In some locations higher river current velocities may reduce boom effectiveness for containment and diversion unless they were angled to prevent entrainment.

In spring, 6–7% of the oil stranded on shorelines covering 200 miles at concentrations that could cause ecological effects. In summer, due to higher evaporation and degradation rates in warmer temperatures, very little (1%) oil would be stranded on about 12 miles of shoreline. In winter, up to 18% of the oil would be stranded on up to 190 miles of shoreline. Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

Flammability during a Bakken crude spill always presents a significant danger for persons in the vicinity of the spill, including responders. Responders may also potentially be exposed to high benzene vapors in the area around the spill. Evacuations would likely be instituted for at least 1,000 feet downwind and up to one-half mile if a fire occurs. In the event of a fire, a specific incident decision would need to be made early as to whether to attack fire or allow it to burn out. If there is a fire and/or explosion, the primary concerns for emergency response would focus on the fire rather than the spilled oil in the river and along the shoreline. While the effects of a fire and/or explosion could be significant, much if not most of the oil may be consumed by the fire reducing the effects to the river compared with the spill without ignition.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations

[119] For more information on the effects of a fire and/or explosion for this scenario, refer to HROSRA Volume 5.

would be disruptive to local communities for weeks to months. The expected challenges for the responses to these spill scenarios are summarized in Table 14.

Table 14: Response Challenges for Albany 155,000-bbl Bakken Crude Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	45% evaporation and rapid spreading will reduce amount that can be recovered mechanically..	Approximately 6% on shoreline.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 37% in water column leading to water intake concerns.
Spring Low Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	47% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	Approximately 7% will end up on shoreline.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 35% in water column leading to water intake concerns.
Summer High Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	50% evaporation and rapid spreading will reduce amount that can be recovered.	Only about 1% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 30% in water column leading to water intake concerns.
Summer Low Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 1% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects;

Table 14: Response Challenges for Albany 155,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
				potential for entrainment of 31% in water column leading to water intake concerns.
Winter High Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	49% evaporation and rapid spreading will reduce amount that can be recovered mechanically.. Potential ice conditions may negatively affect mechanical recovery operations	About 17% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 10% in water column leading to water intake concerns.
Winter Low Tide	River currents between 0.3 kts on flood and 0.8 kts on ebb, will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	49% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect mechanical recovery operations.	About 17% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 10% in water column leading to water intake concerns.

Coxsackie 25,000-bbl Home Heating Oil Spill

This spill scenario would be considered something between an MMPD and a WCD from a tanker that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years.

Depending on the season, a large percentage of the spilled home heating oil evaporated (45% in spring, 66% in winter, and 70% in summer). The oil spread very quickly reducing the amount of oil that might be mechanically recovered. In some locations higher river current velocities may reduce boom effectiveness for containment and diversion unless they were angled to prevent entrainment.

In the spring 6% of the oil stranded on 88 miles of shorelines in concentrations above the ecological threshold for effects. In summer and winter, more oil stranded – 19% and 30%, respectively, in higher concentrations across 70 to 90 miles of shoreline. Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations would be disruptive to local communities for weeks. The expected challenges for the responses to these spill scenarios are summarized in Table 15.

Table 15: Response Challenges for Coxsackie 25,000-bbl HHO Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	45% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 5% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 32% in water column leading to water intake concerns.
Spring Low Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	46% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 6% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 28% in water column leading to water intake concerns.
Summer High Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	70% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 19% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 7% in water column leading to water intake concerns.
Summer Low Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	70% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 19% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 7% in water column leading to water intake concerns.
Winter High Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical recovery operations.	About 30% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 1% in water column leading to water intake concerns.

Table 15: Response Challenges for Coxsackie 25,000-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	conditions may affect boom deployment.			
Winter Low Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical recovery operations.	About 31% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 1% in water column leading to water intake concerns.

Proposed Kingston Anchorage 150,000-bbl Home Heating Oil Spill

This spill scenario would be considered a WCD from a tank vessel that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years.

In this spill scenario, nearly 50% of the spilled home heating oil evaporated, and most of the remaining oil was entrained into the water column. In summer, more oil evaporated in the warmer temperatures.

Floating oil from the spring spills at both high and low tide were transported down river, reaching New York Harbor by 21 days after the spill. In contrast, in the summer, the river flow is much weaker than the tidal flow, and the floating home heating oil was blown upstream past Lorenz Park and downstream to Poughkeepsie when spilled at high tide. Likewise, in the summer, the floating home heating oil was blown upstream past Coxsackie and downstream to Staatsburg when spilled at low tide. In winter, oil spilled was transported downstream past Bear Mountain Bridge (at both high tide and low tide).

Shoreline oiling occurred over about 90 miles in the summer and about 120 miles in spring and winter. Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations would be disruptive to local communities for weeks to months. The expected challenges for the responses to these spill scenarios are summarized in Table 16.

Table 16: Response Challenges for Proposed Kingston Anchorage 150,000-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring High Tide	Average current velocity of 1.1 kts results in high currents that will reduce boom effectiveness, containment and diversionary boom	52% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 2% is anticipated to cause shoreline contamination	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects;

Table 16: Response Challenges for Proposed Kingston Anchorage 150,000-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	configurations to be angled to prevent entrainment and splash over.			potential for entrainment of 26% in water column leading to water intake concerns.
Spring Low Tide	High currents averaging 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	46% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 2% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 31% in water column leading to water intake concerns.
Summer High Tide	High currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 3% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 21% entrainment in water column leading to water intake concerns.
Summer Low Tide	High currents averaging 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 3% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 21% entrainment in water column leading to water intake concerns.
Winter High Tide	Ice conditions may hinder response operations; high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment.	65% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical recovery operations.	About 7% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 9% entrainment in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Winter Low Tide	Ice conditions may hinder response operations; high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect	Ice conditions may hinder response operations; 64% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical recovery operations.	About 7% is anticipated to cause shoreline contamination.	Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 9% entrainment in water column leading to water intake concerns especially

Table 16: Response Challenges for Proposed Kingston Anchorage 150,000-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	boom deployment.			in areas near spill site prior to dilution.

Proposed Kingston Anchorage 150,000-bbl Diluted Bitumen Oil Spill

This spill scenario would be considered a WCD from a tank vessel that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years.

In this scenario, nearly 30% of the spilled diluted bitumen (dilbit) evaporated. Most of the non-volatile portions of the bitumen remained floating for at least 30 days with as much as 7 – 9% of it entering the New York Harbor 21 days after the spill in the spring scenarios. In the summer, with the weaker river flow, oil was carried both up and down the river, but only as far south as Poughkeepsie. Shoreline effects are widespread as the oil floats downstream.

Mechanical containment and recovery operations on the water would likely be hindered to some extent due to higher current velocities.

The sediment contamination and submergence of the oil remained relatively low because the highly viscous oil tended to remain floating and stranded ashore as opposed to being mixed into the water where it could bind with suspended particles and settle. Nevertheless, because of concerns over the potential for submerged oil with diluted bitumen spillage, responders may still elect to monitor areas with high sediment and turbulence to locate any submerged oil.

Shoreline oiling occurred over about 130 miles in the summer and about 150 miles in spring and winter. Some of that oil may be in the form of scattered tar balls. Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations would be disruptive to local communities for weeks to months. The expected challenges for the responses to these spill scenarios are summarized in Table 17.

Table 17: Response Challenges for Proposed Kingston Anchorage 150,000-bbl Dilbit Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring High Tide	Average current velocity of 1 kt results in high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Average 1 kt current velocities may affect skimmer operations, 28% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	Approximately 6% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to

Table 17: Response Challenges for Proposed Kingston Anchorage 150,000-bbl Dilbit Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
				water intake concerns in areas near spill site prior to dilution.
Spring Low Tide	Average current velocity of 1 kt results in high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Average 1 kt current velocities may affect skimmer operations, 28% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	Approximately 6% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to water intake concerns in areas near spill site prior to dilution.
Summer High Tide	Average current velocity of 1 kt results in high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Average 1 kt current velocities may affect skimmer operations, 28% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	Approximately 6% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to water intake concerns in areas near spill site prior to dilution.
Summer Low Tide	Average current velocity of 1 kt results in high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Average 1 kt current velocities may affect skimmer operations, 28% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	Approximately 6% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to water intake concerns.
Winter High Tide	Average current velocity of 1 kt results in high currents will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment.	Average 1 kt current velocities may affect skimmer operations, 28% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect skimmer operations.	Approximately 8% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to water intake and fish kill concerns in areas near spill site prior to dilution.
Winter Low Tide	Average current velocity of 1 kt results in high currents will reduce boom	Average 1 kt current velocities may affect skimmer operations, 28%	Approximately 6% stranded on shoreline.	Potential for submerged oil in high-sediment areas especially as the diluents

Table 17: Response Challenges for Proposed Kingston Anchorage 150,000-bbl Dilbit Spill				
Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
	effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment.	evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect skimmer operations.		evaporate; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 1% entrainment in water column which may lead to water intake concerns in areas near spill site prior to dilution.

Rondout 75,421-bbl Bakken Crude Spill (ACP Scenario)

This spill scenario would be considered a WCD from a tank vessel that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years. Note that this scenario, as presented in the ACP, would hypothetically take place concurrent with the 14,000-bbl spill of heavy fuel oil in the Hudson River off Rondout Creek. If this release were to be concurrent with the heavy fuel oil spill, the response operations would be significantly increased.

The greatest concern about a spill of this volume of Bakken crude would be for a fire and/or explosion.[120]

Floating oil from the spring spills were transported down river, reaching New York Harbor by 21 days after the spill. In contrast, in the summer, oil was blown upstream past Lorenz Park after 14 days, but after 21 or more days the floating oil was pushed back downstream closer to the Catskills. In winter, spilled oil was initially (in the first few days) transported upstream and downstream but after 14 days, the floating oil was past Bear Mountain Bridge.

Mechanical containment and recovery was likely hindered to some extent by moderately-high current velocity.

More oil stranded during the winter than during spring and summer. Less than 2,000 bbl of oil stranded on up to 90 miles of shoreline in the spring. In the winter, 124 miles were oiled with over 10,000 bbl of oil.

Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

Flammability during a Bakken crude spill always presents a significant danger for persons in the vicinity of the spill, including responders. Responders may also potentially be exposed to high benzene vapors in the area around the spill. Evacuations would likely be instituted for at least 1,000 feet downwind and up to one-half mile if a fire occurs. In the event of a fire, a specific incident decision would need to be made early as to whether to attack fire or allow it to burn out. If there is a fire and/or explosion, the primary

[120] For more information on the effects of a fire and/or explosion for this scenario, refer to HROSRA Volume 5.

concerns for emergency response would focus on the fire rather than the spilled oil in the river and along the shoreline. While the impacts of a fire and/or explosion could be significant, much if not most of the oil may be consumed by the fire reducing the effects to the river compared with the spill without ignition.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations would be disruptive to local communities for weeks. The expected challenges for the responses to these spill scenarios are summarized in Table 18.

Table 18: Response Challenges for Rondout 74,521-bbl Bakken Crude Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	48% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 3% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 19% in water column leading to water intake concerns.
Spring Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	39% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About <3% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 24% in water column leading to water intake concerns.
Summer High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	33% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About <7% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 37% in water column leading to water intake concerns.
Summer Low	Average river currents of 1 kt will reduce boom	53% evaporation and rapid spreading will	About <7% is anticipated to cause shoreline	Flammability is a significant danger, as are

Table 18: Response Challenges for Rondout 74,521-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Tide	effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	reduce amount that can be recovered mechanically.	contamination.	high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 37% in water column leading to water intake concerns.
Winter High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect skimmer operations.	About 14% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 11% in water column leading to water intake concerns especially in areas near spill prior to dilution.
Winter Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect skimmer operations.	About 14% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill. Potential for submerged oil in high-sediment areas; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 11% in water column leading to water intake concerns especially in areas near spill site prior to dilution.

Rondout 14,000-bbl Heavy Fuel Oil Spill Scenarios (ACP Scenario)

This spill scenario would be considered a WCD from a non-tank vessel (i.e., its entire load of bunker fuel) that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years. Note that this scenario, as presented in the ACP, would hypothetically take place concurrent with the 75,421-bbl spill of Bakken crude in the Hudson River off Rondout Creek. If this release were to be concurrent with the Bakken crude spill, the response operations would be significantly increased. The response would also be complicated by the concerns about the flammability of the Bakken crude.

The spilled heavy fuel oil acted very differently than the spilled Bakken crude. Only a small percentage of the oil evaporated. Most of the oil remained floating until it went ashore. Little oil was expected to reach the sediments in the river because it is too viscous to be entrained into the water where it might combine with suspended particulate matter and subsequently settle.

Mechanical containment and recovery was likely hindered to some extent by moderately-high current velocity.

Shoreline oiling was observed over 100 miles in summer and over 75 miles in winter albeit in higher concentrations. Some of the shoreline oiling would have been in the form of tarballs and tar mats.

Based on SCAT protocols, shoreline cleanup would have entailed substrate removal, manual cleaning, and oily debris removal. Oiled structures, such as in marinas, might require significant manual cleaning and cleaning with sorbents due to the adhesiveness of the oil. Ice conditions would hinder response operations during the winter.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days. Shoreline cleanup operations would be disruptive to local communities for weeks to months. The expected challenges for the responses to these spill scenarios are summarized in Table 19.

Table 19: Response Challenges for Rondout 14,000-bbl HFO Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 6% evaporation with the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically.	About 70% is anticipated to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	Flammability during a heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.
Spring Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 6% evaporation with the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically.	About 71% is anticipated to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	Flammability during a heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.
Summer	Average river currents of	Only 6% evaporation with	About 54% is anticipated	Flammability during a

Table 19: Response Challenges for Rondout 14,000-bbl HFO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
High Tide	1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically although 17% is projected to remain floating on surface.	to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.
Summer Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 6% evaporation with the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically although 18% is projected to remain floating on surface.	About 53% is anticipated to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	Flammability during a heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.
Winter High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment	Only 4% evaporation with the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically although 5% is projected to remain floating on surface.	About 69% is anticipated to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	Flammability during a heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.
Winter Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment	Only 4% evaporation with the bulk of the spill contaminating the shoreline will reduce amount that can be recovered mechanically although 5% is projected to remain floating on surface; mobilize floating self-propelled skimmers designed for heavy oils; set up shoreline containment boom areas with vacuum-trucks and skimmers; potential ice	About 69% is anticipated to cause shoreline contamination and will require significant shoreline cleanup of contaminated sediment, and debris.	Flammability during a heavy oil spill is not a significant danger, Potential for significant shoreline cleanup, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of oil in water column not a significant factor, responders need to wear disposable Tyvek coveralls.

Table 19: Response Challenges for Rondout 14,000-bbl HFO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
		conditions may affect skimmer operations.		

Newburgh Waterfront Crude-by-Rail 11,000-bbl Bakken Crude Spill

This spill scenario with a CBR train would be major incident in which the greatest concern would be for a fire and/or explosion, particularly because of its proximity to a heavily populated area.[121] A CBR spill of this magnitude has occurred three times in the US in the last 15 years.

Flammability during a Bakken crude spill always presents a significant danger for persons in the vicinity of the spill, including responders. Responders may also potentially be exposed to high benzene vapors in the area around the spill. Evacuations would likely be instituted for at least 1,000 feet downwind and up to one-half mile if a fire occurs. In the event of a fire, a specific incident decision would need to be made early as to whether to attack fire or allow it to burn out. If there is a fire and/or explosion, the primary concerns for emergency response would focus on the fire rather than the spilled oil in the river and along the shoreline. While the impacts of a fire and/or explosion could be significant, much if not most of the oil may be consumed by the fire reducing the effects to the river compared with the spill without ignition.

In the modeling simulations, if the oil did not ignite, about 40% to 50% evaporated and no oil remained on the water surface by 30 days. With the high river flow in the spring, a significant portion (35% to 48%) entered the New York Harbor.

Shoreline oiling was highest in the winter with 4,300 bbl covering about 60 miles, followed by summer with 2,500 bbl covering 45 miles.

Based on SCAT protocols, shoreline cleanup would entail wetland flushing, some substrate removal on shorelines in which penetration occurred, and oily debris removal. Oiled structures, such as in marinas, might require flushing and cleaning with sorbents. Ice conditions would hinder response operations during the winter.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for at least several days in addition to blocking freight rail traffic. Shoreline cleanup operations would be disruptive to local communities for weeks. The expected challenges for the responses to these spill scenarios are summarized in Table 20.

Table 20: Response Challenges for Newburgh CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 23% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of

[121] For more information on the effects of a fire and/or explosion for this scenario, refer to HROSRA Volume 5.

Table 20: Response Challenges for Newburgh CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	entrainment and splash over.			wetlands during response may cause effects; potential for entrainment of 24% in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Spring Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	26% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 23% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 24% in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Summer High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	44% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 39% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 12% in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Summer Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 20% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 26% in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Winter High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent	44% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect	About 39% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of

Table 20: Response Challenges for Newburgh CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	entrainment and splash over. Potential ice conditions may negatively affect boom deployment.	skimming operations.		wetlands during response may cause effects; potential for entrainment of 12% in water column leading to water intake concerns especially in areas near spill site prior to dilution.
Winter Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom deployment.	44% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About 39% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 12% in water column leading to water intake concerns especially in areas near spill site prior to dilution.

Bear Mountain Bridge 2,500-bbl Home Heating Oil Spill

This spill scenario represents a MMPD spill from a tank vessel. While this type of spill has not occurred in the Hudson River since 2000, vessel spills of this volume have occurred in the US nine times since 2000. It would entail a major spill response operation.

The majority (> 56%) of the spilled oil evaporated. About 16% to 20% of the oil stranded, except in the spring when the oil was rapidly swept downstream and entered the New York Harbor. Up to 30 miles of shoreline were oiled, though most of that was rocky where natural cleaning would have been most effective, though some manual methods and sorbents would likely have been employed as well. Very little oil entered sensitive wetland areas.

Higher current velocity would have hindered the efficacy of mechanical containment and recovery operations.

Response operations at the Bear Mountain Bridge area and some other locations might temporarily disrupt vessel traffic. The expected challenges for the responses to these spill scenarios are summarized in Table 21.

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Table 21: Response Challenges for Bear Mountain 2,500-bbl HHO Spill				
Spring High Tide	High currents averaging 0.7 kts will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	68% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 16% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for >1% entrainment in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Spring Low Tide	High currents averaging 0.7 kt s will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	56% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About >1% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for >5% entrainment in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer High Tide	High currents averaging 0.7 kt s will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	74% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 20% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for <4% entrainment in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer Low Tide	High currents averaging 0.7 kt s will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	70% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 19% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for >7% entrainment in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Winter High Tide	High currents averaging 0.7 kt s will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may affect boom deployment.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical recovery operations.	About 19% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for 7% entrainment in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Winter Low Tide	High currents averaging 0.7 kt s will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may affect mechanical	About 18% is anticipated to cause shoreline contamination.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for >7% entrainment in water

Table 21: Response Challenges for Bear Mountain 2,500-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	entrainment and splash over. Potential ice conditions may affect boom deployment.	recovery operations.		column may lead to water intake concerns especially in areas near spill site prior to dilution.

Iona Island Crude-by-Rail 11,000-bbl Bakken Crude Spill

This spill scenario with a CBR train would be major incident in which the greatest concern would be for a fire and/or explosion, particularly because of its proximity to a lightly-populated area at Bear Mountain.[122] At some times of the year, there might be larger crowds of visitors at the popular state park. In addition, the presence of the Bear Mountain Bridge might cause concern for public safety due to the likelihood of a fire and/or explosion. A CBR spill of this magnitude has occurred three times in the US in the last 15 years.

Flammability during a Bakken crude spill always presents a significant danger for persons in the vicinity of the spill, including responders. Responders may also potentially be exposed to high benzene vapors in the area around the spill. Evacuations would likely be instituted for at least 1,000 feet downwind and up to one-half mile if a fire occurs. In the event of a fire, a specific incident decision would need to be made early as to whether to attack fire or allow it to burn out. If there is a fire and/or explosion, the primary concerns for emergency response would focus on the fire rather than the spilled oil in the river and along the shoreline. While the impacts of a fire and/or explosion could be significant, much if not most of the oil may be consumed by the fire reducing the effects to the river compared with the spill without ignition.

In the modeling simulations, if the oil did not ignite, about half evaporated and no oil remained on the water surface by 30 days. In the spring high tide release, about a quarter of the spilled oil reached the New York Harbor.

Much of the oil spilled at low tide in spring and winter entered the Iona Island wetland and settled in the sediments. This would require extensive wetland flushing as part of the cleanup operations. After the summer spills there was little river flow into the Iona marsh area and therefore less oil reached the sediment in the wetlands. In addition to the wetland effects, there would be 20 to 100 miles of other shoreline affected as well.

The extensive response operations that would be required for a spill of this magnitude would interfere with or block vessel traffic and port operations for several days in addition to blocking freight rail traffic. The expected challenges for the responses to these spill scenarios are summarized in Table 22.

Table 22: Response Challenges for Iona Island CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom	51% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 8% is anticipated Tappan Zee to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill;

[122] For more information on the effects of a fire and/or explosion for this scenario, refer to HROSRA Volume 5.

Table 22: Response Challenges for Iona Island CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	configurations to be angled to prevent entrainment and splash over.			wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 7% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Spring Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	42% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 1% is anticipated to cause shoreline contamination which may result in limited shoreline cleanup operations.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 6% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	53% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 12% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 32% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	53% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 11% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 33% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Winter High Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom	50% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 17% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill.

Table 22: Response Challenges for Iona Island CBR 11,000-bbl Bakken Crude Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom deployment.	Potential ice conditions may negatively affect skimming operations.		wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 22% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Winter Low Tide	Average river currents of 1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom deployment.	50% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About 17% is anticipated to cause shoreline contamination.	Flammability is a significant danger, as are high benzene vapors in area around the spill; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 21% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.

Tappan Zee 2,500-bbl Home Heating Oil Spill

This spill scenario represents a MMPD spill from a tank vessel. While this type of spill has not occurred in the Hudson River since 2000, vessel spills of this volume have occurred in the US nine times since 2000. It would entail a major spill response operation.

Moderate currents would somewhat hinder effective on-water mechanical containment and recovery operations.

About two-thirds of the spilled home heating oil evaporated and most of the rest was entrained in the water. Higher evaporation rates up to 79% were observed in the warmer summer weather. In the spring with the high river flow, up to 25% of the oil was carried downstream to the New York Harbor. In the winter, about 12% went that far. In summer, more of the oil evaporated so that none of the spilled oil reached the harbor.

In the spring, virtually no oil reached any shoreline. In summer, up to five miles of rocky shore were affected. In summer and winter up to three miles of shoreline were oiled. Only a small amount of salt marsh was affected. This area would be flushed out to remove oil so as to avoid impacting the wetland with intrusive methods. Oiled rocky areas would have been left to wash off naturally, with heavier pockets of oil and oily debris being removed manually and oiled areas wiped with sorbents.

The presence of response equipment around the Tappan Zee area southward towards Manhattan might have caused some disruption of vessel traffic in both directions for a few days. The ongoing bridge construction (and deconstruction) activities in the Tappan Zee might also have been affected.

Ice conditions might have negatively affected skimming and booming operations in the winter. The expected challenges for the responses to these spill scenarios are summarized in Table 23.

Table 23: Response Challenges for Tappan Zee 2,500-bbl HHO Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About <1% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of <3% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Spring Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	69% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About >1% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of <2% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	79% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 4% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of <13% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Summer Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	76% evaporation and rapid spreading will reduce amount that can be recovered mechanically.	About 6% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of >13% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.

Table 23: Response Challenges for Tappan Zee 2,500-bbl HHO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Winter High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom performance.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About >5% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of >5% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.
Winter Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom performance.	66% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About 7% is anticipated to cause shoreline contamination.	Flammability during a heating oil spill is not significant danger, wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of 5% in water column may lead to water intake concerns especially in areas near spill site prior to dilution.

Tappan Zee 50-bbl Heavy Fuel Oil Spill

This smaller spill scenario represents an AMPD vessel spill which occurs about 17 times per year throughout the US. Response operations for these types of spills are relatively “routine.” However, the persistence of the heavy fuel oil and low evaporation rate would result in a larger fraction (up to 72%) stranding on shorelines.

Black oil adhering to shoreline features, including mostly rocks and piers, covered up to five miles in the area near the spill site. No oil entered the New York Harbor.

Moderate currents would somewhat hinder effective on-water mechanical containment and recovery operations. Ice conditions might have negatively affected skimming and booming operations in the winter.

On-water mechanical containment and recovery operations might have recovered some oil particularly if it was contained against shoreline structures or bridge caissons or piers in calm waters.

A majority of the response effort would have been cleaning black oil from shoreline features.

The presence of response equipment around the Tappan Zee area might have caused some disruption of vessel traffic in both directions for a few days. The ongoing bridge construction (and deconstruction) activities in the Tappan Zee might also have been affected. The expected challenges for the responses to these spill scenarios are summarized in Table 24.

Table 24: Response Challenges for Tappan Zee 50-bbl HFO Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 9% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically.	About 69% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.
Spring Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 8% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically.	About 70% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.
Summer High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 9% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically.	About 69% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.
Summer Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over.	Only 8% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically.	About 70% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.
Winter High Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom performance.	Only 6% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About 72% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.
Winter Low Tide	Average river currents of 0.7 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Potential ice conditions may negatively affect boom performance.	Only 6% evaporation is anticipated thus evaporation and rapid spreading will minimally reduce amount that can be recovered mechanically. Potential ice conditions may negatively affect skimming operations.	About 72% is anticipated to cause shoreline contamination so anticipation would be for a significant shoreline cleanup operation.	Wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment in this scenario is for 0% in water column.

Yonkers Anchorage 155,000-bbl Gasoline Spill

This spill scenario would be considered a WCD from a tank vessel that would require a very large response effort. A vessel spill of this volume has not occurred from in the US in the last 15 years.

The greatest concern about a gasoline spill, particularly of this volume, is the possibility of a fire and/or explosion.[123]

Flammability during a gasoline spill always presents a significant danger for persons in the vicinity of the spill, including responders. Responders may also potentially be exposed to high benzene vapors in the area around the spill. Evacuations would likely be instituted for at least 1,000 feet downwind and up to one-half mile if a fire occurs. In the event of a fire, a specific incident decision would need to be made early as to whether to attack fire or allow it to burn out. If there is a fire and/or explosion, the primary concerns for emergency response would focus on the fire rather than the spilled oil in the river and along the shoreline. While the impacts of a fire and/or explosion could be significant, much if not most of the oil may be consumed by the fire reducing the effects to the river compared with the spill without ignition.

In the modeling simulations, for which it was assumed that the gasoline did not ignite, the vast majority (> 92%) evaporated. A very small percentage was transported downstream to the New York Harbor. Virtually no gasoline came ashore.

Response operations would have consisted mainly of preventive evacuations. The gasoline would naturally evaporate and degrade on any shoreline surfaces it affected. The expected challenges for the responses to these spill scenarios are summarized in Table 25.

Table 25: Response Challenges for Yonkers Anchorage 155,000-bbl Gasoline Spill

Season/ Tide	Protective Booming	Mechanical Recovery	Shoreline Cleanup	Other Challenges
Spring High Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents.	92% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential flammability issues.	Minimal % is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX residue may remain in shore sediment.	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects; potential for entrainment of small % in water column may not lead to water intake concerns since most spilled material is evaporating into the atmosphere.

[123] For more information on the effects of a fire and/or explosion for this scenario, refer to HROSRA Volume 5.

Table 25: Response Challenges for Yonkers Anchorage 155,000-bbl Gasoline Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
Spring Low Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents.	93% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential flammability issues.	Minimal % is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX residue may remain in shore sediment.	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects.
Summer High Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents.	94% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential flammability issues.	Minimal % is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX residue may remain in shore sediment.	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects.
Summer Low Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents.	94% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential flammability issues.	Minimal % is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX residue may remain in shore sediment.	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects.
Winter High Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not	94% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential	Minimal <1% is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting

Table 25: Response Challenges for Yonkers Anchorage 155,000-bbl Gasoline Spill				
Season/ Tide	**Protective Booming**	**Mechanical Recovery**	**Shoreline Cleanup**	**Other Challenges**
	containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents. Potential ice conditions may negatively affect boom deployment.	flammability issues. Potential ice conditions may negatively affect skimming operations.	residue may remain in shore sediment.	resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects.
Winter Low Tide	Average river currents of >1 kt will reduce boom effectiveness, containment and diversionary boom configurations to be angled to prevent entrainment and splash over. Consideration by Unified Command to not containing gasoline might be prudent to eliminate gas vapor concentrations and potential flammable incidents. Potential ice conditions may negatively affect boom deployment.	93% evaporation and rapid spreading will reduce amount that can be recovered mechanically. Consideration by Unified Command of not performing skimming operations may be prudent in light of the potential flammability issues. Potential ice conditions may negatively affect skimming operations.	Minimal <1% is anticipated to cause shoreline contamination. Perform SCAT; wetland flushing; some substrate removal due to penetration on sandy beaches; contaminated debris removal; BTEX residue may remain in shore sediment.	Flammability during a gasoline spill is an extremely significant danger as are high BTEX vapors to responder and public health and safety spill area; notify public to potential fire danger; ensure firefighting resources are on scene and mobilized; wetland access may be challenge; disturbance of wetlands during response may cause effects.

Enhancing Risk Mitigation of Hudson River Oil Spills

Preventing spills is more cost-effective than response, cleanup, and restoration. It is far less expensive to prevent an oil spill than it is to clean one up. No spill is acceptable — once oil is released into the environment, harmful consequences have already occurred. All oil spills are toxic and pose a significant risk to the environment, economy, public health, and historical and cultural resources. The aim should be for a zero spills strategy to prevent any oil or hazardous substances from entering waters of the United States. The waters of the United States are a treasured environmental and economic resource that should not be put at undue risk from an oil spill. Understanding the causes of spills is important for preventing them. Most oil spill incidents are caused by human and organizational factors, some say human factors may account for up to 80% of spill incidents.

Firefighting and Vessel Salvage Regulations

The Oil Pollution Act of 1990 requires certain ships to have vessel response plans (VRPs). Vessel owners and operators are charged with identifying spill response resources by contract or other approved means, capable of being on-scene within established timeframes. Because ships move from port to port, owners identify response resources in each captain of the port zone for their area of operations. The number of spills and volume of oil spilled in US waters has substantially decreased with the development of response capability and processes that were implemented for tank vessels by industry and the Coast Guard together.

Timely response activities are key to preventing the escalation of incidents. Because salvage and marine firefighting expertise can both prevent oil spills and minimize threats of spills from escalating, the same VRP resource planning principles were put into place for salvage and marine firefighting services. A long and collaborative development process led to the identification of various distinct salvage and marine firefighting (SMFF) services for assessment, stabilization and special operations. This consultative process resulted in the promulgation of regulations that went into effect in 2009, requiring tank vessels to plan for SMFF services.

Originally applicable to tank vessels, it became apparent that oil spill risks from non-tank vessels increased as the vessels grew in size. In 2013, SMFF services became a required component for non-tank VRPs as well. Today, all vessels which must have a VRP are required to plan for SMFF response services as part of their VRP.

The vessel owner / operator is responsible for determining the adequacy of the resource providers included in their response plan, and must certify in the VRP that the identified SMFF provider meets regulatory criteria. The Coast Guard is responsible for review of the VRPs and notifies the vessel owner / operator of VRP approval, or that the VRP does not meet all the requirements.

According to 33 CFR Section 155.4030: Required Salvage and Marine Firefighting Services to List in Response Plans:

> (a) You must identify, in the geographical-specific appendices of your VRP, the salvage and marine firefighting services listed in Table 155.4030(b) - Salvage and Marine Firefighting Services and Response Timeframes. Additionally, you must list those resource providers that you

have contracted to provide these services. You may list multiple resource providers for each service, but you must identify which one is your primary resource provider for each Captain of the Port (COTP) zone in which you operate. A method of contact, consistent with the requirements in §§ 155.1035(e) (6) (ii), 155.1040(e) (5) (ii), and 155.5035(e) (6) (ii) must also be listed, in the geographical-specific appendices of your VRP, adjacent to the name of the resource provider.

(b) Table 155.4030(b) [Table 26] lists the required salvage and marine firefighting services and response timeframes.

(c)Integration into the response organization. You must ensure that all salvage and marine firefighting resource providers are integrated into the response organizations listed in your plans. The response organization must be consistent with the requirements set forth in Sections 155.1035(d), 155.1040(d), 155.1045(d), and 155.5035(d).

(d)Coordination with other response resource providers, response organizations and OSROs. Your plan must include provisions on how the salvage and marine firefighting resource providers will coordinate with other response resources, response organizations, and OSROs. For example, you will need to identify how salvage and marine firefighting assessment personnel will coordinate response activity with oil spill removal organizations. For services that, by law, require public assistance, there must be clear guidelines on how service providers will interact with those organizations. The information contained in the response plan must be consistent with applicable Area Contingency Plans (ACPs) and the National Oil and Hazardous Substances Pollution Contingency Plan as found in Sections 155.1030(h) and 155.5030(f).

(e)Ensuring the proper emergency towing vessels are listed in your VRP. Your VRP must identify towing vessels with the proper characteristics, horsepower, and bollard pull to tow your vessel(s). These towing vessels must be capable of operating in environments where the winds are up to 40 knots.

(f)Ensuring the proper type and amount of transfer equipment is listed in your VRP. Your salvage resource provider must be able to bring on scene a pumping capability that can offload the vessel's largest cargo or fuel tank, whichever is greater, in 24 hours of continuous operation. This is required for both emergency transfer and lightering operations.

(g)Ensuring firefighting equipment is compatible with your vessel. Your plan must list the proper type and amount of extinguishing agent needed to combat an oil fire involving your vessel's cargo fuel, other contents, and superstructure. If your primary extinguishing agent is foam or water, you must identify resources in your plan that are able to pump, for a minimum of 20 minutes, at least 0.016 gallons per minute per square foot of the deck area of your vessel, or an appropriate rate for spaces that this rate is not suitable for and if needed, an adequate source of foam. These resources described are to be supplied by the resource provider, external to the vessel's own firefighting system.

(h)Ensuring the proper subsurface product removal. You must have subsurface product removal capability if your vessel(s) operates in waters of 40 feet or more. Your resource provider must have the capability of removing bulk liquid cargo and fuel from your sunken vessel to a depth equal to the maximum your vessel operates in up to 150 feet.

Table 26: Required Salvage & Marine Firefighting Services and Response Timeframes

Service Category	Specific Capability	Location of Incident Response Activity Timeframe[124]	
Salvage Assessment & Survey	Remote assessment and consultation	1 hour	
	Begin assessment of structural stability	3 hours	
	On-site salvage assessment	6 hours	
	Assessment of structural stability	12 hours	
	Hull and bottom survey	12 hours	
Salvage Stabilization	Emergency towing	12 hours	
	Salvage plan	16 hours	
	External emergency transfer operations	18 hours	
	Emergency lightering	18 hours	
	Other refloating methods	18 hours	
	Making temporary repairs	18 hours	
	Diving services support	18 hours	
Specialized Salvage Operations	Special salvage operations plan	18 hours	
	Subsurface product removal	72 hours	
	Heavy lift[125]	Estimated	
Marine Firefighting Assessment & Planning	Remote assessment and consultation	1 hour at pier	1 hour on site
	On-site fire assessment	2 hours at pier	6 hours on site
Marine Firefighting Fire Suppression	External firefighting teams	4 hours at pier	8 hours on site
	External vessel firefighting systems	4 hours at pier	12 hours on site

Extending New York HVPA to Albany, NY

Oil spills are likely to result in a negative impact to the ecosystem and the economy of the surrounding area. These represent social welfare effects that are not accounted for solely by the amount of oil spilled into the water. In many cases, the scope of the impact is contingent on the vulnerability and resiliency of the affected area. A barrel of spilled oil may not have the same impact in one area as it would in another. Some locations are more sensitive or vulnerable than others. The Hudson River is a unique ecosystem which has just been designated a critical habitat by NOAA for the Atlantic Sturgeon for practically the full length of the river.

Vessel and Facility Response Plans could mitigate impacts to habitats that house multiple species. An area with an ecosystem that is damaged as a result of previous environmental incidents or damaged due to

[124] CONUS: nearshore area; inland waters; Great Lakes; and OCONUS: <or = 12 miles from COTP city (hours).
[125] Note: Heavy lift services are not required to have definite hours for a response time. The plan holder must still contract for heavy lift services, provide a description of the heavy lift response and an estimated response time when these services are required, however, none of the timeframes listed in the table in Section 155.4030(b) will apply to these services.

the cumulative effects of environmental injuries over time can be expected to have higher benefits from oil spill mitigation.

The primary benefit of expanding the New York HVPA to include the Hudson River up to Troy, NY, is to ensure that in the event of a spill, adequate response resources are available and can be mobilized within the expanded HVPA and arrive on site in a faster time span than the current non-HVPA requirements. This will ensure a timely response by vessel and facility owners and operators and the Oil Spill Response Organizations (OSROs) in an effort to reduce the likelihood, and mitigate the impact of an oil spill on the marine environment that might occur in the expanded Hudson River HVPA.

The benefits of a more rapid spill response have been demonstrated in past studies. When response occurs more quickly, the spread of the oil may possibly be better mitigated, depending on local conditions at the time of the time. Reducing the spread of the oil, in turn, reduces the exposure that sensitive organisms and habitats will have to toxic components of the oil. The exact nature and extent of this mitigation will depend on the specific circumstances of each spill scenario. It will be evaluated in greater detail in the HROSRA for the scenarios selected for the Hudson River.

Hudson River Vessel Traffic Service

The purpose of a Vessel Traffic Service (VTS) is to provide active monitoring and navigational advice for vessels in particularly confined and busy waterways. The Hudson River is a confined and busy waterway that merits the implementation of a VTS to prevent accidents.

Currently, there are VTS in 12 locations in the US. The traffic and tonnage for a number of VTS locations are summarized in Table 27 and compared with the Hudson River.

Table 27: Example Traffic and Tonnage for Existing Vessel Traffic Systems in the US[126]

Location	Annual Vessel Traffic[127] (2015)			
	Tonnage		Transits (Trips)	
	Petroleum	All Commodities	Petroleum	All Commodities
New York	27,416,000	79,334,000	2,822	64,204
San Francisco	43,960,000	73,697,000	2,114	6,779
Los Angeles/Long Beach	30,770,000	121,170,000	7,062	41,735
Puget Sound	19,781,000	61,079,000	4,748	187,000
Prince William Sound	26,715,000	26,747,000	490	1,222
St. Mary's River (Sault Ste. Marie)	0	16,068,000	0	86,487
Berwick Bay (Morgan City)	7,495,000	18,749,000	3,614	13,418
Louisville[128]	3,194,000	19,034,000	2,576	11,159
Hudson River[129] [For Comparison]	**10,578,000**	**15,123,000**	**2,524**	**15,785**

[126] https://www.navcen.uscg.gov/?pageName=vtsLocations
[127] All traffic directions.
[128] Louisville's VTS is only activated during high water conditions when the Ohio River velocity and flow substantially impacts the tows (https://towmasters.files.wordpress.com/2011/01/vts_louisville_user_manual.pdf)
[129] Spuyten Duyvil (Harlem River) to Waterford, NY.

From 1994 through 2012, oil volumes transported by vessels on the Hudson River averaged 8,217,158 tons annually, whereas, from 2013 through 2015, crude oil and petroleum products had an average annual tonnage movement of 11,267,667. That is over a 37% increase in hazardous material tonnage being transported by tank vessels on this environmentally sensitive waterbody and as of this date, neither the USCG nor the maritime industry has conducted a transportation risk analysis of that increased oil tonnage movement which should include evaluation of a VTS since the tonnage of oil transported has changed drastically with increased potential for a major pollution incident.

With the growth of crude oil and petroleum products being transported on the Hudson River, as part of the current USCG PAWSA November Workshops, a systemic evaluation should be conducted concerning the extension of the current NY Harbor VTS to cover the Hudson River from NY Harbor to Troy, NY. This is a risk mitigation measure to enhance navigation safety and minimize the risk of an oil pollution incident that might be the consequence from a collision between two vessels. The VTS would also play a vital role in complying with the anchorage management requirements on the Hudson River.

Besides anecdotal evidence that VTS is effective in reducing accidents and near-misses, there are risk models that quantified the benefits. For example, one analysis has determined that under good visibility, VTS can reduce collisions by 19%. Under poor visibility conditions, the reduction is slightly higher – 20%.[130]

Crew Fatigue/Endurance

Tugboats, towboats, and push boats, all considered towing vessels, are usually navigated underway by a single operator who navigates, steers, and acts as lookout. With two officers on board, the pilot house watch standing period is usually six hours on watch and six hours off watch, any deck crew usually has the same watch standing routine. This is permitted regardless of the length of the voyage. The result has been that officers and crew are working at least 12 hours a day which amounts to an 86-hour work week. Typically two watch crews work 30 days onboard the boat and 15 days ashore, other on and off time schedules are also used.

Many of the tank vessels that move clean products and crude oil on the Hudson River are tank barges being pushed by tugs. In recent years, an increasing number of tug and barges transporting petroleum are Articulated or Integrated. Articulated Tug Barges (ATBs) and Integrated Tug Barges (ITBs) are large barges with ship shaped bows. They have notches on their sterns in which tugs specially designed and built for each barge fit into and are locked in place with hydraulic rams. Effectively, they are a unit, but the tugs can be disconnected relatively easily for dry-docking and repairs. With ITBs, the tug is locked rigidly to the barge. With ATBs, the connection is hinged to allow flexing in larger waves. Articulated ATBs and ITBs are used rather than small tankships primarily because Coast Guard crew requirements for tugs involve fewer crewmembers than tankships. Ships usually have three watches, with crewmembers working 4 hours on duty and 8 hours off duty. Tugs usually have two crews, working 6 hours on, 6 off.

The two-watch schedule used on towing vessels and shorter voyages allows a reduced number of deck officers but does not allow any more than six hours off duty. If no layover occurs in port and the watch

[130] Fowler and Sørgård 2000.

schedule continues, the two-watch or six on and six off system does not usually permit readjustment of the crews' circadian-rhythms. Circadian-rhythms are a cyclic variation in physiological state, mental, and physical activity, roughly 24 hours in duration. Portions of the cycle have been identified with drowsiness and low performance.

On July 20, 2016, the final rule on Inspection of Towing Vessels became effective. Included in the final rule preamble is a discussion on Crew Endurance Management Systems (CEMS) and addresses the numerous public comments concerning that issue and commences on page 40076 of the *Federal Register* Vol. 81, No. 118/ Monday, June 20, 2016 and continues for most of page 40078. In the preamble discussion, USCG states:

"*We are considering developing a separate rulemaking for Hours of Service (HOS) and Crew Endurance Management (CEM) based on our authority under 46 USC. 8904(c). If we do so, we will publish a separate document in the Federal Register, therefore, we have limited our responses because we are not proposing HOS or CEM requirements in this document.*"

The USCG should move forward in issuing a rulemaking concerning Hours of Service and Crew Endurance Management and once the regulation is implemented, ensure rigid enforcement is achieved to ensure compliance.

Crew Training

There are various studies and ample anecdotal evidence that indicate or suggest that improvements in the training of marine vessel crews decrease the likelihood of vessel casualties due to the reduced incidence of human errors. The most noteworthy changes in vessel crew training came with the implementation of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW 1978). This convention, which set qualification standards for masters, officers, and watch personnel on seagoing merchant ships, first entered into force in 1984 with significant amendments in 1995 that entered into force in 2002 (STCW 1995); additional amendments entered into force in 2012.

National Preparedness for Response Exercise Program

The National Preparedness for Response Exercise Program (PREP) was developed to establish a workable exercise program that meets the intent of section 4202(a) of the Oil Pollution Act of 1990 (OPA90), amending section 311 (j) of the Federal Water Pollution Control Act (FWPCA), by adding subsection (6) and subsection (7) for spill response preparedness (33 United States Code (USC.) Section 1321 (j)).

PREP was developed to provide a mechanism for compliance with the exercise requirements, while being economically feasible for the US Government and oil industry to adopt and sustain. PREP is a unified federal effort and satisfies the exercise requirements of the US Coast Guard (USCG), the Environmental Protection Agency (EPA), the Pipeline and Hazardous Materials Safety Administration (PHMSA), and the Bureau of Safety and Environmental Enforcement (BSEE). Completion of the exercises described in the PREP Guidelines is one option for maintaining compliance with OPA90-mandated federal oil pollution response exercise requirements.

PREP addresses the exercise requirements for oil pollution response plans. In this edition, the new Non-tank Vessel Response Plan (NTVRP) and Salvage and Marine Firefighting (SMFF) exercise requirements described in Section 3 of these Guidelines apply only to USCG-regulated vessels in accordance with recent changes to Title 33 of the Code of Federal Regulations (CFR), Part 155. There are additional industry planning and exercise requirements contained in other federal statutes that are not addressed in these Guidelines.

PREP helps to clarify OPA90 exercise objectives and provides a methodology for evaluating compliance with federal regulations. PREP does not mandate a given exercise design process. Plan holders are free to design exercises that meet the PREP objectives as well as their own internal ones. Some plan holders have adopted Homeland Security Exercise and Evaluation Program (HSEEP) exercise design guidance for OPA90 exercises. The use of HSEEP planning process is acceptable, but not required, for planning PREP exercises.

The PREP Guidelines describe the minimum expectations for ensuring adequate response preparedness. If government, industry, or plan holders desire to expand their exercise programs beyond the PREP Guidelines, they are highly encouraged to do so. The PREP exercises should be viewed as an opportunity to improve response plans and the response system. Plan holders are responsible for addressing any issues that arise from evaluation of exercises and making changes to their respective response plans to ensure the highest level of preparedness.

Spill Incident Investigations-Lessons Learned Dissemination

Another example of a vessel accident and spill risk mitigation measure is the systematic investigation of incidents and dissemination of “lessons learned,” such as that conducted in Washington State. While the data are specific to that state, there are relevant lessons for other states, including New York.

Washington State categorizes incident causes broadly into “primary cause,” as determined by an investigator. For vessel incidents in Washington:

- Organizational factors account for 45% of primary causes;
- Human factors account for 40%;
- Equipment failure accounts for 13%; and
- Environmental factors account for 2%.

The State of Washington’s detailed investigations show the continued dominance of human and organizational factors in incident cause. Washington State’s findings track closely with the US National Transportation Safety Board data from 1996 through 2006 that indicates:

- Organizational factors account for 48% of primary causes;
- Individual human error accounts for 37% of primary causes;
- Equipment accounts for 12% of primary causes; and
- "Other" causes are 3% of the total.

Washington State also evaluates "contributing factors" — factors that create the underlying environment from which issues progress into incidents — are largely based on how a vessel is managed. The top organizational factors that contribute to incidents are:

- Equipment design or installation;
- Inadequate procedures and policies or the implementation;
- Poor management oversight;
- Inadequately planned maintenance programs; and
- Insufficient personnel.

A prevention action that can be taken to attempt to minimize the occurrence of future spill incidents, is to ensure each near miss and actual spill is fully investigated as to root and casual factors of the incident. Root cause analysis (RCA) is a method of problem solving used for identifying the root causes of faults or problems. A factor is considered a root cause if removal thereof from the problem-fault-sequence prevents the final undesirable event from recurring; whereas a causal factor is one that affects an event's outcome, but is not a root cause.

Once the root and causal factors are known, dissemination of the investigation results should be made to the stakeholders, industry and other agencies to bring to the attention factors that could conceivably be rectified which may avoid a similar occurrence. The Area Committee would be a good organizational framework to disseminate and discuss these investigation results.

Pro-Active GRP and GRS Boom Deployment and Exercising

The GRPs and GRSs for the Hudson River have pre-designated locations for protective and deflective booming that have been developed in the Area Committee in collaboration with local stakeholders. These booming strategies can be very effective provided they are properly deployed and current velocity is considered in angling the booms (see Figure 3).[131]

Since boom deployment takes prior training and time, exercises with local responders and volunteers can be vital to success in the event of an actual spill.

Rapid deployment of the boom at the time of a spill can also be a key factor for success depending on the location of the sensitive resource in relation to the spill site. To enhance protection of the most sensitive sites, pre-positioning of boom for rapid deployment in close proximity to the sites may be a valuable investment. There are even some types of automatic boom deployment systems that are in development. These systems would allow for remote activation of boom.

Another important approach in assuring the effectiveness of protection or deflection boom to protect sensitive sites as per the GRPs and GRSs is to designate specific boom in equipment caches in advance so that they are available if needed during a spill response. Periodic inspection, maintenance, and

[131] If current velocities are very high (over about 2 knots), angling may not be effective. (See Etkin et al. 2008).

replacement of boom are also vital to the effectiveness of the equipment in the field. Poorly-maintained boom can break or otherwise fail during a spill response.[132]

Development of Quick Response Guides (QRGs)

In the event of a spill, the prompt initiation of response operations and the ability to work effectively and efficiently will greatly increase the degree to which the response mitigates effects of the oil in the environment. A practical aid for spill management teams in putting GRSs into action in the event of a spill is a Quick Response Guide (QRG). QRGs could be developed for facilities and vessels along the Hudson River to be used in conjunction with FRPs and VRPs. A QRG would be developed to provide its users with concise, yet detailed information and response strategies for pre-established shoreline sectors on the Hudson River. During a spill incident from either a fixed location facility or vessel anywhere on the Hudson River, the QRG would be designed to provide information on:

- Pre-designated shoreline sectors for Shoreline Cleanup Assessment Team (SCAT) evaluations.
- Pre-established response strategies for the various area of response. These strategies would be derived from the current Geographic Response Strategies (GRSs), front pages which the Area Committee has customized to provide the response with the best options for protection, containment and recovery from an incident. The QRG would also include the data contained in the GRS back pages. The purpose of these site-specific protection guides is to provide detailed information for the Initial Incident Commander and or the On Scene Incident Commander to follow during the initial response. Resources and procedures for each site are contained in detail and is equivalent to a shopping list of materials needed to protect each shoreline located sensitive area.

During an oil spill response, SCAT systematically surveys and documents the affected area to provide a rapid and accurate geographic picture of shoreline oiling conditions. The information is used to develop real-time decisions regarding shoreline treatment and cleanup operations.

Sensitive Area protection relates to booming procedures for protecting some of the high priority sensitive areas that have been identified within the USCG Area Contingency Plan. Each sensitive area protective strategy is described on one or two pages of guidance established for each site. Each site is linked to the Environmentally Sensitive Index Maps for that location. SCAT forms are included.

Currently the GRS front and back pages[133] are not organized and are not easy to locate the specific needed river segment. The QRG would have hyperlinks to all data so that one click on the overall Hudson River segmented map would bring up that specific segment's front and back GRS pages, ESI Maps with SCAT forms. Ability to access this information on personal digital assistants (PDAs),[134] fill out the forms and

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[132] An example of this type of failure occurred in the April 2000 response to the PEPCO pipeline spill in the Patuxent River at Chalk Point, Maryland. Breakage of poorly-maintained boom caused the spread of oil to greatly increase damages (analyzed in Etkin et al. 2006).

[133] See for example Figure 19 and Figure 20.

[134] For example: smartphones, handheld Ipads™ or SurfacePads™, or small portable laptops that have GIS capability.

electronically send back to the Incident Command Post for Planning & Operational use is extremely beneficial.

Potential Additional Prevention & Risk Mitigation Strategies from PAWSA[135]

In reviewing the recently published *USCG Ports and Waterways Safety Assessment Workshop Report for the Hudson River, New York, 2018*, there were a number of Prevention and Risk Mitigation Strategies that were noted in the report made by participants in the Workshops that deserve to be evaluated further:

- Create a Hudson River Harbor Safety Committee;[136]
- Encourage the use of VHF marine radios by small craft operators;
- Implement a mandatory small craft operator licensing program;
- Require mandatory training for small craft operators, kayakers and paddle-boarders that emphasizes the risks of operating near commercial vessels;
- Expand the VTS in New York to cover the Hudson River to Albany;
- Establish a Regulated Navigation Area for the entire river;
- Increase the number of real-time data sensors for tides, currents, and bridge air gaps;
- Expand AIS coverage and information sharing;
- Expand NOAAs Physical Oceanographic Real-Time System to cover the Hudson River to Albany
- Make bridge cameras accessible to the maritime community;
- Establish federally designated anchorages;
- Define "emergency" in the anchorage regulations and establish anchorage areas that are for "emergency" only, such that the definition of emergency not include parking or staging;
- In the anchorage regulations, replace the word "emergency" with "for purposes of safe navigation;"
- The anchorages should be available, clearly marked, and used for short-term emergency purposes;
- Eliminate the [confusing expression] "long-term" from the anchorage regulations.
- Relax conditions allowing vessels to anchor for something less than a "great emergency" such as adverse weather or a mechanical condition; and
- Designate anchorages in appropriate and strategic locations, and define time limits and the definition of emergency or circumstantial anchoring.

Mitigation of Vessel Transfer Spills[137]

The effectiveness of strict safety regulations regarding oil transfer operations (i.e., transfers of oil between a facility and a vessel and/or between two vessels during cargo loading or unloading and fueling/bunkering) has been demonstrated.[138] Implementation of the types of regulations that are in effect in Washington State[139] and California may reduce transfer-related spills by 34%. These two states in

135 Greater detail on the PAWSA is provided in the next section of this volume.
136 This has already begun.
137 Vessel transfer spills are discussed in greater detail in HROSRA Volume 3.
138 Etkin 2006.
139 See Washington Administrative Code (WAC) chapters 173-184-100, 173-180-215, and 173-180-210 for details.

particular have been active in this regard due to the presence of a number of oil refineries and associated tank vessel traffic and terminals.

Effective oil transfer regulations include:

- Advanced notice of oil transfer;
- Specialized training for designated persons in charge;
- Developing of pre-loading and cargo transfer plans;
- Designated communication protocols;
- Safe transfer operational requirements;
- Work hour restrictions for vessel crews and facility personnel;
- Stringent oil transfer equipment requirements;
- Regular testing of oil transfer equipment; and
- Pre-booming during transfer operations based on safety conditions.

In addition to specific safety measures taken to reduce the likelihood of a transfer-related spill, regulations may specific that transfer operations be conducted with vessels "pre-boomed." This means that a containment boom is used to encircle the vessel or otherwise contain any spilled oil up against the dock where it may be more easily removed with vacuum pumps or skimmers.

This measure does not prevent oil from spilling, but may, under certain conditions, prevent the spread of the oil beyond the containment area. There are limitations to this protection strategy, however. First, the containment boom will not be completely effective if the currents in the area exceed 0.7 knots. The effectiveness reduces quickly as the current velocity exceeds this value.

Secondly, pre-booming can be dangerous during the handling of particularly volatile products, such as gasoline, and, possibly, Bakken crude oil. The volatile vapors from the spilled oil could build up in the event of a spill increasing the likelihood of a fire or explosion.

Mitigation of Recreational Vessel Spills

Education of recreational boaters to prevent accidents and to reduce the likelihood of spills during fueling operations is a key to reducing this source of spillage. The topic of boater education for overall safety as well as for reducing spills was addressed in the Hudson River PAWSA workshops.

Preparing and educating recreational boat operators about oil spills would also help to mitigate risk in the event of a spill. Recommendations for boaters include:[140]

- Maintain your boat's engine, making sure fuel lines are attached and undamaged. Faulty lines are the source of many small spills.
- Take care while fueling. Whether at the dock or on the water, accidents occur due to distracted operators missing or overfilling the tank or hands-free fueling clips not operating correctly.

[140] Based on: *Oil Spill Science: A Boater's Guide to Handling Oil and Fuel Spills* (Sea Grant Program of the Gulf of Mexico) – http://masgc.org/oilscience/oil-spill-science-boaters-guide.pdf

- Protect yourself in the event of an oil or fuel leak. Turn off electricity to prevent sparking and always have a fire extinguisher on board. Avoid inhaling fumes and keep gloves available if you must handle toxic chemicals.
- Never use household detergents to remove oil. Use absorbent pads to remove oil safely. Purchase oil absorbent cleanup materials at boating stores and keep on board to prevent and contain spills (Figure 44).

Figure 44: Oil Absorbent Materials to Catch Leaks on Board Recreational Boats[141]

- If you do see a spill, alert authorities. Boaters must report all spills to the National Response Center at 1-800-424-8802 and to the NYSDEC hotline at 1-800-457-7362.
- In the event of a spill, soak up oil from the water using absorbent materials (Figure 45).

Figure 45: Oil Sorbent Pads on Oil Spilled into Water[142]

- Store all used oil and oily absorbent materials in a closed container labeled “Used Oil.”

[141] http://masgc.org/oilscience/oil-spill-science-boaters-guide.pdf
[142] http://masgc.org/oilscience/oil-spill-science-boaters-guide.pdf

- Dispose of used oil and oily absorbent materials at authorized locations.

Mitigation of Facility Spills[143]

Oil facilities in New York State, as in all states of the US, are subject to the US EPA Spill Prevention Control and Countermeasure (SPCC) rule that addresses spill prevention and response preparedness. New York has also enacted regulations for bulk storage of oil and chemicals that are analogous to the federal regulations.[144]

Part of those regulations includes requirements for secondary containment, which would, under most circumstances, capture the total contents of a storage tank should there be a tank failure. This would not prevent the spill per se, but it would contain the oil in a way that would keep it out of waterways, such as the Hudson River, and allow for a more effective cleanup operation. The SPCC rule applies only to facilities that are:

- Transportation-related (i.e., involved in the transport of oil);
- Engage in drilling, producing, gathering, storing, processing, refining, transferring, distributing, using or consuming oil;
- Could reasonably be expected to discharge oil in quantities that may be harmful into navigable waters or adjoining shorelines; and
- Storing a total aggregate capacity of aboveground oil storage containers greater than 1,320 gallons (31 bbl) of oil.

In addition, any facility that has a total aggregate capacity of buried storage tanks with greater than 42,000 gallons (1,000 bbl) of oil are subject to the SPCC rule.

In addition, facilities that store and use oil are required to have facility response plans (FRPs)[145] that include:

- Emergency Response Action Plan, which serves as both a planning and action document, should be maintained as an easily accessible, stand-alone section of the overall plan;
- Facility information, including its name, type, location, owner, operator information;
- Emergency notification, equipment, personnel, and evacuation information;
- Identification and analysis of potential spill hazards and previous spills;
- Discussion of small, medium, and worst-case discharge scenarios and response actions;
- Description of discharge detection procedures and equipment;
- Detailed implementation plan for response, containment, and disposal;
- Description and records of self-inspections, drills and exercises, and response training;
- Diagrams of facility site plan, drainage, and evacuation plan;
- Security (e.g., fences, lighting, alarms, guards, emergency cut-off valves and locks, etc.); and

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[143] Facility spills are addressed in more detail in HROSRA Volume 3.
[144] Chemical Bulk Storage (CBS) Number (Hazardous Substance Bulk Storage Law, Article 40 of ECL; 6 NYCRR Parts 595-599) (SPDES).
[145] 40 CFR 112.

- Response plan coversheet.

An FRP demonstrates a facility's preparedness to respond to a worst-case discharge.

These facility regulations are already in place for the facilities along the Hudson River and would be applicable to any new facilities. Enforcement of these prevention regulations, including inspection of facilities and response exercises[146] will ensure their effectiveness in mitigating spill risk. The National Preparedness for Response Exercise Program (PREP) is the cornerstone of these exercises.

Mitigation of Rail Spills[147]

The prevention of spills from trains, both for crude-by-rail (CBR) transport and other rail traffic (passenger, commuter, and freight trains) is largely related to preventing accidents and derailments. These measures include:

- Reduction in operating speeds;
- Positive train control (PTC);
- Wayside detectors;
- Enhanced electronically-controlled pneumatic braking (ECP braking);[148]
- Track upgrades;
- Two-person crews; and
- Measures to address crew fatigue and training.

For CBR trains, there is also the reduction of the likelihood of spillage from tank cars in the event of accidents and derailments with safer tank car designs and increased thermal protection. These safer tank car designs are analogous to double hulls on tank vessels.

In January 2014, as CBR began to transit through New York, the Governor issued Executive Order 125 (EO 125), directing state agencies to immediately conduct a coordinated review of New York State's crude oil incident prevention and response capacity. In EO 125, Governor Cuomo called upon state agencies to address the following specific issues:

- The State's readiness to prevent and respond to rail and water incidents involving petroleum products;
- Statutory, regulatory, or administrative changes needed at the State level to better prevent and respond to incidents involving the transportation of crude oil and other petroleum products by rail, ship, and barge;
- The role that local governments across the State play in protecting their communities and their residents from spills of petroleum products shipped by rail and water; and

[146] See section on the National Preparedness for Response Exercise Program (PREP) in this volume.
[147] The factors that affect rail accidents and spills are addressed in detail in HROSRA Volume 3 (Appendix E).
[148] In December 2017, the US Department of Transportation rescinded its rule that tank trains carrying flammable commodities be equipped with ECP braking. A year-long study by the Transportation Research Board of the National Academies of Science reported that a comparison between ECP and conventional brakes was "inconclusive." (http://trn.trains.com/news/news-wire/2017/12/05-ecp-brake-rule)

- Enhanced coordination between the State and federal agencies to improve the State's capacity to prevent and respond to incidents involving the transportation of crude oil and other petroleum products by rail, ship, and barge.

On April 30, 2014, five state agencies submitted to the Governor a report entitled *Transporting Crude Oil in New York State: A Review of Incident Prevention and Response Capacity* (EO 125 Report). These agencies included the Department of Transportation (NYSDOT), Department of Environmental Conservation (NYSDEC), Department of Health (NYSDOH), Division of Homeland Security and Emergency Services (DHSES), and Energy Research and Development Authority (NYSERDA). The report provided an overview of the crude oil boom and New York State's capacity to effectively prevent and respond to incidents involving the transportation and storage of crude oil. It included 27 recommendations for action by the federal government as well as steps that could be taken by state and local governments and industry.

In December 2014, a status update report was issued.[149] Since then, no further updates as to the status of the EO 125 Report findings have been made. CBR has also waned in the state. A status review of the EO 125 Report findings is warranted in the event that CBR transport does become a practice again in the future.

[149] https://www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/CrudeOilUpdateReport.pdf

Risk Identification and Mitigation from PAWSA Workshops

On 28 June 2017, the USCG 1st District announced that after review of the "more than 10,200 comments" submitted in response to the Advanced Notice of Proposed Rulemaking (ANPRM) related to proposed anchorages on the Hudson River, Rear Admiral Steven Poulin, Commander of the USCG 1st District, had suspended future rulemaking decisions and directed a formal risk assessment evaluation of the Hudson River, known as a Ports and Waterways Safety Assessment (PAWSA).

In its announcement, the Commander stated:

> "The USCG describes the PAWSA process as "a disciplined approach to identify major waterway safety hazards, estimate risk levels, evaluate potential mitigation measures, and set the stage for implementation of selected measures to reduce risk… In the fall, a group of waterway users and stakeholders will conduct a two-day structured workshop to meet these objectives and ensure the PAWSA process is a joint effort involving waterway users, stakeholders, and agencies to determine the safety of the waterway."

Historic Overview of the PAWSA Process

According to the USCG:[150]

> "The PAWSA process was established to open a dialogue with waterway users and stakeholders to identify needed vessel traffic management (VTM) improvements and to determine candidate Vessel Traffic System (VTS) waterways. PAWSA provides a formal structure for identifying risk factors and evaluating potential mitigation measures through expert inputs. The process requires the participation of professional waterway users with local expertise in navigation, waterway conditions, and port safety. In addition, stakeholders are included in the process to ensure that important environmental, public safety, and economic consequences are given appropriate attention as risk interventions are selected.
>
> Over 50 ports and waterways have completed the PAWSA process, which generally has been well received by local maritime communities and has resulted in some resounding successes. The ultimate goal of PAWSA is not only to establish a baseline of waterways for VTS consideration, but to provide the local host and waterway community with an effective tool to evaluate risk and work toward long term solutions tailored to local circumstances. The goal is to find solutions that are both cost effective and meet the needs of waterway users and stakeholders."

The PAWSA was initially developed by a national dialog group on port safety convened by the National Research Council in 1999.[151] The mission of the committee was to:

- Identify ways that advanced maritime information systems could ameliorate current shortfalls and maintain or improve environmental protection and waterway safety;
- Describe how those systems could minimize the costs and problems of adapting to changes in transportation and contribute to maintaining the nation's competitive position; and

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[150] https://www.navcen.uscg.gov/?pageName=pawsaBackGround

[151] National Research Council 1999.

- Provide a vision of the future showing how advanced information management systems could enhance vessel safety and waterway efficiency.

The findings of the committee were used to develop a methodology to determine the needs (and justify the costs) for vessel traffic systems (VTS).[152] The approach included not only the USCG, but also port users and stakeholders in a collaborative method that would improve the decision-making process and increase the chances for implementing study recommendations. This was considered a significant improvement on a previous process that the USCG had conducted – VTS 2000 – in which the agency analyzed risk factors for 23 ports and determined that seven of them needed a VTS to reduce risk to an acceptable level. The seven VTS contracts were ultimately cancelled after politicians did not allow for budgeting of the projects due to the lack of public involvement in the process. [153]

PAWSA Model

The PAWSA Waterway Risk Model consists of a hierarchy of port or waterway attributes that affect its safety, as summarized in Figure 46. It is generally based on the basic premise that risk is the product of probability (frequency) and impacts or consequences.

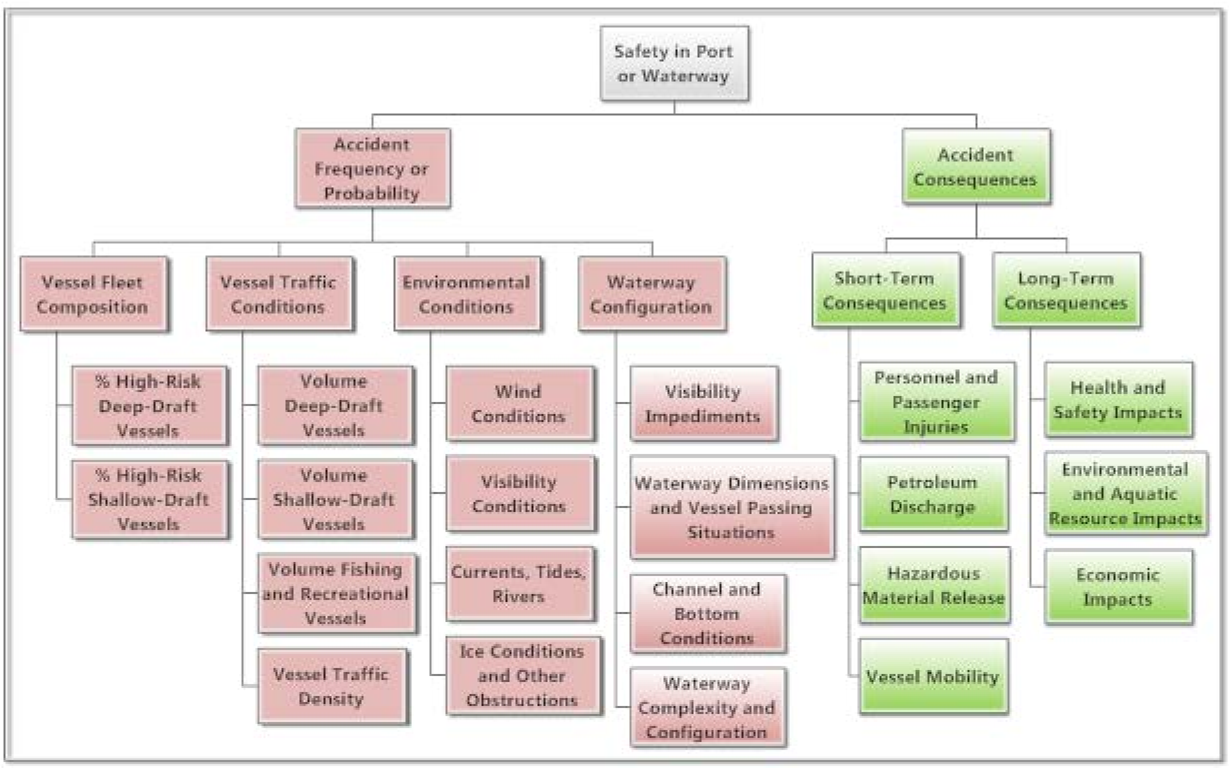

Figure 46: Basic PAWSA Waterway Risk Model[154]

[152] US Coast Guard 2010.
[153] Merrick and Harald 2007.
[154] Based on US Coast Guard 2010 and Merrick and Harald 2007.

The port or waterway attributes that may affect the frequency or probability of vessel accidents or casualties[155] that are incorporated into the PAWSA Waterway Risk Model are:

- **Vessel Fleet Composition:** the types of vessels that operate on the waterways, particularly deep-draft and shallow-draft high-risk vessels operating on a waterway. The high-risk vessels are those that would be either more likely to be involved in an accident, or could cause a significant short- or long-term consequences in the event of an accident. In some descriptions of the Waterway Risk Model this attribute is described as the "quality" of vessels and crew operating on the waterway. The term "quality" in this context does not indicate that there are low-quality or high-quality vessel operators, but rather it refers to the nature or types of vessels in operation. However, in other descriptions of the model, the "quality" of the vessels appears to refer to factors such as: age, maintenance, flag, class society, owner, casualty history, and crew nationalities.
- **Vessel Traffic Conditions:** the numbers and patterns of different types of vessels operating on the river.
- **Navigational Conditions:** the environmental conditions that vessels must deal with in a waterway relating to wind, water movement (i.e., currents, river flow, and tides), and weather conditions that could affect transit (e.g., fog and ice).
- **Waterway Configuration (or Conditions):** the physical properties of the waterway that affect how easy it is to safely maneuver vessels, including channel and bottom conditions (e.g., channel depth/width and navigational hazards), non-weather-related visibility (e.g., blind turns), waterway dimensions and passing conditions, and overall complexity.

The potential consequences of accidents include both immediate (short-term) and subsequent (long-term) impacts of a waterway accident or casualty:

- **Short-Term Consequences:** the immediate impacts of a waterway casualty: people can be injured or killed, petroleum and hazardous materials can be spilled and require response resources, and the marine transportation system can be disrupted.
- **Long-Term Consequences**: the subsequent effects of waterway casualties that are felt hours, days, months, and even years afterwards, such as shoreside facility shut-downs, loss of employment, destruction of fishing areas, decrease or extinction of species, degradation of subsistence living uses, and contamination of drinking or cooling water supplies.

PAWSA Workshops

The primary basis of a PAWSA study is a PAWSA workshop. PAWSA workshops are held when it is determined by the USCG that there is a compelling need to evaluate the safety of a particular port or waterway. This often occurs in response to a specific incident (e.g., a significant vessel-sourced oil spill)

[155] The term "casualty" refers to maritime accidents or incidents in which there is potential for injury and/or pollution. It does not necessarily mean that there are deaths or serious injuries. For example, a vessel that grounds without any spillage, damage, or injuries, is considered to have been involved in a "casualty." This is a different usage of the term than more commonly used in describing the results of a natural disaster (e.g., an earthquake) or a war.

that occurs or issue that arises (e.g., anchorages). The USCG uses the PAWSA results to make a determination about VTS and other risk management strategies for ports and waterways.

The workshop generally consists of invited local subject matter experts, including: USCG officials involved in contingency planning, VTS, aids to navigation (ATON), and waterways management; commercial vessel operators; port officials; pilots; and the relevant NOAA Scientific Support Coordinator (SSC). On a few occasions members of environmental stewardship-oriented non-governmental organizations have been invited as participants if the USCG determines that there is a compelling reason for their participation.

Methodology for PAWSA Workshop

The main focus of a PAWSA workshop is to systematically apply the PAWSA Waterway Risk Model (Figure 46). This is accomplished in a very formulaic manner. The USCG's PAWSA Workshop Guide[156] contains detailed information on the approach, including everything from a description of the basic risk model to workshop floor plans, name tag and table tent templates, and "thank you" letters for organizers to send to participants.

The underlying theoretical concept for the PAWSA workshop is based on the "Delphi" method of converting the opinions of subject matter experts into quantified results. The workshop sponsor, in this case the USCG, selects participants that are knowledgeable with respect to a particular maritime interest and so that all important interests are represented in the group.

Participants are broken out into "teams" within which the participants discuss their expertise in the various aspects of the Waterway Risk Model. Later in the scoring processes, the inputs of the various participants will be weighted with respect to their expertise. For example, a person with significant experience in VTS will have a more heavily weighted input than a person that has never worked with VTS and knows very little about it.

The detailed methodology for the PAWSA workshop is presented in the *USCG Ports and Waterways Safety Assessment Workshop Guide.*[157]

Risk Mitigation Measures Identified in the Hudson River PAWSA

In November 2017, two separate two-day Ports and Waterways Safety Assessment (PAWSA) workshops were conducted by the US Coast Guard for the Hudson River – one in Poughkeepsie and one in Albany.[158] The purpose of the Hudson River PAWSA workshops was to bring together waterway uses, stakeholders, and member of the Hudson River community for collaborative discussions regarding:

- The quality of vessels and crews that operate on the waterway;
- The volume of commercial, non-commercial, and recreational small craft vessel traffic using the waterway; and

[156] https://www.navcen.uscg.gov/?pageName=pawsaGuide
[157] US Coast Guard.2010.
[158] Dagmar Schmidt Etkin of ERC was a participant in the Albany PAWSA workshop on 15-16 November 2017.

- The ability of the waterway to handle current and future increases in traffic volume levels.[159]

The PAWSA discussions addressed a very specific set of issues related to vessel traffic and the waterway, some, not all of which are potentially connected with oil spill risk. Most of the vessel safety recommendations were directly or indirectly related to oil spill risk with respect to the prevention of accidents or casualties that might result in spillage.

The resulting PAWSA report, which combined the outcomes of the two workshops, was released in March 2018.[160] The issues that are at least to some extent related to oil spills (mainly by preventing vessel accidents or casualties that might result in spillage) are reviewed here.[161] *Note that the observations and recommendations are based solely on the opinions of the PAWSA participants. There was not universal agreement on all of the statements made. The statements have not been fact-checked or vetted. The inputs from both the Poughkeepsie and Albany workshops were combined. They are presented in no particular order of importance.*

PAWSA Results: Deep Draft Vessel Quality

The observations made by the PAWSA participants with regard to deep draft vessel quality that would be relevant for oil spill risk were:

- Deep draft vessels are generally in great condition, and the pilots, masters and crews are extremely proficient.
- The majority of deep draft vessels coming up the river are well maintained. Crew proficiency can vary from ship to ship, but it is generally “upper shelf”.
- Vessel quality has improved, but there is still the risk of an incident due to mechanical failures and human error.
- The majority of deep draft vessels are foreign-flagged, but they generally don’t increase waterway risk. They have been boarded and piloted by a state-registered Sandy Hook Pilot prior to entering the Hudson River.
- There are good communications between the Sandy Hook pilots and the Hudson River Pilots. If a safety or material condition issue is identified on a vessel, that information is relayed to the Hudson River pilots.
- Foreign-flagged vessels transit the river as far as Albany. Mixed crew nationalities can increase risk.
- Most of the deep draft vessels are bulk cargo vessels carrying cargo such as salt or iron. These vessels are typically of lower quality when compared to tankers.
- There is a low probability of an incompetent crew or poor quality vessel transiting the Hudson River due to pre-arrival screening, USCG Port State Control (PSC) inspections and internal company vetting programs and procedures.

[159] USCG 2018a.
[160] USCG 2018a.
[161] Note that a significant portion of the PAWSA workshops were devoted to safety issues regarding personal watercraft (e.g., paddleboards, kayaks, and canoes). Since these craft cannot be the source of oil spillage and are extremely unlikely to be the cause of a vessel oil spill, they are not covered in this report. Additional information on personal watercraft can be found in the PAWSA report (USCG 2018a).

- Deep draft vessels are responsive on the radio. Pilots are good at communicating with other vessels and letting them know their intentions.
- Deep draft vessels are generally great quality. Quality has significantly increased over the past 15 years, and most vessels are new. All crews are licensed. The crew quality can vary, but all deep draft vessels have pilots aboard. Pilots have great communication with the USCG, VTS, and other waterway users. They pass issues and concerns to authorities. Pilots are also extraordinarily qualified and courteous.
- Bulk carrier quality is usually less than vessels transporting higher-value cargo.
- Deep draft vessel casualties are rare and occur mostly in the southern portion of the river.
- Ships are required to run on diesel in coastal areas, but some ships were not designed to maneuver with a diesel plant. This can affect maneuverability in narrow portions of the river.
- Some new technology actually increases risk. For instance, a modern propulsion plant may shut down entirely due to a faulty lube oil sensor.

Existing risk mitigations measures that would be related to oil spill risk were identified by the PAWSA participants as:

- All deep draft vessels are vetted and evaluated by the Coast Guard for safety concerns.
- USCG Port State Control inspections evaluate the condition of the ship, the company's operating history, the classification society, and prior inspection history.
- New York has some of the highest quality pilot training in the country. Pilots have the power to "veto" a transit due to vessel or weather conditions.
- Vessel boardings occur near the Indian Point nuclear power plant and before entering New York Harbor. Problem vessels are identified before entering the confined waters of the Hudson River.
- International Maritime Organization (IMO) International Safety Management Code provides international standards for the safe management and operation of ships and for pollution prevention.
- The Ship Inspection Report Program (SIRE) system is a tank vessel risk assessment tool that is used by industry to track and document a tank vessel's compliance with safety and inspection requirements.
- The International Convention of Standards of Training, Certification and Watchkeeping (STCW) sets qualification standards for masters, officers and watch personnel on seagoing merchant ships.
- The USC issues certificates of inspection and marine credentialing.
- USCG Port State Control inspection program is used to vet vessels prior to arriving in US ports.
- Vessels submit a 96-hour notice of arrival, and high risk vessels are inspected.
- Vessels check in/out with the VTS as they enter and depart the river in New York Harbor.
- All mechanical issues are reported to the USCG before they enter the river.
- All deep draft vessels have state pilots on board. The pilots take annual physical exams and proficiency exams. The number of pilots is continually monitored to ensure there are enough to meet demand.

- Foreign-flagged vessel captains are certified by their respective flag states. Foreign vessels must comply with Safety of Life at Sea (SOLAS) requirements. Most crews on foreign flagged vessels are proficient in English.
- Any vessel entering the US must have a Certificate of Fiscal Responsibility (COFR). All vessels, including tankers and non-tankers, must also have a vessel response plan. The plan requires the designation of an Oil Spill [Removal] Organization (OSRO) and ensures they have the equipment to respond to an incident
- Some tankers are doubled-hulled.[162]
- Private cargo facilities also vet ships.
- Industry is driving a culture of safety.

PAWSA Results: Shallow Draft Vessel Quality

The observations made by the PAWSA participants with regard to shallow draft vessel quality that would be relevant for oil spill risk were:

- Tug and barges can be big (approaching deep draft size). They are more cost efficient to operate due to manning requirements.
- Passenger vessels transit the river seasonally. There is a daily commuter ferry between Haverstraw and Ossining.
- The quality of these passenger vessels is good.
- Tug and barges represent most commercial traffic on the river. All are US-manned and built. They are double-hulled and twin-screwed. Overall quality is excellent as supported by various inspection and audit programs.
- Barges at anchor usually have bright deck lights illuminated for safety reason.
- Some hazardous cargo is transported in double-hulled barges.
- Crews are vetted and US-licensed.
- Navigation season is limited due to ice, so there is a high operational tempo during the open season.
- Vessels are new with an average age of about 6 years old.
- Masters and engineers have certification and qualifications.
- Shipping companies have training sessions ever year, which include simulators and bridge resource management topics.
- There may be safety issues associated with crew fatigue. However, companies do maintain crew management standards, and there are federal crew rest requirements. Companies employ a computer program called Watch Keeper 3 to assist in developing watch schedules.
- Some incidents may be attributed to a lack of local knowledge, but the USCG and shipping companies have recency requirements for captains and pilots to ensure they remain proficient for the route that they are navigating.
- There are ferries between Ossining and Haverstraw and Newburgh and Beacon. Ferry operators are proficient, and the vessels are well maintained.

[162] All tankers (tank ships) and tank barges are now double-hulled.

Existing risk mitigation measures related to shallow draft vessels were identified as:

- Stringent safety standards and inspections requirements for tugs, barges and passenger vessels.
- SIRE (Ship Inspection and Reporting) inspections are conducted every 6 months.
- The Oil Company International Marine Forum (OCIMF) Tanker Management Self-Assessment (TMSA) program is used by oil companies to improve their safety management systems.
- Many towing companies have already begun implementing new safety and environmental standards for towing vessels, including inspection requirements under USCG Sub-chapter M inspection requirements for towing vessels.[163]
- The Towing Management Safety System (TMSS) has greatly improved operational safety.
- Crews go through extensive training: firefighting, bridge resource management, radar, and navigation training.
- Crews on spill response vessels are trained semi-annually and annually.
- Passenger vessels are inspected annually by the USCG. Inspections include a review of watch standing, crew training, and emergency procedures.
- Anchored vessels are manned at all times in the river.
- Mariners are subject to drug-testing and undergo physical examinations.
- The mindset of mariners and shipping companies has shifted from strictly profit driven to safety driven.
- Double-hulled tank barges protect the oil cargo and reduce the probability of a hull breach and oil spill.
- Shallow draft vessels (towing vessels) will soon be subject to sub-chapter M requirements. Many companies are voluntarily meeting sub-chapter M requirements before the implementation deadline.
- All tankers and tank barges subject themselves to additional inspections/requirements: International Convention on Standards of Training, Certification and Watchkeeping (STCW); Ship Inspection Report Program (SIRE); and internal inspections.
- Tank barges are double-hulled.
- US crews are some of the best qualified crews in the world.
- Navigation technology is top notch, and it has improved safety.
- Tugs/barges don't have pilots, but the captains are certified and proficient to operate on the river.
- Some towing vessel companies expand the bridge crew to three people while operating on the river. They also complete a risk assessment before every evolution/transit. It is in the company's best interest to safely transport cargo.
- Vessel system redundancy is being implemented. For equipment, there is a backup to the backup. Furthermore, redundant systems are independent of each other.
- Shallow and deep draft vessels must comply with ballast water and discharge regulations.

[163] 46 CFR Chapter I, Subchapter M – Towing Vessels supersedes the jurisdiction of the Occupational Safety and Health Administration (OSHA) and any state regulations on vessel design, construction, alteration, repair, maintenance, operation, equipping, personnel qualifications and manning. Subchapter M will be phased in over a six-year period for existing vessels. Although the law took effect in July 2016, existing vessels will not be required to meet most of its requirements until July 20, 2018.

PAWSA Results: Small Craft Quality

The observations made by the PAWSA participants with regard to small craft quality that would be specifically relevant to oil spill risk were:[164]

- There is heavy recreational traffic on the Hudson River, but it is seasonal (April to October).
- Vessel quality varies widely; it is the largest variable and risk. There are a lot of small plastic craft that may not be in great repair.
- The power driven recreational vessels are usually older.
- Power boating has diminished or leveled off in recent years.
- There are boating safety programs available and sometimes required for recreational operators. Until a couple years ago, required boating safety courses included 6 hours of classroom training. A four-hour, online class is now an alternative to the classroom requirement, which may be less effective than the classroom training.
- Vessels are getting faster (70-80+ mph), and there are various waterfront bars on the river.
- Some recreational boats only have one person onboard. This can increase risk in the case of a vessel casualty.
- Small boaters are generally not experienced with the river's tides and currents.
- Navigation proficiency, including the use of onboard navigation equipment, is not as great in the recreational community. They may not understand the danger to themselves or others.
- Local recreational boating guides are careful and knowledgeable.
- In general, the quality of recreational vessels and education of users has increased over the past 20-30 years.
- There are recreational boats on the river from Memorial Day to Labor Day. The majority knows what it is doing but some do not.
- Pilots have issues with recreational boaters on almost every trip. Examples include anchoring and water skiing in the channel.
- Some recreational boaters are not aware of river dangers such as rocks and currents. They generally lack the proficiency of commercial operators.
- A boating safety course is not required for everyone, but some yacht clubs and marinas require insurance and their own training.
- Licensing is a great way to raise government funds, but it might not be a cure all for recreational boating safety. The most effective mitigation is education.

Existing mitigation measures related to small craft risk include:

- All recreational boaters born after May 1996 must take a boating safety course.
- All river communities, except for one, have a marine patrol. The state has marine patrols as well.
- The USCG promotes a robust recreational boating safety program. This is supported by the USCG Auxiliary courses, courtesy dockside examinations, outreach and training.

[164] Safety for boaters (as well as for personal watercraft and paddleboarders) was a major topic of concern at the PAWSA. Risks and mitigation measures specifically related to personal safety are not included in this report as they would not have a direct bearing on oil spill risk. Accidents with small craft might cause oil spills.

- There are seated field sobriety tests that can be completed on a rocking/moving vessel. This has increased law enforcement's ability to enforce Boating While Intoxicated (BWI) laws.
- New York State has the Tiffany Heitkamp Law in which driving and boating infractions can be considered together by the courts.
- Commercial operators use sound signals to warn recreational boaters.
- New York State enforces the Inland Rules of the Road, and sound producing devices are required.
- The state provides boating safety training for law enforcement officials.
- There is a web platform for safe boating (including traffic mix issues) in the area: www.thesafeharbor.us.
- Some local marinas have their own signs and rules regarding alcohol consumption on recreational vessels.
- The state mitigates with education and enforcement. They provide grants and boating safety classes. They reimburse local authorities for marine patrols. A boating safety class is mandatory for personal watercraft (PWC) operators and motor boat operators born after May 1, 1996.
- There are multiple opportunities for education: online, state parks classes, USCG Auxiliary, and US Power Squadron.
- Over-enforcement can be a concern. There are some instances of people being boarded several times in a single day. However, boaters can display proof of a boarding to avoid further boarding's. Local authorities focus on safety, not just enforcement. Stops result in education, not tickets.
- New York State provides grants for communities that would like to establish a harbor management program.
- Over 23,000 New York recreational boaters took a boating safety class in 2015.

Additional potential mitigation strategies for small craft quality issues related to spill risk that were identified by the PAWSA included:

- Establish a Hudson River Harbor Safety Committee.
- Increase BWI enforcement.
- Improve USCG Auxiliary presence, outreach, and courtesy inspections.
- Pay USCG Auxiliary members to improve membership.
- Increase Federal grant money for State National Boating Safety Programs.
- Rebuild local boating safety outreach programs - people that go from marina to marina.
- Implement stricter boating safety education requirements.
- Increase the number of on-the-water training programs.
- Create a Hudson River specific website with boating information; post the link on signs at marinas.
- Promote vessel safety education at small craft launch points and marinas, use local parks and recreation officials to promote boating safety.
- Place signs near launch points and marinas that highlight the danger of large vessels in the channel.
- Dedicate more law enforcement resources and increase outreach efforts.

- Encourage the use of VHF marine radios by small craft operators.
- Implement a mandatory small craft operator licensing program.
- Increase recreational boating regulations and requirements.
- Develop a video describing "best practices" for commercial/recreational interactions on the water, incorporate traffic mix and other local information in boating safety courses.
- Expand the boating safety courses to cover more aspects of commercial traffic.

PAWSA Results: Volume of Commercial Traffic[165]

The volume of commercial traffic is directly related to oil spill risk. The observations made by the PAWSA participants with regard to the volume of commercial traffic that would be relevant were:

- USACE Waterborne Commerce data suggests there was a 19% reduction in transits and 9.9% decrease in tonnage over the past 6 years. This data may not be accurate because it's based on industry reporting. In some cases, these estimates are lower than actual transits/tonnage.
- Reasonable annual cargo estimates are: 1.5 billion gallons of gasoline, 1.3 billion gallons of home heating oil, and 6.5 million tons of dry bulk.
- The number of cargo handling facilities and permits has increased in recent years.
- Cargo volume is a function of consumer demand and regional projects. For example, a windmill project temporarily increased shipments of windmill parts.
- Commercial traffic volume is relatively high when compared to other similar waterways. However, it is not high when compared to the nation's biggest ports such as New York or Houston.
- Over a period of 20 years, traffic has remained relatively stable except for petroleum shipments. Petroleum shipments fluctuate greatly with consumer demand.
- The Hudson River is designated as a Marine Highway by the Maritime Administration (MARAD).
- The US Army Corps of Engineers (USACE) classifies the river as a "high use" waterway (carrying over a million tons of cargo per year).
- There is usually a minimum of eight commercial ship movements per day on the Hudson River.
- There are 600,000 transits per year in New York Harbor. Based on VTS checkout/in data, there are at least
- 3,000 transits per year on the Hudson River above the Holland Tunnel.
- In addition to what passes through New York Harbor, there are vessels such as rock boats that only transit above the VTS zone.
- USACE Waterborne Commerce Data from 2015: 1,441 commercial deep draft transits and 14,344 commercial shallow draft transits; 15,785 transits per year and approximately 43 per day.
- USACE Waterborne Commerce Data may not be accurate. Pilots have seen cargo that was not included in the data.
- Even with moderate traffic, there can be delays due to weather and berth congestion. Traffic volume does not necessarily correlate with the frequency and length of delays. Maximum delays are around 24 hours.

[165] Note: Detailed data on vessel traffic in the Hudson River are presented in the HROSRA Volume 3.

- There is traffic in Tarrytown for construction of the new Tappan Zee Bridge.

Existing mitigations measures to deal with the volume of commercial traffic on the Hudson River were identified as:

- Vessels must have detailed voyage plans.
- Shipping companies and vessels communicate and coordinate.
- There are Automatic Identification System (AIS) carriage requirements.
- Security calls are used frequently and alert mariners to known or possible dangers.
- Convoys are formed for ice breaker escorts.
- Existing anchorages promote the safe management of traffic volume. These traditional anchorages have been used for over 100 years. A *Coast Pilot* in 1966 states vessels anchor off Kingston to await transit to Albany. The ability and authority for masters to stop due to inclement weather conditions is critical.
- A vessel in distress can anchor at any time and in any location. However, this does not mitigate risks associated with routine traffic management practices.

PAWSA Results: Volume of Small Craft Traffic

Small craft present a smaller risk with regard to oil spills, however, they should be considered. PAWSA participant observations regarding the volume of small craft traffic in the Hudson River were identified as:

- Recreational vessel traffic is seasonal and weekend based.
- Striper season (recreational fishing) can significantly increase traffic from April to June.
- Marine events, such as 4th of July, can drastically increase traffic.
- The number of small boat rental facilities is increasing. There are currently about a dozen.
- Gasoline prices can influence small craft traffic volumes. Higher gas prices equates to lower numbers of small craft out on the water.
- The number of registered motor boats in New York State has leveled off at about 400,460.[166]

Existing risk mitigation measures related to small craft traffic were identified as:

- The state has a local waterfront use program that includes harbor management plans for recreational boating. These can have restrictions for small craft traffic management. Only one community in the study area has one of these harbor management plans.
- Increased outreach to promote responsible traffic management.
- There is a speed limit when vessels are within 100 feet of the shore, piers, anchored vessels, etc.
- Enforcement is increased during popular boating periods such as the 4th of July.
- The USCG establishes safety zones and issue permits for marine events.
- There are areas where recreational boaters cannot transit. Examples of these areas include near Indian Point and the Tappan Zee Bridge. These safety and security zones shown on nautical charts and are published in the federal regulations and local notice to mariners.

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[166] Note: These are not all on the Hudson River.

Additional potential mitigation strategies for small craft traffic volume issues related to spill risk that were identified by the PAWSA included:

- Require small craft liability insurance similar to automobile insurance requirements.
- Require an on water practical examination and licensing for small craft operators.
- Expand boating safety education and outreach programs.
- Require mandatory boating safety education, training and licensing for small craft operators.
- Automatically issue small craft operator licenses, but make them subject to revocation for serious violations such as BWI.
- Require mandatory boating safety education every 10 years and not just for those born after a certain date.
- Increase enforcement of existing boating safety regulations.
- Require carriage of VHF marine radios by small craft operators and monitoring of VHF channel 13.
- Require training on the Inland Navigation Rules of the Road for small craft operators.

PAWSA Results: Traffic Mix

Observations made by the PAWSA participants regarding the vessel traffic mix as potentially related to oil spill risk included:

- Small vessels sometimes anchor in the channel, which poses problems to deep draft vessel transits.
- The entire river is a mixed use waterway except during the winter. From November to April, the waterway is single (commercial) use.
- There are lots of conflicts between recreational boaters and commercial traffic. Conflicts are seasonal because recreational traffic is seasonal.
- Traffic mix is really bad on the 4th of July and other periods of high recreational traffic.

Existing risk mitigation measures identified in the PAWSA workshop were:

- Harbor management plans include policies for managing the traffic mix.
- Many yacht clubs and marinas on the river regularly communicate and discuss safety issues.
- Commercial vessels have a look out and constantly monitor radio traffic.
- Some educational programs emphasize safe interactions between commercial and recreational vessels. The Hudson River Valley Greenway's program focuses on this.
- There is communication between commercial vessels. They warn each other of risky small craft.

Additional potential risk mitigation measures that were identified for traffic mix issues that may relate to oil spill risk included:

- Establish a Hudson River Harbor Safety Committee.
- Improve long-range and/or contingency planning and better coordinate activities, improve dialogue between waterway users and stakeholders.

- Require mandatory training for small craft operators, kayakers, and paddle borders that emphasizes the risks of operating near commercial vessels.
- Increase outreach and voluntary boating safety programs.
- Expand AIS coverage.
- Required small craft to carry VHF radios.

PAWSA Results: Congestion

Vessel congestion is a concern for oil spills. Observations made by the PAWSA participants regarding vessel congestion included:

- Rondout Creek, Catskill Creek, and Espouse Creek are areas that can be particularly congested with recreational boaters on the weekends.
- There is an amphitheater on the water in Albany, north of the port facilities, which sometimes attracts large numbers of small craft.
- North of Kingston there can be congestion due to ice.
- All communities with boat clubs/ramps can be congested.

Existing mitigation measures to alleviate the risk of vessel congestion were identified as:

- Great communication between pilots and shipping companies.
- Existing anchorages promote the safe management of traffic volume and also mitigate congestion problems.
- Events that are a hazard to navigation must be permitted. This may include safety zones and notifications (Broadcast Notice to Mariners or BNM, and Local Notice to Mariners or LNM).
- USACE permits structures in the waterway, including those associated with marine events.
- Vessels use VHF radios, AIS, and radars to mitigate congestion.

Additional identified potential risk mitigation strategies related to congestion that may also have implications for oil spill risk included:

- Establish a Hudson River Harbor Safety Committee.
- Improve coordinating and planning between the different waterway user types.
- Incorporate traffic mix and other local information in boating safety courses.
- Expand the VTS in New York to cover the Hudson River to Albany.
- Federally designate historically-used anchorages.
- Establish a Regulated Navigation Area for the entire river.
- Increased information sharing on traffic congestion.
- Promote increased training for tour boat operators, require the carriage of VHF radios on tour boats.
- Improve the ability to communicate bridge-to-bridge or ship-to-shore.

PAWSA Results: Winds

Observations regarding wind conditions in the Hudson River included:

- From a commercial perspective, the winds are typically moderate and from the west. Besides extreme weather events, winds do not affect normal operations.
- Hurricanes and other extreme events can cause vessels from the lower river to seek shelter in the upper river.
- All waterway users have adequate and accurate weather forecasting tools.
- Winds are generally out of the west or northwest. They usually come at the worst time, and northwest winds can be difficult for commercial vessels.
- Winds are well forecasted, and the forecasts are improving.
- Winds pose the greatest risk in areas that are narrow or congested (above 4-mile Point).
- Wind direction and speed varies by season.
- Climate change could be causing more extreme weather events.

Existing mitigation measures were identified as:

- Weather forecasts are readily available, accurate, and adequate. These forecasts are used by both commercial and recreational boaters.
- Mitigated by voyage planning and accurate forecasting.

PAWSA Results: Water Movement

Observations regarding water movement in the Hudson River included:

- Tides and currents can make the river dangerous in almost all areas.
- Winds and tides can be a dangerous combination.
- Water movement can create risky interactions between commercial vessel and small recreational traffic.
- The current and water elevation can fluctuate greatly depending on the weather. This impacts voyage planning for commercial traffic.
- Tidal currents usually max out at 2 kts.
- Voyage planning is greatly influenced by tides and currents.
- Snow melt and rains increase currents. This can lead to strong currents in the Port of Albany.
- There is a lack of real-time sensors/data.
- Tides and currents could impact oil spill containment and clean up.
- Currents don’t exceed 5 kts, unless there is an extreme weather event.
- Opposing winds and currents can create chop that is difficult for paddle craft.
- Water releases and freshets can increase risk. Sometimes these events can even pull buoys under the water.
- Water movement is generally not well understood by recreational boaters.

Existing mitigation measures related to tide and current issues as related to vessel movements were identified as:

- Water movement is incorporated in voyage planning.
- Tide and current predictions are readily available and accurate.

- There is a certified tide station at Turkey Point. It is part of a sea level and climate change study.
- The NOAA Hydrographic Division completed a new bottom survey in 2016, and the data is under review. It should be added to charts relatively soon.
- Transits and passing arrangements are planned according to tide and current predictions.
- Tidal predictions are accurate, especially since the models were updated with new data.
- Voyage plans incorporate keel clearance.
- Local area knowledge and broadcast communication mitigate risk associated with water movement.
- NOAA maintains tide and current sensors, and they are committed to updating them.

Additional identified potential risk mitigation strategies related to water movement on the Hudson River that may also have an effect on oil spill risk included:

- Increase the number of real-time data sensors for tides, currents, and bridge air gaps.
- Improve accuracy of existing navigation and hydrographic sensors.
- Expand AIS coverage and information sharing.
- Expand NOAAs Physical Oceanographic Real-Time System to cover the Hudson River to Albany.
- Expand the VTS in New York to cover the Hudson River to Albany.

PAWSA Results: Visibility Restrictions

The PAWSA participants identified a number of safety issues regarding visibility restrictions:

- Fog is seasonal.
- Kingston to Hudson and Castleton to Albany usually have fog from midnight to 9:00am.
- Most common fog is radiation fog in the fall. This generally burns off in the morning after sunrise.
- North and south winds can produce fog.
- Snow and heavy rain can restrict visibility.
- Fog can be patchy, but it’s a game changer for commercial traffic. Pilots and tug captains will avoid fog, which means they will try to anchor or remain moored.
- Fog is seasonal. It is usually worse in the spring and fall.
- Commercial fisherman must go out to save their nets, regardless of restricted visibility. Fixed nets were traditionally set below Peekskill.
- According to the National Climate Data Center, there are about 25 days of dense fog a year in the Hudson Valley. However, this might not accurately describe conditions on the river.
- There are microclimates on the river, and visibility conditions can change rapidly.
- Heavy rain and snow can be worse than fog because it clutters the radar.
- Glare can be a problem on clear days.

Existing mitigation measures related to visibility restrictions were identified as:

- There is a live camera on Saugerties Lighthouse (www.saugertieslighthouse.com) that can be used to assess visibility.
- In the future, existing bridge cameras could be used in the same way.
- Electronic ATON supplement physical ATON.
- There is great communication on the waterway. Mariners will seek visibility information from other vessels underway.
- Captains and pilots have the authority to terminate a voyage because of restricted visibility. They will not proceed north to the narrow sections if visibility is poor.
- If already underway, anchoring is the primary mitigation strategy.
- Technology helps, but its benefits are limited due to the narrowness of the channel.

Additional potential risk mitigation strategies relevant to visibility restrictions that were identified by the PAWSA participants included:

- Establish a Hudson River Harbor Safety Committee.
- Improve AIS coverage and carriage requirements, install more AIS repeater stations.
- Improve collection and dissemination of real-time weather data.
- Improve the federal presence on the river: EPA, NOAA, USACE, and USCG.
- Make Hudson River bridge crossing cameras accessible to the maritime community.
- Expand the VTS in New York to cover the Hudson River to Albany.
- Dredge west of Hudson, so there are channels on both sides of the island.
- Increase frequency of Safety Broadcast Notice to Mariners (BNM).
- Install additional ATON.
- Limit vessel sizes so that vessels are not tide restricted due to vessel draft during their transits.
- Establish commercial moorings.
- Do not categorically exclude anchorages from National Environmental Policy Act (NEPA) requirements.
- Define "Great Emergency" in the anchorage regulations.
- Specify time limits for anchorages.
- Avoid placing anchorages in aquatic habitat areas.
- Implement federal anchorages as proposed in the ANPRM.
- Make bridge cameras accessible to the maritime community.
- Expand NOAAs Physical Oceanographic Real-Time System to cover the Hudson River to Albany.
- Expand the VTS in New York to cover the Hudson River to Albany.
- Improve information sharing between from federal stakeholders (USCG, NOAA, etc.) and waterway users.
- Establish federally designated anchorages. Define "emergency" in the anchorage regulations. Establish anchorage areas that are for "emergency" only. The definition of emergency should not include parking or staging. In the anchorage regulations, replace the word "emergency" with "for

purposes of safe navigation." The anchorages should be available, clearly marked, and used for short-term emergency purposes. Eliminate "long-term" from the anchorage regulations.[167]

- Relax conditions allowing vessels to anchor for something less than a "great emergency" such as adverse weather or a mechanical condition.
- Designate anchorages in appropriate and strategic locations, and define time limits and the definition of emergency or circumstantial anchoring.
- Establish a Regulated Navigation Area for the entire river.

PAWSA Results: Obstructions

Observations about waterway obstructions in the Hudson River made during the PAWSA workshops included:

- Ice can form from January to March, and it fluctuates from year to year. The effect on navigation can be huge. Ice can influence the following: visibility, aids to navigation discrepancies, and transit times (four times longer transits). Silver Point, Worlds End, and Kingston can be choke points. Plate ice can be up to 1.5 ft thick, and refrozen brash can be up to 6 ft thick. Brash builds up in choke points. Drifting ice can cause vessels to drag anchor.
- Lots of debris enters the river following: precipitation events greater than 1 inch, high tide with calm winds, and lock openings in the Spring. This debris can include up to full size trees.
- Construction projects and submerged cables can be obstructions. Some submerged cables are abandoned and on top of the sediment. Cables running parallel to the channel can be hazardous because of questions regarding the exact location.
- Marinas located close to the channel can be obstructions.
- There are few fixed fishing structures. The shad fishery is closed, but there are some nets used for herring.
- Bridges can be obstructions. Pilots prefer 2-3 feet of excess air draft.
- Cable and pipelines are obstructions, and some are not charted.
- Ice is major obstruction. Some crews lack experience in ice. Ice drags buoys off station, and it is difficult to meet or overtake in ice. Vessel interactions with ice can break docks and marina infrastructure.
- Commercial traffic can destroy fishing nets. Not a relevant issue for today's fishing practices.
- Most incidents have occurred near reefs. They are obstructions, but they are habitat for aquatic resources.
- Some fuel storage locations have transfer pipes that protrude onto the pier.
- Sometimes kayakers are mistaken for debris fields or birds.

Existing mitigation measures related to waterway obstructions were identified as:

[167] The designation of anchorages as "long term" in USCG regulations is not meant to determine the amount of time that vessels may anchor but rather to distinguish them from "temporary" anchorages. The existing Hudson River anchorages and those that were proposed in the ANPRM are all designated as "long-term," which differentiates them from "temporary" anchorages, such as those that are set up during special circumstances, such as boat races, construction activities, fireworks launching, etc. Typical long-term anchorages are limited to 96 hours (four days).

- Vessels communicate with each other.
- Convoys are formed for ice breaking escorts.
- The USCG has a regulated navigation area that has horsepower restrictions based on ice thickness.
- The USCG tracks vessel transits during ice conditions.
- Communication between captains/pilots and USCG cutters improve the effectiveness of ice breaking operations.
- Ice operations are well managed. The USCG has an annual ice breaking meeting and conducts daily overflights.
- Captains and pilots are experienced in ice.
- Vessels form convoys that are escorted by a USCG ice breaker.
- Commercial vessels will slow down to limit wake damage to private structures and docks. However, this is not always effective.
- There are horsepower restrictions during the ice season.
- The USACE has a crane barge on the river that is capable of removing obstructions.
- Mariners report obstructions and warn others.

Additional potential mitigation measures for obstructions that were identified by the PAWSA participants included:

- Establish federally designated anchorages.
- Define "emergency" in federally designated anchorages.
- Expand AIS coverage.
- Improve clearing of debris from the river.
- Improve ice breaking capacity.

PAWSA Results: Visibility Impediments

Observations made by the PAWSA participants with regard to visibility impediments on the Hudson River included:

- Bridges can obstruct visibility, especially for small vessels.
- AIS coverage is intermittent from Tarrytown to Albany.
- For a small vessel's height of eye, background lighting from large communities can obstruct lighted aids to navigation. The risk is greatest is areas south of Stony Point.
- Railroad lights can be confused for vessel lights when transiting south through Worlds End. Some vessels have run aground because of this.
- Background lighting is bad near Catskill, Newburgh Water Plant, Tarrytown, Haverstraw Bay, and Albany.
- There are dark shadows near Hudson.
- Port of Coeymans can be lit up.
- Silver Point Range near German Reach can be too bright. Sometimes it's blinding.
- There are some blind spots for AIS and VHF coverage, especially in the Hudson Highlands.

Existing mitigation measures were identified as:

- AIS, radar, and bridge to bridge communications reduce risks associated with visibility impediments.
- Commercial operators communicate well when approaching turns and bends. Some recreational boats listen to this communication.
- There are minimum lighting requirements for stationary barges.
- Vessels carry a chart and VHF radio.

PAWSA Results: Dimensions

Observations regarding the dimensions of the Hudson River that were made by PAWSA participants included:

- There are air draft concerns with the Mid-Hudson and Castleton bridges for deep draft vessels.
- Ice tracks can be restricted to 100 feet wide.
- Perceived channel width can be less than actual channel width, especially in the southern portions of the river.
- Up to Kingston the channel is 600 feet wide. Above Kingston the channel is 400 feet wide. Project depth is 32 feet.
- The channel is constantly shoaling, and shoaling affects a ship's movement.
- Pilots will review recent surveys, and avoid meeting in shallow areas.
- There are certain areas where commercial vessels will avoid meeting. Meeting locations are usually planned well in advance. Communication is key.

PAWSA participants identified the following existing mitigation measures related to river dimensions:

- The river was surveyed in 2016.
- Portions of the river can be shut down for shipping large equipment.
- Good communication and planning between the shipping industry and the USCG.
- Shipping companies will limit their draft based on under keel clearance calculations. If the calculations do not match reality, they will not make the trip.
- Mitigations from other categories also apply to dimensions.

PAWSA Results: Bottom Type

Bottom type in the river could have implications for environmental impacts as well as the likelihood of a vessel accident. Observations on the Hudson River bottom type included:

- The river channel bottom is usually soft. There is more sand and gravel north of Catskill.
- There are rocky outcroppings near the channel edges in areas just north and south of Kingston.
- Eel grass is in shallow areas where light meets the bottom.
- Short-nosed and Atlantic sturgeon require a hard bottom for spawning. Some areas with a hard bottom are just above Hyde Park, Poughkeepsie Yacht Club, and across from Esopus Meadows Light.

- New York State has designated some bottom types as critical habitats.[168]
- Sand wave bottoms are important habitat for sturgeon. This bottom type is near Crum Elbow.
- North of Kingston and in the Hudson Highlands is rocky and narrow.

Existing mitigation measures related to bottom type were identified as:

- The NOAA nautical charts are updated weekly, and chart discrepancies can easily be reported. NOAA quickly responds to chart discrepancies. The river was recently surveyed by NOAA.
- Bottom types are charted and publically available.
- USACE and state permits regulate submerged or overhead cables.

PAWSA Results: Configuration

The PAWSA participants identified the following safety issues regarding configuration of the Hudson River:

- There are several turns and bends greater than 45 degrees. Some of them include Four Mile Point, Bear Mountain Bridge, Worlds End, Kingston, Silver Point, Catskill, and Hudson.
- From Kingston to Albany (45 miles), it is long and narrow. There are few points to bail out; it is the point of no return.
- The Hyde Park Anchorage does not always serve as an adequate point of no return because fog conditions can quickly change north of the anchorage.
- Due to the length of the river, waterway and environmental conditions can significantly change during a transit.
- Transit time can fluctuate between 12 hours and 36 hours.
- There are two vessels that take 300 to 500 passengers from NYC to the Bear Mountain Bridge or Cold Spring.
- Recreational vessels will also make this transit over the course of several days. These transits are seasonal, usually during “leaf peeper” season.
- The length of the river is a risk. Shipping orders or assignments can change while en route to a facility.
- Many turns are greater than 45 degrees.
- Many secondary channels/creeks meet the river. For example, Rondout Creek in Kingston.

The PAWSA participants identified these risk mitigation measures related to river configuration that are already in place:

- In general, the aids to navigation are adequate.
- The quality of nautical publications has improved.
- There are no fleeting operations in the anchorages in question.
- Passing arrangements are carefully coordinated.
- Technology helps determine ideal meeting locations for vessels.
- Pilots rarely transit between Hudson and Albany at night.

[168] https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=318

PAWSA Results: Petroleum Discharge

The PAWSA participants made the following observations related to petroleum discharges in the Hudson River:

- Primary petroleum shipments are: Ethanol (2-3 trips per year), asphalt (demand driven by construction projects), gasoline, and home heating oil.
- The average barge varies, about 50,000 barrels, and the maximum is about 155,000 barrels.
- Tankers are typically carry about 80,000-220,000 barrels.
- Bakken crude shipments headed south from Albany have decreased due to crude oil prices. Some argue the decrease in shipments is due to increased rail capacity.
- Liquefied natural gas (LNG) is taking over heavy fuel oil. This may result in a decrease in petroleum shipments, but recent trends have been increasing.
- There limited locations to deploy large response equipment.
- No two spills are the same, and all responses are different. The general rule of thumb is 10-20% recovery.
- Local first responders are not capable of handling a medium or major spill.
- Most petroleum moves by tank barge. Tank barges are usually 80,000 barrels, and the largest tank barges are 150,000 bbl. Most units are articulated tug barges (ATBs).
- There are petroleum and asphalt tankers.
- Barge drafts range from 19-30 feet, depending on cargo type and amount.
- You can never clean up all the spilled oil.
- Equipment may not be provided quickly enough, and local authorities may not be experienced in spill response.

The PAWSA participants identified the following existing petroleum discharge mitigation measures:

- Response plans are well established and routinely practiced with drills. However, they will not alleviate all risk; there will be an impact if there is a major spill.
- The state has pre-staged spill response equipment and regularly conducts exercises.
- Contracted Oil Spill Response [sic] Organizations (OSROs)[169] have equipment staged throughout the entire river. The OSRO is inspected by their clients and the Environmental Protection Agency [sic].[170]
- There are several OSROs in the state, and they all work well together.
- The USCG has spill response assets and equipment.
- There are substantial federal requirements for response plans and equipment.

[169] OSROs are officially designated as Oil Spill Removal Organizations.

[170] OSRO resource inspections are the mission of the USCG as established during the 1990's "Reg-Neg" Committee deliberations. However, other agencies can and do participate, namely BSEE and the intent is that the Bureau of Safety and Environmental Enforcement (BSEE) and USCG mutually conduct OSRO inspections either as a team or one agency will accept the other agency inspection results, so as to avoid duplication as much as feasible. EPA is not precluded from inspecting OSROs, but this is not an established practice. The OSRO Classification Guidelines was developed by USCG and the classification process is overseen by USCG, periodic resource inspections included. In the New York/New Jersey area this would be primarily a USCG role as this is a region that has no BSEE activity.

- There has been a significant improvement in overall spill response capability over the past 20 years.
- The design of the vessels/barges and facilities minimizes the risk of spills.
- There are efforts underway to develop better spill modeling on the Hudson River.
- Aids to Navigation Team Saugerties has a USCG oil spill response kit.
- The Oil Spill Removal Organizations (OSROs) have response equipment staged along the river. The OSROs work together. They are annually inspected by the USCG and their clients. They serve vessels and facilities. They are well versed in emergency response operations.
- Port facilities have oil spill response equipment, and they are evaluated on their ability to use the
- equipment.
- There are large spill response exercises involving multiples agencies and stakeholders.
- The USCG maintains an area contingency plan. It covers local, state, and federal responsibilities. It is a 1000-page document that is comprehensive. The committee meets monthly.
- Vessel quality and crew training prevent spills.
- Vessels and facilities have response plans.
- There are advanced oil spill models.
- OSROs are subject to government-initiated, unannounced exercises.
- 1,000 feet of boom must be deployed within 1 hour and vacuum equipment must be on-scene within 2 hours. Tier 1equipment is well staged and would be on-scene quicker than 12 hours.
- Facilities are well lit and extensively inspected before, during, and after the offload of petroleum products.
- Petroleum offload/onload hose gaskets are replaced before every use.
- Hoses on barges are pressure tested every year and replaced every 5 years.
- The state has established geographic response plans (GRPs), and the USCG has geographic response strategies (GRSs).
- The state does training with local fire departments, and state response assets are robust.
- The USCG and state have funds dedicated to responses. These can be used if there is no responsible party (RP).
- The USCG has a national response center that manages notifications.
- Mariners must report all spills, regardless if they caused it.

The PAWSA participants identified additional potential petroleum discharge risk mitigation strategies for the Hudson River including:

- Encourage reporting of spills by the public.
- Increase types and quantities of emergency response equipment to increase response capability.
- Conduct dispersant modeling to evaluate impacts.
- Provide funding for equipment for local emergency responders.
- Display contact information to report spills on signs at small boat marinas and boat ramps.
- Improve long-range and/or contingency planning and better coordinate activities.
- Improve dialogue between waterway users, stakeholders, emergency responders and members of the general public.

- Conduct an inter-agency emergency response drill for the upper Hudson River.
- Train local responders on contents and use of the Federal Government Area Contingency Plan (ACP).

PAWSA Results: Mobility

Observations made by the PAWSA participants with regard to mobility issues on the Hudson River included:

- North of Kingston any grounding or incident would likely close the river. South of Kingston a closure would depend on the severity of the incident.
- Ice can severely restrict mobility. One vessel becoming beset in ice can stop traffic.
- Rail or facility accidents could close the river or affect marine mobility.
- West Point and Indian Point are particularly sensitive to closures.
- An incident in the Hudson Highlands could easily result in a waterway closure.
- According to modeling, a worst-case discharge (150,000 barrels of petroleum) in Kingston would spread from Saugerties to Yonkers.[171] It would impact traffic on the entire stretch because the river is narrow.
- A petroleum spill would likely result in a waterway closure.
- The river will shut down if a vessel runs aground.

Mobility-related risk mitigation measures that were identified as already being in place included:

- There is good communication amongst the pilots.
- The Captain of the Port (COTP) has broad authority to manage risks that could impact mobility. This includes establishing safety zones.
- Commerce could be shipped by road or rail, but this does not necessarily reduce risk. The road and rail infrastructure is extensive.
- There is good communication to notify mariners of port closures or interruptions. There is a formal written policy to notify traffic in the immediate area and appropriate authorities.
- State marine law enforcement training includes safety zone implementation and enforcement.
- There are multi-agency exercises that improve communication between agencies.
- Closures are continually monitored and assessed by the Captain of the Port.
- The Port of New York adds salvage and heavy lift resources.
- The USCG can activate its Marine Transportation System Recovery Unit (MTSRU).

PAWSA Results: Health and Safety

Health- and safety-related issues in the Hudson River were identified by PAWSA participants as:

- The river is the only drinking water source in the area. A serious spill could render hundreds of thousands of people without water.

[171] The ERC team had provided PAWSA participants with preliminary modeling outputs for a 150,000-bbl oil spill at Kingston.

- Perceived health and safety issues can be just as bad as an actual issue. This is particularly important for economic effects.
- Some port and waterfront facilities are located near populated areas. Even tug idling affects air quality.
- Most communities along the river are under 25,000 people. Cities such as Albany, Poughkeepsie, and Newburgh have greater populations.
- Bridge damage could affect marine and roadway safety.
- Tidal variations can impact north/south movement of a floating hazard. It can take 20+ days for an object to float from Albany to New York City due to the tide.
- There are 7 different water intakes on Hudson River. Most are near Kingston and Poughkeepsie. There are no backups for these drinking water systems.
- About 1.5 million people live on the water from Yonkers to Albany.
- Home heating oil is an important commodity. Inability to ship refined petroleum products could impact the health and safety of the region.

Existing health and safety risk mitigation measures were identified as:

- Medical and transportation infrastructure is great and well developed.
- There is a medical reserve corps that educates the public in disaster preparedness.
- New York State recently transitioned from an agency organized response to an emergency management organized response. Emergency response is one of the Governor's top priorities.
- There is an area emergency response plan that involves the local communities.
- The national response center notifies appropriate authorities.
- The state health department has water quality rapid response teams.

PAWSA Results: Environmental

The PAWSA participants identified the following environmental issues for the Hudson River:

- Atlantic sturgeon, shortnose sturgeon, and their critical habitat are federally protected by NOAA. Their critical habitat is throughout the entire river. The Fish and Wildlife Service has other federally protected species.
- Most of the river is environmentally sensitive; it is more than 50% but probably less than 90%.
- Hyde Park is a critical area for Atlantic sturgeon from May to July.
- Port Ewen is an overwintering area for shortnose sturgeon.
- Marlboro is a spawning area for shortnose sturgeon.
- Shortnose sturgeon are found all the way up Troy, and Atlantic sturgeon are found up to Kingston.
- The NY Department of State has designated significant habitat areas. There areas include Kingston, the Hudson Highlands, and the Flats. There are about 35 of these areas, and they are in the deeper portions of the river.[172]

[172] https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=318

- North of the salt line (around West Point) the freshwater estuary/wetlands are rare. These wetlands are sensitive.
- There are about 200-300 different species of fish in the river, but there also birds and mammals that could be affected.
- Haverstraw Bay is important habitat for bald eagles and common loons.
- The state has designated many areas as scenically significant.
- Anchors can damage benthic habitat.
- The river has already experienced many environmental setbacks (i.e., PCB contamination).
- The state has designated most of the river a significant habitat.
- The freshwater wetlands above the salt line are globally rare.
- There are locations, such as Con Hook and Diamond Reef, where navigational hazards are close to sensitive habitats.
- The river is the largest superfund site in the nation. It is vulnerable to pollution because it has already been polluted so much.
- Sinking oils could have serious impacts because some of the fish are benthic.
- Contrary to popular belief, the Hudson River is not healthy. The fisheries have collapsed.
- Some portions of the river have been designated essential fish habitat by NMFS.

Existing risk mitigation measures related to environmental sensitivity of the Hudson River were identified as:

- There are shore cleanup and restoration efforts underway.
- Engineering practices for coastal restoration are mature.
- Environmental mitigation measures are covered by other categories such as "Vessel Quality".
- Hudson River Emergency Management Association has collected environmental data for 20 years.
- The Hudson River Estuary Plan provides funding for stabilization and restoration.
- There is a Hudson River Comprehensive Restoration Plan: www.thehudsonweshare.org[173]
- Communities are outspoken and aware of environmental issues.
- Federal agencies complete a national restoration damage assessment to formulate restoration plans.
- The "Riverkeeper" model[174] was started at the Hudson River, and there is expertise in the area.
- There are ongoing cleanup and remediation efforts.
- The predictive modeling has aspects related to long-term environmental consequences.
- There is an ongoing effort to update the area contingency plan (ACP). Updates so far have greatly
- improved preparedness.

[173] Several not-for-profit organizations, in consultation with state and federal agencies, are working to create a comprehensive, federally recognized Hudson River Comprehensive Restoration Plan (the Plan) for the Hudson River Estuary, from the Tappan Zee Bridge to the Federal Dam at Troy. This region-wide restoration plan aims to improve the function and health of natural systems, enhance regional economic potential and increase community resiliency.

[174] https://www.riverkeeper.org/

- There are habitat maps available that outline critical habitat areas. These areas are included in the new ACP.

PAWSA Results: Aquatic Resources

Observations related to Hudson River aquatic resources included:

- The river is a spawning area for some fish species. Indirectly, the river contributes to aquatic resources throughout the Eastern Seaboard.
- Recreational fishing is important on the river.
- According to the state, Haverstraw Bay and other areas are important to recreational and commercial fisheries. These are the 35 significant habitat areas as mentioned in the "Environmental" category.
- There is a significant population that subsistence fishes.
- Striped bass is the number one recreational species in the United States. The Hudson River is one of three producing estuaries for striped bass in the United States.
- The Hudson River estuary is important for the health of fisheries along the eastern seaboard. The marshes and tidal stretches are important spawning areas for the Atlantic coast herring, striped bass, bluefish, and blue crab.
- Commercial fishing has existed on the Hudson, but it does not exist right now. Just because it does not exist, does not mean it's not important.
- Eating fish from the river can be dangerous because they are contaminated.

The PAWSA participants noted that the mitigation measures listed in the "Environmental" section are also applicable to the "Aquatic Resources" risk factor. Additional spill risk mitigation strategies related to aquatic resources that were identified by the PAWSA participants included:

- Ensure contingency plans identify sensitive area for booming.
- Place aquatic habitat and spawning locations on navigational charts.
- Expand emergency response capabilities and resources.
- Improve hazardous materials spill preventative measures in environmentally sensitive areas.
- Increase the types and quantities of emergency response equipment to increase response capability.
- Improve long-range contingency planning and better coordinate activities.
- Create a dynamic relationship between the shipping industry and fishery biologists to identify locations for anchorage areas.
- Enhance communications between the shipping industry and waterway users.
- Increase inventories of emergency response equipment.
- Expand the VTS [sic][175] in New York to cover the Hudson River to Albany to increase spill response capabilities.
- Improve capability to immediately respond and protect critical habitats.

[175] This likely was mean to read HVPA (High-Volume Port Area).

PAWSA Results: Economic

The trends and observations noted by the PAWSA participants with regard to the economic features of the Hudson River that would be affected by oil spills included:

- Many towns have dedicated money to revitalizing the riverfront habitat and parks.
- Tourism is important to the area, and it contributes $5.2 billion/year to the regional economy. Recreational boating contributes $184 million/year to the area's economy.
- Maritime commerce is significant. Issues with home heating oil, gasoline, and heavy lift shipments would be costly. Disruptions to the heavy lift equipment could have indirect impacts to other areas of the country.
- Damage to bridges would greatly affect the everyday life of local citizens.
- The river's connection to the Port of New York could result in a national impact.
- New York State ships 28 million tons of marine cargo per year. This value of shipped manufactured goods is $96.4 billion per year. This contributes $32 billion to the state's economy.
- The economy of shoreline communities is shifting from industrial manufacturing to tourism. This could make the communities more vulnerable to pollution or changes in water quality.
- Shortage of heating oil could be detrimental. There would be direct and indirect impacts.
- The river has spawning grounds and are important to fisheries along the entire eastern seaboard.
- Disruptions to home heating oil and gasoline shipments could have a regional impact. It would be difficult to find an alternative transportation system, and prices would skyrocket.
- Expensive, heavy lift cargo is also important. Some pieces of equipment are shipped internationally.
- The river is important to tourism, and tourism drives the local economy. Tourism is susceptible to river pollution.
- There is a passenger and cargo rail line on the river. An issue with the rail line could impact the waterway.
- On an average day, 5 million gallons of fuel are shipped on the river. This equates to about 400 trucks per day.
- A New York City economic study suggested barges in New York Harbor eliminated 3.1 million trucks per year.

Existing mitigation measures with respect to economic factors in the Hudson River region were identified as:

- There are robust road and rail networks in the area.
- If a third party is impacted by a spill, they can file a claim with the responsible party. If the claims exceed the liability limit, claims can be filed under the Oil Spill Liability Trust Fund (OSLTF).
- Ice breakers facilitate the movement of commerce in the winter. The Hudson River is the USCG First District's top ice breaking priority.
- There are methods to facilitate the movement of priority cargo (i.e., heating oil) in the case of an incident.
- Cargo could be rerouted to other cities.

- The MTSRU would minimize economic impact. There are thresholds and guidelines for standing up the MTSRU.
- Maintaining the marine transportation system is one of the USCG's top priorities.
- The Hudson River is extremely vital to the regional economy, and reducing all risk is difficult.
- There are not enough trucks to transport the fuel oil shipped on the Hudson River.
- The state does table top exercises that include contingency operations for port disruptions.
- The state is completing a regional resilience assessment program. It reviews every piece of energy infrastructure in the state.
- Vessels can anchor nearby and restart operations immediately.

The PAWSA participants identified additional potential economic impact risk mitigation strategies for the Hudson River including:

- Identify resources for individuals to seek compensation when they have been impacted by a spill, ensure redundancy in the supply of resources to impacted communities, increase federal and state relief funding.
- Provide education for the general public on the Oil Spill Liability Trust Fund.
- Prohibit oil laden barges to remain at anchorage in order to avoid and prevent the economic impact of spills.
- Increase the types and quantities of emergency response equipment to increase response capability.
- Increase storage capacity for heating oil reserves.
- Increase ice breaking capacity.
- Develop emergency response plans that provide for alternate heating oil transportation.
- Provide funding for equipment for local emergency responders.

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American Petroleum Association R&D Center: http://www.oilspillprevention.org/oil-spill-research-and-development-cente:

- Spill Response Planning
- Oil Sensing and Tracking
- Dispersant
- In-Situ Burning
- Mechanical Recovery
- Shoreline Protection
- Alternative Response Technologies
- Inland

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Appendix A: SCAT Oiling Classifications & Shoreline Types[176]

Shoreline Types

Table 28: Environmental Sensitivity Index (ESI) Classifications

ESI Number	ESI Classification Description
1A	Exposed Rocky
1B	Exposed, Solid Man-Made Structures
2A	Exposed Wave-Cut Platforms in Bedrock
2B	Exposed Scarps and Steep Slopes in Clay
3A	Fine- to Medium-Grained Sand Beach
3B	Scarps and Steep Slopes in Sand
4	Coarse-Grained Sand Beach
5	Mixed Sand and Gravel Beach
6A	Gravel Beach
6B	Riprap
7	Exposed Tidal Flat
8A	Sheltered Rocky Shore
8B	Sheltered, Solid Man-Made Structures
9A	Sheltered Tidal Flat
9B	Sheltered, Vegetated Low Banks
10A	Salt- and Brackish-Water Marsh
10B	Freshwater Marsh
10C	Swamp
10D	Mangrove (Scrub-Shrub Wetlands)

Exposed Rocky Shores (ESI=1A)

Description

- The intertidal zone is steep (greater than 30 degree slope) and narrow with very little width.
- Sediment accumulations are uncommon and usually ephemeral, because waves remove the debris that has slumped from the eroding cliffs.
- There is strong vertical zonation of intertidal biological communities.
- Species density and diversity vary greatly, but barnacles, snails, mussels, sea stars, limpets, sea anemones, shore crabs, polychaetes, and macroalgae can be abundant.

[176] Source: *NOAA Shoreline Assessment Manual 4th Edition*, August 2013.

Figure 47: ESI 1A: Exposed Rocky

Predicted Oil Behavior

- Oil is held offshore by waves reflecting off the steep, hard surfaces.
- Any oil that is deposited is rapidly removed from exposed faces.
- The most resistant oil would remain as a patchy band at or above the high tide line.
- Impacts to intertidal communities are expected to be short-term; an exception would be where heavy concentrations of a light refined product came ashore very quickly.

Response Considerations

- Cleanup is usually not required.
- Access can be difficult and dangerous.

Exposed, Solid Man-Made Structures ESI =1B

Description

- These are solid, man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes.
- Often there is no exposed substrate at low tide, but multiple habitats are indicated if present.
- Attached animals and plants are sparse to common.

Figure 48: Exposed Solid Man-Made

Predicted Oil Behavior

- Oil is held offshore by waves reflecting off the steep, hard surface in exposed settings.
    - Oil readily adheres to the dry, rough surfaces, but it does not adhere to wet substrates.
- The most resistant oil would remain as a patchy band at or above the high tide line.

Response Considerations

- Cleanup is usually not required.
- High-pressure water spraying may be conducted to remove risk of contamination of people or vessels, or to improve aesthetics.

Exposed Wave-Cut Platforms in Bedrock (ESI = 2A)

Description

- These shores consist of a bedrock shelf or platform of highly variable width and very gentle slope.
- The surface of the platform is irregular; tidal pools are common.
- The shoreline may be backed by a steep scarp or low bluff.
- There may be a perched beach of sand- to boulder-sized sediments at the base of the scarp.
- Small accumulations of gravel can be found in the tidal pools and crevices in the platform.
- These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities; barnacles, snails, mussels, and macroalgae are often abundant.

Figure 49: Exposed Wave-Cut Rocky Platform

Predicted Oil Behavior

- Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high tide line.
- Persistence of oiled sediments is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity.

Response Considerations

- Cleanup is usually not required.
- Where the high tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.

Exposed Scarps and Steep Slopes in Clay (ESI = 2B)

Description

- These habitats generally occur along exposed wetlands and major river tributaries in the marsh where the currents cut a steep bank into the marsh soils.
- Scarp heights vary from about 0.3 to 1 m and usually consist of a heavily rooted, peaty soil.
- May be fronted by a narrow beach of fine to medium-grained sand and/or shell fragments.
- Low biological utilization because of eroding banks.
- Typically backed by wetland vegetation.

Figure 50: Exposed Scarps and Steep Slopes in Clay

Predicted Oil Behavior

- Oil is not expected to adhere to the wet, impermeable clay surface.
- There may be a thin band of oil left at or above the high water line.

Response Considerations

- Cleanup is usually not required, because any stranded oil is quickly removed by wave action.
- Access may be difficult.

Fine- to Medium-Grained Sand Beaches (ESI = 3A)

Description

- These beaches are flat to moderately sloping and relatively hard packed.
- There can be heavy accumulations of wrack present.
- They are utilized by birds and sea turtles for nesting.
- Upper beach fauna include ghost crabs and amphipods; lower beach fauna can be moderate, but highly variable.

Figure 51: Fine- to Medium-Grained Sand Beach

Predicted Oil Behavior

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide.
- Maximum penetration of oil into fine- to medium-grained sand is about 10-15 cm.
- Burial of oiled layers by clean sand within the first week after a spill typically will be less than 30 cm along the upper beach face.
- Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infauna, which can affect shorebird foraging areas.

Response Considerations

- These beaches are among the easiest shoreline types to clean.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixing of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high tide line to the middle intertidal zone can be effective along beaches.

Scarps and Steep Slopes in Sand (ESI = 3B)

Description

- Occurs where sandy bluffs are undercut by waves or currents and slump.
- Some scarps are fronted by narrow beaches, if the erosion rates are moderate and episodic.

- Trees growing at the top of these slopes are eventually undercut and the logs can accumulate at the base of the scarp.
- Biological utilization by birds and infauna is low.

Figure 52: Scarps and Steep Slopes in Sand

Predicted Oil Behavior

- Any stranded oil will concentrate at the high-water line and may penetrate sandy sediments.
- Oil will also adhere to the dry surfaces of any logs that have accumulated at the base of the scarp.
- There is little potential for burial except when major slumping of the bluff occurs.

Response Considerations

- In many cases, cleanup is not necessary because of the short residence time of the oil.
- The need for removal of oiled sediments and debris should be carefully evaluated because of the potential for increased erosion.
- Closely supervised manual labor should be used so that the minimal amount of material is removed during cleanup.

Coarse-Grained Sand Beaches (ESI = 4)

Description

- These beaches are moderate sloping, of variable width, and have soft sediments. These characteristics combine to lower their trafficability.
- Generally species density and diversity is lower than on fine-grained sand beaches.

Predicted Oil Behavior

- During small spills, oil will be deposited primarily as a band along the high tide line.
- Under very heavy accumulations, oil may spread across the entire beach face, though the oil will be lifted off the lower beach with the rising tide.
- Penetration of oil into coarse-grained sand can reach 25 cm.

- Burial of oiled layers by clean sand can be as rapid as one tidal cycle and to depths of 60 cm or more.
- Burial to depths over 1m is possible if the oil comes ashore at the start of a depositional period.
- Biological impacts include temporary declines in in faunal populations, which can also affect important shorebird foraging areas.

Figure 53: Coarse-Grained Sand Beach

Response Considerations

- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- Efforts should focus on preventing mixing of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high tide line to the middle intertidal zone can be effective along beaches.

Mixed Sand and Gravel Beaches (ESI = 5)

Description

- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles.
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand offshore during storms.
- Because of sediment mobility and desiccation, exposed beaches tend to have low densities of attached animals and plants.
- Presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.

Figure 54: Mixed Sand and Gravel Beach

Predicted Oil Behavior

- During small spills, oil will be deposited along and above the high-tide swash.
- Large spills will spread across the entire intertidal area.
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40%.
- Burial of oil may be deep at and above the high tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves.
- In sheltered pockets on the beach, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations because most of the oil remains on the surface.

Response Considerations

- Remove heavy accumulations of pooled oil from the upper beach.
- All oiled debris should be removed; sediment removal should be limited as much as possible.
- Sediment removal should be limited as much as possible.
- Low-pressure flushing can be used to float oil away from the sediment for recovery by skimmers or sorbents. High-pressures should be avoided because of potential for transporting contaminated finer sediment (sand) to the lower intertidal or subtidal zones..
- Mechanical reworking of oiled sediments from the high tide zone to the middle intertidal zone can be effective in areas regularly exposed to wave activity. Oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers on exposed beaches.

Gravel Beaches (ESI = 6A)

Description

- Gravel beaches are composed of sediments ranging in size from pebbles to boulders.
- They can be very steep, with multiple, wave-built berms forming the upper beach.

- Attached biota are usually restricted to the lowest parts of the beach, where the sediments are less mobile.
- The presence of attached biota indicates beaches that are relatively sheltered, with the more stable substrate supporting richer biological communities.

Figure 55: Gravel Beach

Predicted Oil Behavior

- Stranded oil is likely to penetrate deeply into gravel beaches because of their high permeability.
- On exposed beaches, oil can be pushed over the high tide and storm berms, pooling and persisting above the normal zone of wave wash.
- Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves.
- On sheltered portions of beaches, chronic sheening and formation of asphalt pavements is likely where accumulations are heavy.

Response Considerations

- Heavy accumulations of pooled oil should be removed quickly from the upper beach.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low- to high-pressure flushing can be used to lift oil from the sediments for recovery by skimmers or sorbents.
- Mechanical reworking of oiled sediments from the high tide zone to the middle intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). Oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers on exposed beaches.

Riprap (ESI = 6B)

Description

- Riprap structures are composed of cobble- to boulder-sized blocks of rock, concrete, etc..

- Riprap structures are used as revetments and groins for shoreline protection and breakwaters and jetties around inlets and marinas.
- Attached biota are sparse at the upper intertidal zone, but more common in the lower intertidal.
- They are common in highly developed waterfront areas.

Figure 56: Riprap

Predicted Oil Behavior

- Deep penetration of oil between the blocks is likely, with oiling of trapped debris.
- Oil adheres readily to the rough surfaces of the blocks.
- Uncleaned oil can cause chronic leaching until the oil hardens.

Response Considerations

- When the oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective if all liberated oil is recovered.
- Heavy and weathered oils are more difficult to remove, requiring.

Exposed Tidal Flats (ESI = 7)

Description

- Exposed tidal flats are broad, flat intertidal areas composed primarily of sand and minor amounts of shell, gravel, or mud.
- The presence of sand indicates that tidal currents and waves are strong enough to mobilize the sediments.
- They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets.
- The sediments are water saturated, with only the higher ridges drying out during low tide.
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.

Figure 57: Exposed Tidal Flat

Predicted Oil Behavior

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil does not penetrate water-saturated sediments, but may penetrate the tops of the ridges and coat gravel/shell.
- Biological damage may be severe, primarily to infauna, reducing food sources for birds and fish.

Response Considerations

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup can be done only during low tide, thus there is a narrow window of opportunity.
- Use of machinery should be restricted to prevent mixing of oil into the sediments.
- Manual removal methods are preferred, though worker access may be difficult.

Sheltered Rocky Shores (ESI = 8A)

Description

- These shores are characterized by a rocky substrate that can vary widely in permeability. Of particular concern are rocky shores that have a semi-permeable veneer of angular rubble overlying the bedrock.
- The wider shores may have some surface sediments, but the bedrock is the dominant substrate type.
- Species density and diversity vary greatly, but attached biota may be present at high densities at lower tidal elevations.

Figure 58: Sheltered Rocky Shore

Predicted Oil Behavior

- Oil will adhere readily to the rough rocky surface, forming a distinct oil band along the high tide line.
- Even on wide ledges, the lower intertidal zone usually stays wet (particularly when algae covered), preventing oil from adhering to the rock surface.
- Heavy and weathered oils can cover the upper zone with little impacts to the rich biological communities of the lower zone.
- Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments.

Response Considerations

- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.
- Extreme care must be taken not to spray in the biologically rich lower intertidal zone or when the tidal level reaches that zone.
- Do not cut oiled, attached algae; use sorbents to recover oil as it is remobilized by tidal action.

Sheltered, Solid Man-Made Structures (ESI = 8B)

Description

- These are structures such as seawalls, groins, revetments, piers, and port facilities, constructed of concrete, wood, or metal.
- Most of the structures are designed to protect a single lot, thus their composition, design, and condition are highly variable.
- Often there is no exposed shore at low tide.
- There can be dense attachments of animal and plant life.

Figure 59: Sheltered, Solid Man-Made Structures

Predicted Oil Behavior

- Oil will adhere readily to rough surfaces, particularly along the high tide line, forming a distinct oil band.
- The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface.

Response Considerations

- Cleanup of seawalls is usually conducted for aesthetic reasons or to prevent leaching of oil.
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.

Sheltered Tidal Flats (ESI = 9A)

Description

- Sheltered tidal flats are composed of mud with minor amounts of sand and shell.
- They are present in calm-water habitats, sheltered from major wave activity, and frequently backed by marshes.
- The sediments are very soft and cannot support even light foot traffic in many areas.
- Large concentrations of bivalves, worms, and other invertebrates are in the sediments.
- They are heavily utilized by birds for feeding.

Predicted Oil Behavior

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Oil can strand on the flat during a falling tide if concentrations are heavy.
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows or other crevices in muddy sediments.
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the flats.

- Biological impacts may be severe.

Figure 60: Sheltered Tidal Flat

Response Considerations

- These are high-priority areas because cleanup options are limited.
- Cleanup of the flat surface is very difficult because of the soft substrate; many methods may be restricted.
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be attempted.

Sheltered, Vegetated Low Banks (ESI = 9B)

Description

- These habitats are either low banks with grasses or trees and tree roots exposed to the water.
- They are flooded occasionally by high water.

Figure 61: Sheltered, Vegetated Low Banks

Predicted Oil Behavior

- During low-water conditions there is little impact, with the oil coating a narrow band of sediment at the water level.
- During high-water conditions, the oil will cover and coat the grasses and base of trees.
- May cause loss of the grasses, but the trees should survive unless oil penetrates and persists in the substrate.

Response Considerations

- Low-pressure flushing of oiled areas is effective in removing moderate to heavy accumulations of oil from along the banks.
- Sorbent and containment boom should be placed on the water side of the cleanup operations to contain and collect oil outflow.
- Low- to high-pressure flushing can be used to remove oil from tree roots and trunks, if deemed necessary in high-use areas.

Salt-and Brackish-Water Marshes (ESI = 10A)

Description

- These are intertidal wetlands that consist of emergent, herbaceous vegetation. Depending on location and inter-annual variations in rainfall and runoff, associated vegetation may include species tolerant of or adapted to salt, brackish, or tidal freshwater conditions.
- The marsh width may vary widely, from a narrow fringe to extensive areas.
- Sediments are composed of organic-rich mud except on the margins of islands or along rivers.
- where sand is abundant.
- Exposed areas are located along bays with wide fetches and along heavily trafficked waterways.
- Sheltered areas are not exposed to significant wave or boat wake activity.
- Resident flora and fauna are abundant with numerous species with high utilization by birds, fish, and shellfish.

Figure 62: Salt-and Brackish-Water Marsh

Predicted Oil Behavior

- Oil adheres readily to the vegetation of most species.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation; there may be multiple bands.
- Large slicks will persist through multiple tidal cycles and coat the entire stem from the high tide line to the base.
- Heavy oil coating will be restricted to the outer fringe of thick vegetation, although lighter oils can penetrate deeper, to the limit of tidal influence.
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows.
- Light oils can penetrate the top few centimeters of sediment; under some circumstances oil can penetrate burrows and cracks up to 1 m.

Response Considerations

- Under light oiling, the best practice is natural recovery.
- Natural removal processes and rates should be evaluated prior to conducting cleanup.
- Heavily pooled oil can be removed by vacuum, sorbents, or low-pressure flushing.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity must not mix the oil deeper into the sediments; trampling of the roots must be minimized.

Freshwater Marshes (ESI = 10B)

Description

- These are grassy wetlands composed of emergent herbaceous vegetation.
- They occur upstream of brackish vegetation in the upper estuary and along creeks and rivers.
- Those along major channels are exposed to strong currents and boat wakes; smaller channels tend to be sheltered.
- Resident flora and fauna are abundant.

Figure 63: Freshwater Marsh

Predicted Oil Behavior

- Oil adheres readily to the vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation; there may be multiple bands.
- Most of the time, there will be a narrow band because of the small changes in water levels; the band can be very large during high-water events.
- Heavy oil coating will be restricted to the outer fringe of thick vegetation, although lighter oils can penetrate deeper.

Response Considerations

- Under light oiling, the best practice is natural recovery.
- Natural removal processes and rates should be evaluated prior to conducting cleanup.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized.
- Aggressive cleanup methods should be considered only when other resources present (listed species, nesting birds) are at great risk from leaving the oiled vegetation in place.

Swamps (ESI = 10C)

Description

- Swamps consist of shrubs and hardwood forested wetlands, essentially flooded forests.
- Vegetation is taller, on average, than 6 m.
- The sediment tends to be silty clay with large amounts of organic debris.
- They are seasonally flooded, though there are many low, permanently flooded areas.
- Resident flora and fauna are abundant with numerous species.

Figure 64: Swamp

Predicted Oil Behavior

- Oil behavior depends on whether the swamp is flooded or not.
- During floods, most of the oil passes through the forest, coating the vegetation at the waterline, which changes levels throughout the flood event.
- Oiled woody vegetation is less sensitive than grasses to oil coating.
- Some oil can be trapped and pooled on the swamp flood plain as water levels drop.
- Penetration into the floodplain soils is usually limited because of high water, saturated soils, muddy composition, surface organic debris, and vegetation cover.
- Large amounts of oily debris can remain.
- During dry periods, terrestrial spills flow downhill and accumulate in depressions or reach waterbodies.

Response Considerations

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing.
- Under stagnant water conditions, herding of oil with water spray may be needed to push and thicken oil to collection areas.
- Oily debris can be removed where there is access.
- Any cleanup activity must not mix the oil deeper into the sediments.

Mangroves (Scrub-Shrub Wetlands) (ESI = 10D)

Description

- Roots and trunks are typically intertidal; the lower leaves are flooded at high tide.
- The width of the forest can vary from one tree, to many kilometers.
- The substrate types can include mud, sand, leaf letter, or peat, often as a veneer over bedrock.
- Wrack accumulations can be very heavy.
- They are highly productive, serve as nursery habitat, and support a great diversity of animal and plant species.

Figure 65: Mangrove (Scrub-Shrub Wetland)

Predicted Oil Behavior

- Oil can wash through mangroves if the oil comes ashore at high tide.
- If there is a berm or shoreline present, oil tends to concentrate and penetrate into the sediments or accumulated wrack/litter.
- Heavy and emulsified oil can be trapped in thickets of mangrove prop roots or dense young trees.
- Oil readily adheres to prop roots, tree trunks, and pneumatophores.
- Re-oiling from re-suspended or released oil residues may cause additional injury over time.
- Oiled trees may start to show evidence of effects (leaf yellowing) days to weeks after oiling; tree mortality may take months, especially for heavy oils.

Response Considerations

- Oiled wrack can be removed once the threat of oiling has passed. Wrack can actually protect the trees from direct oil contact.
- Sorbent boom can be placed in front of oiled forests to recover released oil.
- In most cases, no other cleanup activities are recommended.
- Where thick oil accumulations are not being naturally removed, low-pressure flushing or vacuum may be attempted at the outer fringe.
- No attempt should be made to clean interior mangroves, except where access to the oil is possible from terrestrial areas.
- It is extremely important to prevent disturbance of soft substrates by foot traffic; thus most activities should be conducted from boats.

Shoreline Oil Distribution Categories

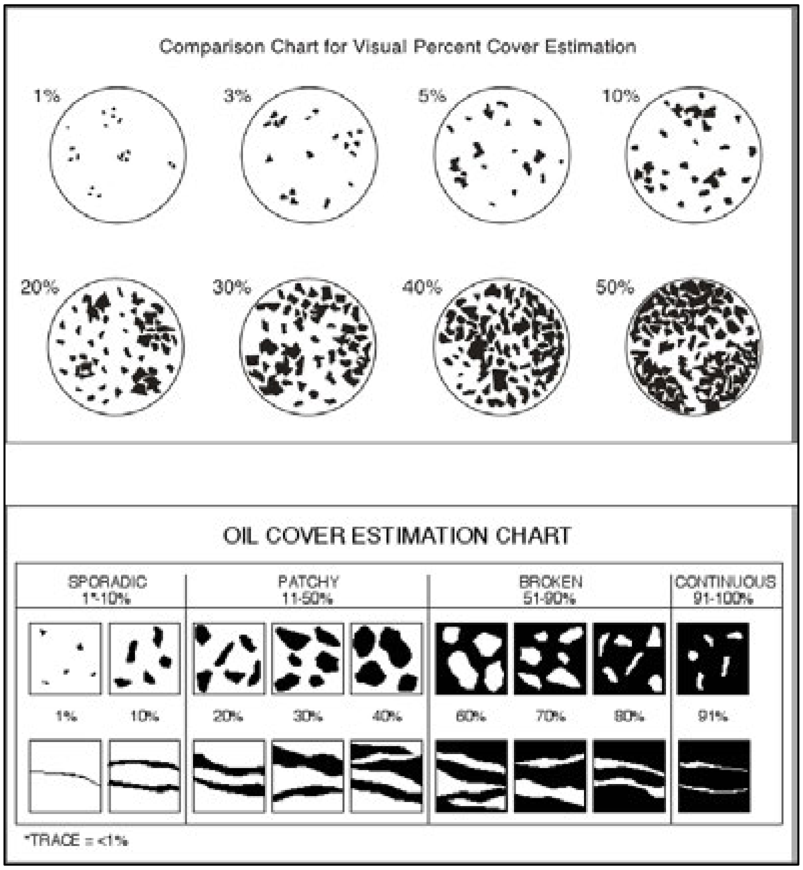

Figure 66: Oil Cover Estimation Charts[177]

Figure 67: Continuous Shoreline Cover (91 – 100%)

[177] Source: Owens and Sergy 2000.

Figure 68: Broken Shoreline Cover (51 – 90%)

Figure 69: Patchy Shoreline Cover (11 – 50%)

Figure 70: Sporadic Shoreline Cover (1 – 10%)

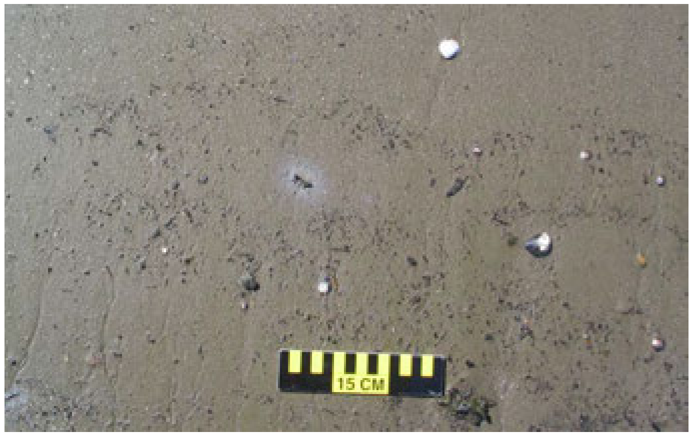

Figure 71: Trace Shoreline Cover (<1%)

Oil Thickness Categories

Figure 72: Thick Oil (Fresh Oil or Mousse >1 cm Thick)

Figure 73: Cover Oil Thickness (Oil or Mousse from >0.1cm to <1 cm)

Figure 74: Coat Oil Thickness (Visible Oil <0.1 cm that can be Scraped with Fingernail)

Figure 75: Stain Oil Thickness (Visible Oil that cannot be Scraped with Fingernail)

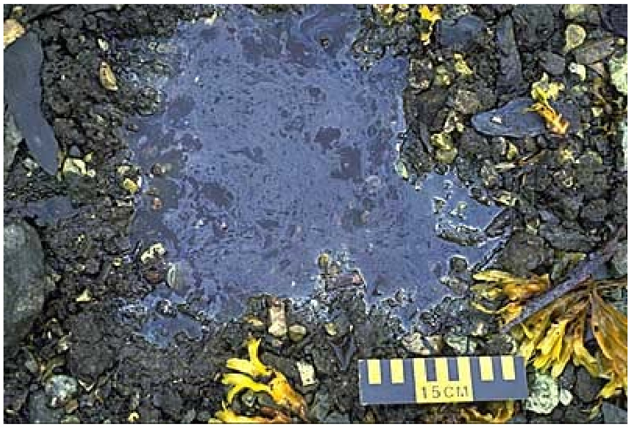

Figure 76: Film Oil Thickness (Transparent or Iridescent Sheen, or Oily Film)

Surface Oiling Descriptors

Figure 77: Fresh Oil (Unweathered Liquid Oil)

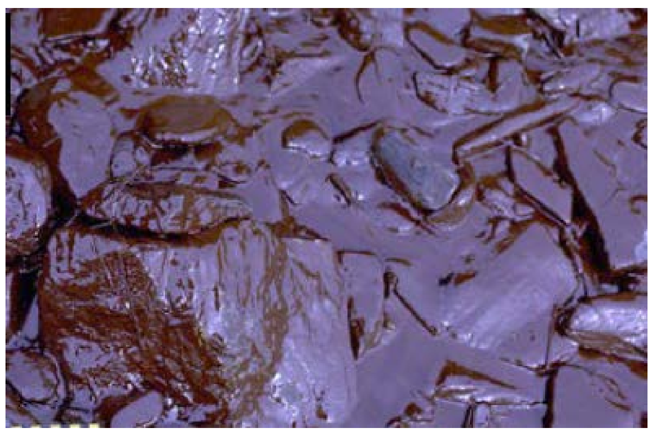

Figure 78: Mousse (Emulsified Oil)

Figure 79: Tar Balls (Discrete Accumulations of Oil <10cm in Diameter)

Figure 80: Patties (Discrete Accumulations of Oil >10cm in Diameter)

Figure 81: Tar (Highly Weathered Oil of Tarry, Near Solid Consistency)

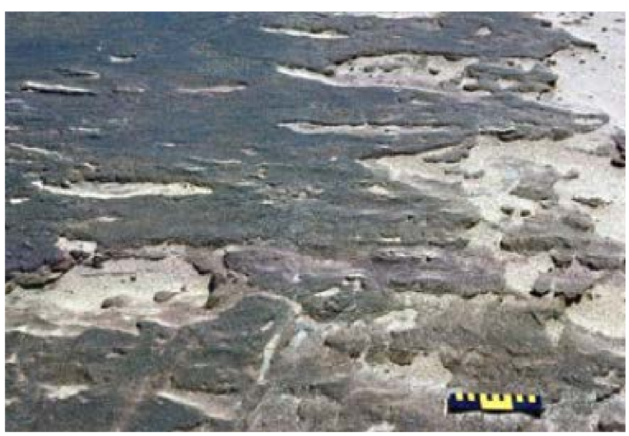

Figure 82: Surface Oil Residue (Non-Cohesive, Heavily Oiled Surface Sediments)


Figure 83: Asphalt Pavement (Cohesive, Heavily Oiled Surface Sediments)

Appendix B: New York/New Jersey Classified OSROs[178]

COTP Zone: New York – District 1 – High Volume Port

Table 29: OSRO Ken's Marine Service, Inc. #2

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●		●	●	●	

Table 30: Marine Pollution Control Corporation #2

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal			●	●			●	●
Inland			●	●			●	●

Table 31: OSRO Lewis Environmental Group #3

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●		●	●	●		●	●
Inland	●			●	●		●	●

Table 32: Oil Mop Inc. #12

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal			●	●	●	●	●	●
Inland				●	●		●	●

Table 33: Clean Harbors Environmental Service #13

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●	●	●	●	●	●	●	●
Inland	●		●	●	●		●	●

Table 34: National Response Corporation #16

Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●
Ocean			●	●	●	●	●	●
Nearshore	●	●	●	●	●	●	●	●
Offshore	●	●	●	●	●	●	●	●

[178] Source: USCG Response Resource Inventory System (RRI), https://cgrri.uscg.mil/UserReports/WebClassificationReport.aspx

Table 35: Miller Environmental Group #20								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●

Table 36: Marine Spill Response Corporation #22								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●
Ocean	●		●	●	●	●	●	●
Nearshore	●		●	●	●	●	●	●
Offshore	●		●	●	●	●	●	●

Table 37: Clean Harbors Cooperative #30								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●

Table 38: Heritage Environmental Services, Inc. #45								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal			●	●			●	●

Table 39: Clean Venture, Inc. #46								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●				●			

Table 40: All State ORC #87								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●				●			

Table 41: Atlantic Response Inc. #137								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●				●			
Inland	●				●			

Table 42: T&T Marine Salvage, Inc. #115								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal			●	●			●	●
Inland			●	●			●	●
Ocean				●				●
Nearshore				●				●
Offshore				●				●

Table 43: EQ Terminal Services, LLC #150								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●				●			
Inland	●				●			

Table 44: Moran Environmental Recovery #151								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●

Table 45: Allstate Power Vac #155								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●	●	●	●	●	●	●	●
Inland	●				●			

Table 46: Environmental Restoration, LLC #156								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal			●	●			●	●
Inland			●				●	

Table 47: Alpine Environmental Services LLC #177								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal	●				●			
Inland	●				●			

Table 48: Environmental Management Specialists, Inc. #473								
Operating Environment	Facility MMPD	Facility WCD1	Facility WCD2	Facility WCD3	Vessel MMPD	Vessel WCD1	Vessel WCD2	Vessel WCD3
River or Canal			●	●			●	●
Inland							●	

COTP Zone: New York (Albany) – District 1

Table 49: Oil Mop Inc. #12								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal			●	●	●	●	●	●
Inland				●	●		●	●

Table 50: Clean Harbors Environmental Services #13								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●		●	●	●	●	●	●

Table 51: National Response Corporation #13								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●
Ocean			●	●	●	●	●	●
Nearshore	●	●	●	●	●	●	●	●
Offshore	●	●	●	●	●	●	●	●

Table 52: Miller Environmental Group #20								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●

Table 53: Marine Spill Response Corporation #22								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal	●	●	●	●	●	●	●	●
Inland	●	●	●	●	●	●	●	●
Ocean	●		●	●	●	●	●	●
Nearshore	●		●	●	●	●	●	●
Offshore	●		●	●	●	●	●	●

Table 54: Heritage Environmental Services, Inc. #45								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal			●	●	●		●	●
Inland					●		●	

Table 55: Environmental Restoration, LLC #156								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal			●	●	●		●	●
Inland			●		●		●	●

Table 56: Environmental Management Specialists, Inc. #473								
Operating Environment	**Facility MMPD**	**Facility WCD1**	**Facility WCD2**	**Facility WCD3**	**Vessel MMPD**	**Vessel WCD1**	**Vessel WCD2**	**Vessel WCD3**
River or Canal			●	●	●	●	●	●
Inland					●		●	