NUKA RESEARCH AND PLANNING GROUP, LLC

Permitting the Use of Oil Spill Simulants: Identifying Options and Building Consensus
Final Report

April 30, 2015

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Table of Contents

Executive Summary

Permitting the Use of Oil Spill Simulants: Identifying Options and Building Consensus (#E13PS00032) was funded by the Bureau of Safety and Environmental Enforcement (BSEE) to advance the issue of using oil simulants and surrogates for oil spill response preparedness. Nuka Research and Planning Group, LLC (Nuka Research) implemented the project from October 2013 – June 2015.

The goal of the project was to identify oil simulants and surrogates used nationwide and develop a permit for the use of simulants for oil spill training and exercises, fate and behavior studies, and research and development in addition to testing the detection and recovery of oil under Arctic sea ice. A national work group was convened to clarify the federal requirements and limitations for using oil simulants and surrogates to support research and development of technologies to detect or recover oil in the Arctic and, potentially, other marine regions.

The work group first defined oil simulants and surrogates and other terms for the purposes of the project. They then provided information that was compiled with the results of a literature review into a Discussion Document summarizing the current state of knowledge of the use of simulants and surrogates in the U.S. and internationally. The work group also developed Decision-making Guide for oil simulant or surrogate use in research and exercises, which was presented to the National Response Team. The Discussion Document and Decision-making Guide explain the role of simulants and surrogates and guide users through choosing a release material. Both can assist future policy considerations and development and be referenced and expanded upon in future work.

Documentation of simulant and surrogate use in U.S. is sparse and permitting approaches vary by state. While a wide range of surrogate materials have been used, to date there is no known oil *simulant* that has been used to mimic the behavior or recovery of oil spilled to U.S. waters. This project highlighted the need for such information to be documented and consolidated going forward to inform the future selection and permitting of materials for the benefit of oil spill preparedness.

The project was modified to focus strictly on consolidating knowledge on the use of simulant and surrogate materials, without the permit application process. Although the project was not able to produce a test permit, the work group was successful in compiling and documenting available information and collective knowledge about past and ongoing use of oil surrogates by the U.S. oil spill response community.

The project resulted in the following recommendations:

- Continue to refine state-of-knowledge regarding oil simulant or surrogate materials by documenting future use.
- Better characterize simulant materials.
- Develop an environmentally benign oil simulant material.
- Finalize and test a permitting process for surrogate or simulant use.
- Circulate the Decision-making Guide for broader review.

1.0 Introduction

Permitting the Use of Oil Spill Simulants: Identifying Options and Building Consensus (#E13PS00032) was funded by the Bureau of Safety and Environmental Enforcement (BSEE) to advance the issue of using oil simulants and surrogates for oil spill response preparedness. Nuka Research and Planning Group, LLC (Nuka Research) implemented the project from October 2013 – June 2015.

1.1 Project Overview

The original goal of the project was to identify oil simulants and surrogates used nationwide and develop a permit for the use of simulants for testing the detection and recovery of oil under Arctic sea ice. The project was subsequently modified to focus strictly on consolidating knowledge on the use of simulant and surrogate materials, without the permit application process. The project resulted in the development of a Discussion Document (Appendix A) and Decision-making Guide (Appendix B) that was presented to the National Response Team. A list of resources compiled for the project is provided as Appendix C.

The project included the following key tasks:

- **Establish and facilitate a national work group.** Representatives of public and private entities concerned with oil spill response preparedness convened throughout the project to provide input to all project tasks.
- **Clarify regulatory context for permitting oil simulants and surrogates.** A Discussion Document was developed that captured the current state-of-knowledge regarding oil simulant and surrogate use and permitting in the U.S. and worldwide.
- **Develop test permit.** The intention of the test permit was to navigate standing federal, state, and local permitting requirements and request permission for a surrogate or simulant release to the U.S. Arctic Ocean. Due to external circumstances, this project task was removed and the scope of work was modified with agreement from the work group and BSEE.
- **Develop Oil Surrogate or Simulant Release Decision-making Guide.** A Decision-making Guide was developed to support decision-making for potential releases of simulant or surrogate materials in U.S. waters.
- **Present to National Response Team's (NRT) Science and Technology (S&T) Committee.** The Decision-making Guide was presented to the NRT S&T Committee to frame a broader discussion of the role of simulants and surrogates within the National Response Framework.

Project deliverables also included quarterly progress reports, workgroup meeting documentation, an internal project website, a peer-reviewed journal submission (pending completion by June 2015), and this final report.

The project was conducted from October 2013 – June 2015.[1] The workgroup was active from December 2013 – February 2015.

[1] The draft peer reviewed paper remains as the final deliverable following acceptance of this final report.

1.2 Foundational Work

This project builds on two previous initiatives: (1) an Oil Spill Simulation Materials Review in 2008 and (2) an Oil Simulants Workshop hosted by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC), the Oil Spill Recovery Institute (OSRI), and the Spill Control Association of America (SCAA) in 2013.

PWSRCAC commissioned the Oil Spill Simulation Materials Review (SAIC, 2008) as the first compilation and comparison of oil simulant and surrogate materials available for use during training exercises. The study also contained a preliminary exploration of permitting requirements for oil simulants and surrogates with a focus on Alaska.

In March 2013, PWSRCAC, OSRI, and SCAA hosted a high-level workshop of national experts to address key questions regarding the potential permitting and use of oil simulants in U.S. waters. The workshop was the culmination of a six-month workgroup process that brought together government and industry professionals with knowledge and experience in oil spill response, research and development, spill modeling, and regulatory oversight. Many of the participants from that first work group continued their efforts by joining the work group convened under this BSEE project.

While national in scope, the 2013 Oil Simulant Workshop project was spearheaded in Alaska, where stakeholders and regulators had recognized the need for a simulant material to enhance oil spill preparedness. The workshop concluded with a consensus among attendees that there is a need for simulants to facilitate advances in oil spill response technologies, research and development, and training. There was also agreement that the current permitting regime is uncertain and untested, and that a pilot project that attempted to obtain a federal permit to use oil simulants in a field setting was needed. The workshop participants also agreed that there was a need to include oil simulants in the national response framework (Nuka Research, 2013).

1.3 Organization of this Report

This report summarizes the project activities and results. Subsequent sections describe the work group (Section 2), provide background information on the use of simulants and surrogates for oil spill preparedness worldwide (Section 3) and regulatory context in the U.S. (Section 4), and describe the Decision-making Guide (Section 5) and presentation to the National Response Team (Section 6). Section 7 provides discussion and recommendations. Three appendices incorporate interim project deliverables: the Discussion Document (Appendix A); the Decision-making Guide (Appendix B); and a compendium of research and reference materials (Appendix C).

2.0 Simulants Work Group

Nuka Research convened and facilitated a work group of oil spill response regulators and practitioners to direct project tasks, including the development of the Discussion Document and the Decision-making Guide.

2.1 Selection and Outreach

The workgroup included participants from the 2013 Oil Simulants Workshop as well as new members invited for this project. The entire project was contingent on securing subject matter experts to serve on the work group. Members represented the Association of Petroleum Industry Cooperative Managers (APICOM), National Oceanic and Atmospheric Administration (NOAA), Spill Control Association of America (SCAA), and U.S. Coast Guard (USCG). These agencies had been previously identified through the 2008 report and 2013 workshop described in Section 1.2 as key players to navigate a federal permitting process for oil simulants and surrogates. Work group members and their relevant expertise are listed in Table 1.[2]

Table 1. Work Group Participants

Organization	Representatives	Area of Expertise
U.S. Coast Guard Office of Marine Environmental Response Policy (USCG-MER)	William Vocke LT Sara Booth LT Rhianna Macon CAPT Claudia Gelzer	U.S. federal policy on oil spill response preparedness; National Response Framework
U.S. Coast Guard Research and Development Center	Kurt Hansen	Mechanical oil spill response technology development; drills and exercises
National Oceanic and Atmospheric Administration (NOAA), Division of Response and Restoration	Ed Levine Elizabeth Kretovic Dave Westerholm Debbie Payton	Scientific support of spill response; Modeling; National Response Team Science & Technology Committee; Liaise with federal permitting authorities (fisheries, marine mammals)
Association of Petroleum Industry Cooperative Managers (APICOM)	Lee Majors Ken Linderman Chris Hall	Oil spill response technologies; Alaska North Slope operations
Spill Control Association of America (SCAA)	Brian House John Silva	Spill response technologies; oil spill removal organization training and response needs
Bureau of Safety and Environmental Enforcement	Lori Medley	Contract Officer Representative BSEE; Oil spill response research

2.2 Work Group Process

Work group members actively represented their agency or organization in discussions relating to oil simulant and surrogate use in U.S. waters.

Work group communication was conducted via email, teleconferences, webinars, and one in-person meeting to discuss issues, share updates, and advance the project by providing guide and feedback on project deliverables and process. Meeting details and supplementary materials were sent to each work group member via listserv. Details of each project meeting are provided in Table 2. An internal project website was used to organize meeting information, draft and final project deliverables, and relevant reports and articles.

[2] The U.S. EPA was an initial participant in the workgroup but later withdrew.

Table 2. Work Group Meetings

Meeting Date	Purpose of Meeting
January 31, 2014	Articulate project goals and establish project work plan
March 31, 2014	Identify consensus items, identify an approach to gain NRT support, and consider candidate substances and process for permitting oil simulant or surrogate
May 5, 2014 (In-person Meeting)	Review permit research on state and international oil simulant and/or crude oil releases and discuss what should be considered for a federal permitting process
August 12, 2014	Finalize Discussion Document, review draft Decision-making Guide, and discuss updated status of permit application
September 19, 2014	Review revised draft Decision-making Guide and discuss status of presenting project progress to NRT S&T Committee
November 4, 2014	Review revised draft Decision-making Guide, establish a timeline and plan for presenting to NRT S&T Committee, and discuss future of permitting component of the project
December 11, 2014	Review the revised draft Decision-making Guide and finalize it as a project deliverable, plan for presentation to NRT S&T Committee, and discuss goals and timeline for project completion

3.0 Background of Oil Spill Simulants and Surrogates

This section discusses associated terminology, the role of simulants and surrogates in different aspects of oil spill prevention and response, and typical materials used to fulfill these roles.

3.1 Terminology

The work group developed the following standard definitions regarding oil simulants and surrogates. These were eventually incorporated into the Decision-making Guide.

- **Oil Simulant:** A non-oil substance with physical and/or chemical characteristics that closely mimics the fate and behavior of oil released to a water body. Oil simulants are not petroleum oil, but may include non-petroleum oils. There is no documented evidence that oil simulants have been released in U.S. waters because available simulants are all considered oils and therefore prohibited for release under the Clean Water Act (Clean Water Act of 1972).
- **Oil Surrogate:** A substance that does not necessarily share the physical or chemical characteristics of oil but when released into the environment would represent the movement of oil released to a water body. Oil surrogates may be liquid or particles, but are more commonly particle based.

3.2 Role of Oil Simulants and Surrogates

The work group also developed terms to describe the primary uses of oil spill simulants or surrogates:

- **Research and Development:** Encompasses all tests or experiments that are performed to evaluate the performance of oil spill response technologies, equipment, or techniques.
- **Training and Exercises:** Field activities during which practical aspects of oil spill response is exercised to achieve specific objectives related to response techniques, responder proficiency, equipment performance, logistics, or other related topics.
- **Oil Spill Fate and Behavior Studies:** Scientific or practical research projects that aim to improve the understanding of the fate and behavior of oil, including transformation and transport tendencies – both physical and chemical – when spilled or released into the water.

3.3 Materials Used as Oil Surrogates and Simulants

Based on the definitions used in the project, many different materials have been used as oil surrogates in the U.S., but the work group was not aware of any uses of oil simulants to date.

3.3.1 Oil Surrogate Materials

The following surrogate materials have a history of use in the U.S., based on a review of professional literature and information gathered from practitioners:[3]

- **Algae or seaweed (may be ground into sludge)**
- **Bagasse (fibrous remnants of sugarcane or sorghum processing)**
- **Citrus fruit (oranges are preferred)**
- **Coir (coconut fibers)**
- **Cork**
- **Dog food**
- **Drift cards**
- **Dyes**
- **Evergreen needles**
- **Hay**
- **Organic materials (naturally occurring local organic materials)**
- **Peanut shells**
- **Peat moss**
- **Perlite**
- **Popcorn**
- **Protein-based foam**
- **Rice hulls**
- **Sunflower seeds**
- **Wood chips**

Materials most commonly used as oil surrogates include oranges, peat moss, and fluorescent dye (Nuka Research, 2013; SAIC Canada, 2008).

[3] This is not an exhaustive list of all potential oil simulant and surrogate materials, but based on written and anecdotal information from work group members.

3.3.2 Potential Oil Simulant Materials

The literature lists canola and rapeseed oil as potential oil simulants, but there are no documented intentional releases of these or other vegetable oils in U.S. waters in the context of oil spill field studies. As part of an ongoing BSEE-funded study, EPA Region 5 is working on an environmentally benign oil simulant to mimic the behavior of dispersed oil in the environment (Conmy, 2015). The University of Utah has also been awarded a patent for an oil simulant, but there is no indication that this has been released to U.S. waters to date (USPTO, 2009).

4.0 U.S. Regulatory Context for Permitting Use of Oil Spill Simulants and Surrogates

No state or federal statute stipulates permitting authority explicitly for oil simulants or surrogates; however, protecting the U.S. waters from various types of pollutants falls under both state and federal agency jurisdiction depending on location and other factors. With the 2013 workshop as a starting point (Nuka Research, 2013), Nuka Research developed a brief summary of state and federal requirements and presented this summary to the work group for review and input. The Discussion Document (Appendix A) summarized the results of a literature review and firsthand research (interviews with researchers and practitioners) to compile available information about parameters and processes that have been used by other jurisdictions in evaluating, granting, waiving, or denying permits for intentional releases of oil, simulants, and surrogates. Because there were few examples of permitting in the U.S., research was expanded internationally. Research focused on permitting activities within the past decade, although some older examples were considered.

4.1 Domestic Use and Permitting

4.1.1 Federal

The work group was unable to specify a clear federal permitting process for oil simulants or surrogates. The foundational work discussed in Section 1.2 and initial work group meetings resulted in a consensus that multiple federal agencies have some authority over permitting surrogate or simulant releases, including U.S. Environmental Protection Agency (EPA)'s authority under the Clean Water Act (Sections 311 and 301), NOAA's authority under the Endangered Species Act, Marine Mammal Protection Act, Marine Protection, Research, and Sanctuary Act (Ocean Dumping Act), and Marine Debris Research, Prevention, and Reduction Act.

Federal guidelines for permitting intentional releases (U.S. EPA, 2001) outline requirements for the release of oil for scientific research; however, these guidelines are presently undergoing internal agency review.

4.1.2 State

Oil surrogates have been released for oil spill research and development and for training and exercises in several states, both with and without permitting processes or formal documentation. Work group members and others offered examples of the release of surrogates including fluorescein dye, oranges, peat moss, rice hulls, and dog food. For example, several oil surrogate releases have taken place in California marine waters, including releases of fluorescein dye (Nuka Research, 2013) and fruits and vegetables (Watabayashi, 2014). Geographic response plan and geographic response strategy field exercises are held in many coastal states, and surrogates are often used to evaluate booming arrays (SAIC, 2008). In some instances, written permits were issued by state authorities; in other instances verbal authorizations were obtained from state or federal authorities (USCG, 2011; USCG, 2012). A full list of written permitting documentation is included in Appendix C.

The work group identified three written examples of state level permits for the use of oil surrogates: Alaska, Maine, and Michigan (see Table 3). Some surrogate materials are released without permits, while others have blanket permits that make it difficult to track individual releases. The last column in the table identifies the considerations cited in determining whether to issue a permit.

Table 3. Examples of U.S. State Permits for Oil Surrogates

Activity and Location	Substances Released	Permitting Authority	Major Considerations
Alaska North Slope, Alaska Clean Seas Summer Oil Spill Containment and Recovery Activities (1992 - Ongoing)	Fluorescent Dye and Peat Moss	Alaska Dept. of Natural Resources under AS 16.05.871 and AS 16.05.841	***Toxicity*** ▪ Provide MSDS for substances released ***Environmental impacts*** ▪ Consider effects for birds and wildlife, even if substance is biodegradable ***Receiving environment*** ▪ Streams only
Maine (Penobscot River, Scarborough River, Upper Damariscotta River) Geographic Response Plan Deployment Exercises (2012)	Oranges and Peat Moss	Maine Dept. of Environmental Protection, Water Statutes (Title 38), 362-A	***Volume*** ▪ Limited quantities ***Accountability and oversight*** ▪ "Under strict control of the commissioner or the commissioner's designees" ***Purpose*** ▪ Scientific research & experimentation
Michigan USCG Michigan Oil-On-Ice Spill (2012, 2013)	Oranges and Peat Moss	Michigan Dept. of Environmental Quality, Rule 97 of Michigan's Water Quality Standards	***Volume*** ▪ Small amounts ***Toxicity*** ▪ Considered MSDS and toxicity of the substance given concentration into water ***Receiving environment*** ▪ Distance offshore ***Environmental impacts*** ▪ Proximity to wildlife/environments that could be affected ***Accountability and oversight*** ▪ Coast Guard assuming liability as lead agency

4.2 International Use and Permitting

Some countries, most notably Norway, have a history of using intentional oil spills to test equipment, conduct exercises, and study the fate and transport of oil. An initial search of published literature provided limited examples of permitted intentional oil releases in Norway, Canada and the United Kingdom (Fisheries and Oceans Canada, 2013; Foley, 2014; Government of Canada, 2007; NOFO, 2014). Additionally, both surrogates and intentional oil releases are used in other countries. An example is the use of perlite as an oil simulating substance in Poland, although the exercise report document did not specify the permitting process for the release (HELCOM, 2006).

4.3 Similarities in Permitting Examples

The permitting parameters listed in Table 4 were identified as being similar across the limited permitting examples identified for oil simulants, surrogates, or the intentional release of oil.

Table 4. Sample Permitting Parameters

Considerations	Examples of Evaluation Factors
Environmental Impacts	▪ Proximity to seabirds ▪ Proximity to other sensitive receptors or environments ▪ Potential to disturb environmental resources ▪ Potential for adverse wildlife impacts
Toxicity	▪ Published information about environmental toxicity and human health effects (e.g. MSDS) ▪ Concentration of substance in water body ▪ Professional discretion ▪ Naturally-occurring vs. chemically-derived
Volume Released	▪ Volumetric limits typically established in permit ▪ Minimize total volume released ▪ Set volume limits based on experimental design
Receiving Environment	▪ Distance from shoreline ▪ Time and location of release ▪ Permitting body may influence type of water body or location of release (based on jurisdictional authorities, e.g. ADNR permit for streams only) ▪ Water depth ▪ On-scene weather conditions
Purpose	▪ Scientific research ▪ Credible oil spill risks (e.g. Alaska permit is tied to ongoing oil and gas activities) ▪ Improving oil spill response techniques and technologies ▪ Training value ▪ Demonstration of technology ▪ Economic benefits ▪ Specificity of activities to be conducted and their purpose

Accountability and Oversight	▪ Ability to remove or collect material released ▪ Notification of potentially impacted parties (e.g. fishing vessels, local residents, etc.) ▪ Notification of authorities not directly involved in permitting ▪ Documentation and reporting ▪ Inclusion of oil spill response organizations ▪ Previous permit approvals ▪ Partner jurisdiction approval

5.0 Decision-making Guide for Oil Simulant and Surrogate Releases

The Decision-making Guide (Appendix B) was developed to help researchers and spill responders determine the best available simulant(s) or surrogate(s) to use for a given purpose and to inform agency decision-making when considering approval of such activities. It provides an outline of a four-step process, shown in Figure 1 and summarized in this section.

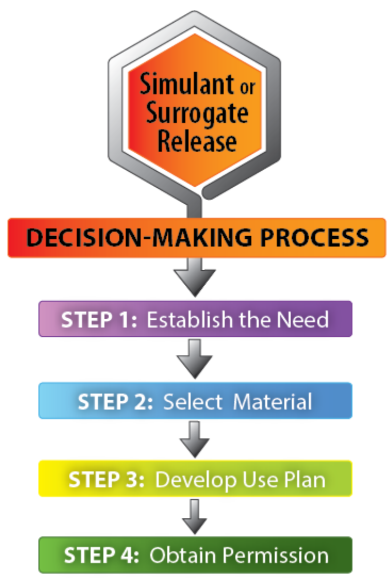

Figure 1. Four-step process described in Decision-making Guide

5.1 Establishing the Need for Surrogates and Simulants

Step 1 in the decision-making process is to establish the need for a release. The purpose of this step is to help a potential user determine whether a surrogate or simulant release to U.S. waters is necessary. The work group reviewed all the information gathered on oil simulant and surrogate permitting and releases to determine criteria that should be considered before making the choice to release a material into the environment.

The first consideration is the purpose of the release: Research and Development, Training and Exercises, or Oil Spill Fate and Behavior. For decision-making on releases for Research and Development, it is important to ensure that any foundational studies, such as proof-of-concept trials in controlled environments, are completed prior to a field trial with oil simulant or surrogate release.

The objectives of a release are also important to consider and should be specific and measureable. All viable alternatives should be considered; other approaches such as laboratory trials, computer simulations, tank test experiments, or field trials could be preferred means of achieving the same objectives. The user should consider if there are net environmental or economic benefits to conducting a release.

5.2 Considerations for Selecting Materials

Step 2 established considerations for selecting the oil simulant or surrogate material to release. The preferred material will vary depending on the intended use; location; and purpose of the test, exercise, or drill. As in Step 1, the first consideration for selecting a suitable material is the purpose of the release. From there, users should determine the suitability of the material by considering the specific technologies, tactics, or equipment being applied, the benefits of liquid versus particle-based materials, and which properties of oil are most important to mimic (i.e. spreading, clumping, buoyancy, trajectory, emulsification, and visibility).

After determining the suitability of a material based on the objectives of the release, the Decision-making guide suggests practical considerations, such as deployment method, feasibility of retrieval, degradation or persistence in the environment, particle size, toxicity, and previous examples of domestic use. Cost and availability should also be considered.

5.3 Development of Use Plan

The Oil Simulant and Surrogate Use Plan, or Step 3, was created as a planning tool to assist with the decision-making process and provides a fill-in-the-blank form to compile and organize information specific to the intended release. The form parallels the flow charts in Steps 1 and 2 and prompts the user to document the purpose of the release, determine the suitability of the selected material, and identify environmental and wildlife considerations.

The Use Plan incorporates considerations from past oil simulant and surrogate releases (Table 6). This step is not associated with any specific federal or state permitting authority or process.

5.4 Obtain Permission

The final step is to obtain permission for a simulant or surrogate release into the environment. The work group was unable to specify a federal process to permit simulants or surrogates, so no specific guidance is outlined.

5.5 Surrogate Materials Summaries

Surrogate material summaries were developed for each known oil surrogate and included at the end of the Decision-making Guide. The material summaries provide information on known oil surrogates to assist the user in completing the Oil Simulant and Surrogate Use Plan in Step 3. Each summary provides a brief description of the material along with Properties, Practical Considerations, and History of Use in the U.S. The summaries also serve as an archival compilation of all information collected on each oil surrogate material during this project.

6.0 National Response Team Presentation

In February 2015, BSEE and Nuka Research presented the Decision-making Guide to the NRT S&T Committee for their review and comments. The NRT S&T Committee will play a key role in establishing any national policy on oil simulant use (Nuka Research, 2013).

The Committee received the document positively and indicated that it would be a useful reference. They were given the opportunity to provide comments, which have been incorporated into the final draft (Appendix B).

The S&T Committee identified the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) as another standing body with interest in this topic area.

7.0 Conclusion

Nuka Research offers the following observations and recommendations based on our experience compiling information, developing the Decision-making Guide, and facilitating the work group for this project.

7.1 Observations

This project benefitted from the willingness of both public and private spill response professionals to examine the current status of simulant and surrogate use and permitting.

The work group articulated a clear consensus that using oil surrogates or simulants may enhance oil spill response research, training, drills, and exercises. It is clear from the information shared by the work group and gathered from other sources that diverse materials are currently being used for this purpose and other materials may be used in the future.

While the work group reached clear agreement that there is a role for oil simulants and surrogates, they were unable to specify a federal permitting process for the release of these materials to U.S. waters. As the work group attempted to clarify the federal permitting context, it became clear that there is some sensitivity associated with this issue. On the one hand, there is interest from the spill response community in ensuring the responsible and appropriate use of surrogate or simulant materials in a way that is protective of the environment and human health. On the other hand, the introduction of a new or revised federal permitting process has the potential to complicate ongoing exercise and research efforts or deter people from using materials that they have used for years.

Although the project was not able to produce a test permit, the work group was successful in consolidating available information about past and ongoing use of oil surrogates by the U.S. oil spill response community in the Discussion Document. The group also synthesized this state of knowledge into a Decision-making Guide that may be a first step in standardizing approaches to future releases. Perhaps most important, this effort created a dialogue among some of the top professionals in the U.S. oil spill response community that will likely continue informally even after the work group is dissolved.

7.2 Recommendations

We recommend the following next steps:

- **Continue to refine state-of-knowledge regarding oil simulant or surrogate materials by documenting future use**. This project and the foundational work that preceded it represent the only documented efforts to bring together knowledge from around the U.S. on the use of oil spill simulants and surrogates. While there is a general familiarity with the use of surrogates, documentation of the details of surrogate use and observations regarding its effectiveness or behavior in the water is sparse. Regularly updating a database of what materials are used, where, in what quantity, by whom, for what purposes, and to what effect would provide a valuable resource for the spill response community. This could also be achieved by updating the Discussion Document and Decision-making Guide developed under this project. *This recommendation could be implemented immediately*.
- **Better characterize simulant materials.** This project sought to identify and document the full range of materials used as oil surrogates (and simulants, though, as noted, there have not been any such materials used to date) in past research or exercises. The Decision-making Guide, including surrogate material summaries, is based on the results of this effort and includes general characterization of materials based on work group member experience, which was largely anecdotal. As a next step, we suggest evaluating surrogate materials in a controlled setting (e.g., lab, bench, test tank) to quantify and document their characteristics and the extent to which each mimics different characteristics of petroleum oil when released to water or subject to actions such as containment or recovery. *This recommendation could be implemented immediately*.
- **Develop an environmentally benign oil simulant material.** Oil simulants have physical and/or chemical characteristics that closely mimic the fate and behavior of oil released into water. An ongoing BSEE-funded study seeks to develop one such material and may provide the foundation for future work. From the end user perspective, oil simulants may provide a better option for certain activities, such as evaluating skimming systems or testing certain oil detection technologies. *The development of one oil simulant is ongoing, and additional efforts could be initiated immediately but may require some time to complete; the release of any such material may be contingent on permitting.*
- **Finalize and test a permitting process for surrogate or simulant use.** Once federal permitting authorities and requirements are clarified, one or more test cases could be developed to evaluate the timing, critical path, and key decision factors for release of surrogate or simulant materials in U.S. waters. This could be done informally through a series of discussions or the development of sample permits. The development of blanket permits for certain common activities could be considered. *This recommendation may require federal agency action.*
- **Circulate the Oil Surrogate or Simulant Release Decision-making Guide for broader review.** The information compiled in this project can be expanded on and disseminated to continue to incorporate surrogates and simulants into the national response framework. Additional reviewers may include Regional Response Teams, Area Committees, and ICCOPR. *This recommendation can be implemented immediately*.

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Appendices

Appendix A: Discussion Document (Task 3 Deliverable)

Appendix B: Decision-making Guide (Task 4 Deliverable)

Appendix C: Resource List

Appendix A – Discussion Document

Regulatory Context for Permitting Releases of Simulated Oil and Oil Surrogates in US Waters

Prepared by: Nuka Research and Planning Group, LLC

April 2015

1.0 Introduction

1.1 Project Purpose

The Permitting the Use of Oil Spill Simulants project (BSEE Project #E13PC00021) convened a national work group to clarify the federal requirements and limitations for using oil simulants and surrogates to support research and development of technologies to detect or recover oil in the Arctic and, potentially, other marine regions. The work group intends to develop decision- making guidance for simulant and/or surrogate use in research and exercises to enhance oil spill response preparedness. This work may culminate in the development of an application to release oil simulant and/or surrogates during a field exercise in the US Arctic Ocean.

1.2 Scope of this Report

This report is the deliverable for Task 3 of the BSEE Permitting the Use of Oil Simulants Project. It summarizes available information about permitting processes for oil simulant, surrogate, or intentional crude oil releases in US and international jurisdictions in order to identify typical parameters used to guide permit decision-making (Task 3A). Emphasis is placed on permitting activities that have occurred within the past decade, although some older examples are considered. Based on these examples, the report recommends a set of parameters that are typically considered in granting permits for intentional releases (Tasks 3B and 3C).

The report is intended for use by the Oil Simulants work group to compile and synthesize information about potential permitting and decision-making parameters for oil simulant and surrogate releases. This report includes an explanation of our approach, results of initial research, permitting considerations, and potential next steps.[1]

[1] The report has been revised based on input from work group participants.

2.0 Background

2.1 Preliminary Research

Task 3 of the Simulants Permitting Project (BSEE Project #E13PC00021) involves clarifying the federal permitting regime governing oil simulant and surrogate releases in US waters. The foundational work leading up to this project and initial work group meetings resulted in a consensus that while multiple federal agencies have authority over permitting surrogate or simulant releases, the EPA's authorities under the Clean Water Act are a critical component (Nuka Research, 2013). The guidelines for permitting intentional releases (US EPA, 2001) outline requirements for the release of oil for scientific research. The precise requirements for an intentional release of an oil simulant or surrogate are less clear. Because the EPA is currently reviewing their 2001 guidance for intentional oil releases, it was not possible to precisely determine what the parameters might be for an oil simulant or surrogate release in US waters at this time.

Absent a clear framework, the work group recommended that Nuka Research compile information about permits that had been issued by other jurisdictions, including US states and international agencies. This report summarizes the results of a literature review and firsthand research (interviews with researchers and practitioners) to compile available information about parameters and processes that have been used by other jurisdictions in evaluating, granting, waiving, or denying permits for intentional releases of oil, simulants, and surrogates.

2.2 Terminology

For the purpose of this paper and subsequent project reports, standard definitions have been developed based on work group input to clarify and distinguish key terms.

Oil: Oil, as defined at 33 USC 1321: "oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil."

Oil simulant: A substance with physical and/or chemical characteristics that closely mimics the fate and behavior of oil released to a water body. Oil simulants are *not* petroleum oil, but may include *non-petroleum oils,* also defined at 40 CFR 112.2: "Non-petroleum oil means oil of any kind that is not petroleum-based, including but not limited to: Fats, oils, and greases of animal, fish, or marine mammal origin; and vegetable oils, including oils from seeds, nuts, fruits, and kernels."[2]

Oil surrogate: A substance that does not necessarily share the physical or chemical characteristics of oil but can be released into the environment to represent the movement of oil released to a water body. Oil surrogates may be liquid or particle-based, but are more commonly particle-based.

Particle-based surrogate: A substance made up of individual particles that may be released into the environment to mimic the movement of oil. Particle-based simulants have been described as most closely mimicking oil's density properties (i.e. they float and move in a manner similar to oil). (SAIC, 2008)

Research and Development: Tests or experiments that are performed to enhance the understanding of scientific nature of oil spills and response technologies.[3]

Training and Exercises: Field activities during which practical aspects of oil spill response is exercised to achieve specific objectives related to response techniques, responder proficiency, equipment performance, and other related topics.

3.0 US Permitting Examples

3.1 Federal

After a thorough review of published literature and queries to US federal agencies, we found no examples of federal permits for oil simulants or surrogates. A single intentional oil release was permitted under the EPA's intentional oil discharge for research process in 1994 for a bioremediation study on Fowler's Beach, Delaware (Venosa, 1995). The permitting process reportedly took approximately 18 months to complete (Nuka Research, 2014). A literature review yielded additional reports of intentional oil releases during the 1970s and 1980s in the United States in Louisiana, Virginia, Maine, and Texas; however, there is no documentation of the permitting process in the published reports, and their dates are beyond the scope of this review (Cox et al., 1975; Bender et al., 1977; Kator

[2] Note that this definition was developed with work group input because there is no statutory or regulatory definition of "oil simulant" at this time.

[3] Oil spill fate and behavior studies, which focus on the movement and trajectory of oil in water, were specifically broken out from this category in the Decision-making Guide produced during this project.

& Herwig, 1977; Fleeger & Chandler, 1983; and API, 1986).

3.2 State

There is very little published information about oil simulant and surrogate permits granted by state authorities. A query of US spill response organizations and regulatory agencies revealed that oil simulants and surrogates have been released for oil spill research and development and for training and exercises in a number of states, under a range of permitting arrangements. Some substances are released without permits, while others have blanket permits that make it difficult to track details about individual releases. For cross comparison, accountability, and future reference purposes, this lack of information encourages the need for a central oil surrogate usage data repository. State cases we looked at included Alaska, California, Michigan, Maine, and Georgia and only include experiments occurring within the past decade. Table 1 summarizes the permit examples that we found through our research.[4]

The Alaska Department of Natural Resources (ADNR) has issued a permit for the release of fluorescent dye and peat moss in streams on the North Slope of Alaska as part of the Alaska Clean Seas (ACS) Summer Oil Spill Containment and Recovery Activities. The permit is granted under the ADNR Commissioner's statutory authority to oversee activities of a person or governmental agency desiring to "use, divert, obstruct, pollute, or change the natural flow or bed of a specified river, lake, or stream," per Alaska regulations at 5 AAC 95.011(a). Considerations for the permit issuance included toxicity of the substance, potential affects on birds and wildlife, and the rationale for conducting oil recovery exercise, i.e., whether oil exploration and production activities ongoing and creating a spill risk to justify the need for preparedness (J. White, personal communication, April 28, 2014). The permit does not specify maximum volumes to be released, although ACS typically includes information about the size of the release in their notifications to ADNR. The permit was initially issued in 1992 and does not require annual reissuance as long as the associated activities remain in good standing. The only modifications to the permit have been to expand the geographic scope to include areas of

[4] This list is not exhaustive, and Nuka Research will continue to compile and track information about simulant and surrogate permitting for the duration of this contract, with an updated list provide as part of the final project report.

new oil and gas operations.

As part of a USCG Oil-Under-Ice Exercise, a permitting process was used in Michigan to allow for the release of peat moss and oranges into Lake Huron in 2012 and 2013. The permit was issued by the Surface Water Assessment Section, Water Resources Division, Michigan Department of Environmental Quality under Rule 97 of Michigan's Water Quality Standards. The 2012 permit was issued for a three-week period, and was renewed in 2013 for an additional five months (USCG, 2013). Rule 97 provides a process for permitting water treatment additives, bacterial augmentation, and tracer dye studies for a range of purposes (MDEQ, 2013). The permission granted for the Lake Huron surrogate releases included notification requirements under Rule 97, and specified that “small amounts” of peat and oranges were permitted for release (USCG, 2013).

The Maine Department of Environmental Protection led a series of Geographic Response Plan Exercises during 2012, which included the release of peat moss and oranges to evaluate the effectiveness of booming strategies (ME DEP, 2014). No permit was granted, because an exemption was identified that allowed for substances to be “discharge(d), omit(ted), or place(d)… on the land or in the air or waters of the state” exclusively for the purpose of scientific research and experimentation in the field of pollution and pollution control under the State of Maine Department of Environmental Protection Water Statues 38. The professional discretion of the organization was that the substances being used were exempt from further permitting beyond the provisions of this statute.

During the 2014 International Oil Spill Conference in Savannah, Georgia, BSEE representation sought a permit for a release of dog food, which was intended to act as an oil surrogate during an on-water demonstration.[5]

There was a 2003 permit granted for a dispersant release at a natural oil seep off Coal Point in Santa Barbara, and while this is not directly related to oil surrogate or simulant releases, it provides an example of an intentional release of a potential contaminant for the purpose of scientific study. The Regional Water Quality Control Board (RWQCB) permitted the release through the RWQCB General Permit for

[5] It is unclear whether this authority was granted directly by EPA Region 4 or by the State of Georgia under NPDES authority.

Discharges with Low Threat to Water Quality.[6]

Table 1. Examples of US State Permits for Oil Surrogates and Simulants

Activity & Location	Substances Released	Permitting Authority	Major Considerations
Alaska North Slope Alaska Clean Seas Summer Oil Spill Containment and Recovery Activities (1992- Ongoing)	Fluorescent Dye and Peat Moss	Alaska Department of Natural Resources under AS 16.05.871 and AS 16.05.841	***Toxicity*** • Provide MSDS for substances released ***Environmental impacts*** • Consider effects for birds and wildlife, even if substance is biodegradable ***Receiving environment*** • Streams only
Santa Barbara, California Dispersant tests on naturally-occurring oil seeps (2003)	Corexit 9500[7]	RWQCB General Permit for Discharges with Low Threat to Water Quality (Order No. 2003-0003-DWQ)	***Environmental impacts*** • Experiment does not result in serious or major disturbance to an environmental resource ***Purpose*** • Will provide valuable information
Maine (Penobscot River, Scarborough River, Upper Damariscotta River) Geographic Response Plan Deployment Exercises (2012)	Oranges and Peat Moss	Maine Department of Environmental Protection, Water Statutes (Title 38), 362-A	***Volume*** • Limited quantities ***Accountability and oversight*** • "Under strict control of the commissioner or the commissioner's designees" ***Purpose*** • Scientific research & experimentation
Lake Huron, Michigan USCG Michigan Oil-On-Ice Spill (2012, 2013)	Oranges and Peat Moss	Michigan Department of Environmental Quality, Rule 97 of Michigan's Water Quality Standards	***Volume*** • Small amounts ***Toxicity*** • Considered MSDS and toxicity of the substance given concentration into water ***Receiving environment*** • Distance offshore ***Environmental impacts*** • Proximity to wildlife/environments that could be affected ***Accountability and oversight*** • Coast Guard assuming liability as lead agency.

[6] The California Coastal Commission (CCC) also reviewed the permit and recognized the RWQCB process as being equivalent, therefore a separate CCC permit was not required. An additional permit was required from the Santa Barbara Air Pollution Control District for the boat exhaust created during the exercise.

[7] Not an oil simulant, but cited as an example because of permitting process.

Savannah River, Georgia IOSC On-Water Demonstration (2014)	Dog Food	EPA Region 4, Verbal Confirmation	***Toxicity*** • Professional discretion that substance was non-toxic ***Environmental impacts*** • Professional discretion that substance was non-threatening to the environment ***Purpose*** • Demonstrating recovery and research technologies for an international audience

Although several federal agencies were consulted during the initial project design, no federal permits were required. According to the study proponents, they were required to provide justification to the EPA that a federal permit was not necessary and obtain written confirmation from the US Coast Guard that they would assume lead federal responsibility. A categorical exclusion was granted under the California Environmental Quality Act because the project involved research and data collection. After the Coal Point dispersant trials were halted because the dispersant was not effective on the seep oil, the investigators contemplated continuing their work in Alaska, utilizing the EPA's intentional release permit. However, they ultimately opted to terminate the project, and cited concerns over the complexity and uncertainty associated with permitting (Payne and Allen, 2005).[8]

Throughout the process of researching this document, Oil Simulants work group members have offered examples of firsthand experience in oil spill exercises or demonstrations where surrogates such as fluorescein dye, oranges, peat moss, rice hulls, and dog food have been released without any documented attempts to acquire agency permits. For example, several oil simulant and surrogate releases have taken place in California marine waters, including releases of fluorescein dye (Nuka Research, 2013) and fruits and vegetables (G. Watabayashi and G. Shigenaka, personal communications, May 2, 2014). Geographic response plan and geographic response strategy field exercises are held in many coastal states, and surrogates are often used to evaluate booming arrays (SAIC, 2008). We were unable to locate information about specific permit applications or approvals for these activities.

[8] The paper states, "We anticipated a minimum one-year permitting process based on the level of effort for the natural oil seep studies and on information gathered from the EPA Revised Interim Application Guidelines for EPA Permits to Discharge Oil for Research Purposes (EPA 2001). Following permit approvals, we then hoped to complete the three planned spills in the project's second year. Unfortunately, our pre-proposal was not selected for full proposal submission; the CICEET review panel concluded that committing $95,000 of their then current $700,000 funding budget for the permitting aspect of our proposed project was too risky."

4.0 International Examples

Because there are so few documented examples of US permits for oil simulant or surrogate releases and intentional oil spills, we also researched the permitting regimes in other countries. An initial search of published literature turned out limited examples of intentional oil releases in Norway, Canada and the United Kingdom, and no examples of permitting oil simulants or surrogates.

4.1 Norway

Norway has historically permitted intentional oil releases in order to gain more advanced understanding of response methodologies and effectiveness of clean-up technologies. Intentional releases go back to the 1980s (Bonsdorff, 1984) and have continued to the present.

The Norwegian Clean Seas Association for Operating Companies (NOFO) has been conducting annual oil-on-water exercises to promote offshore oil spill response technology developments and improved capabilities since 1980 (Allers, 1997). The location and scale of these exercises has varied. The exercises have involved a range of oil types, including crude oils, various emulsions, and plant oils. The most recent on-water exercise was executed during June 2014 (NOSCA, 2014). The releases are permitted by the Norwegian Climate and Pollution Agency, through a process described by NOFO as "extensive," including both a written application and hearings during which various parties are provided comment opportunities (Kristoffersen, 2012). The discharge permits issued by the Norwegian Climate and Pollution Agency (Application for permission to discharge oil for research purposes) establish parameters for the release, including the following:

- Time and location of release;
- Parameters for weather during the release/trials;
- Identification of potentially impacted wildlife (e.g. seabirds) – an example permit from a 2013 release included a biologists' report verifying sea bird information;
- Record-keeping requirements;
- Notification requirements for fishing vessels operating in the vicinity;

- Total volumes permitted to be released;
- Specific activities to be tested during the release and their purpose. (NOFO, 2013)

In addition to annual NOFO exercises, Norway has hosted several intentional oil releases in recent years as components of larger international Joint Industry Projects (JIP) focused on oil spill response research and development and field assessments. As part of an oil-in-ice JIP that took place from 2006-2009, the Norwegian research organization SINTEF sought permission in 2006 for an intentional release in Svalbard to test remote sensing and detecting, evaluate the fate and behavior of oil in ice, and evaluate in-situ burning as a response option for Arctic oil spills. The permit for an intentional release of up to 3,500 liters (approximately 925 gallons) of Statfjord crude oil into ice-covered waters was issued by the Governor of Svalbard's environmental section through a process that included an initial consultation prior to the application. The volume was determined based on the needs to provide a "realistic field scale" to test the selected technologies. Since the experiment included in-situ burning, approximately 2,400 liters of the oil was burned (after 63 days of weathering in the environment), and the burn residue was recovered (Dickins et al., 2006).

Other large-scale experimental releases in Norway have included the 1989 Haltenbanken experiment, conducted in the North Sea, and the Marginal Ice Zone experiment in 1993, conducted in the Northern Barents Sea. The Haltenbaken experiment involved a release of 30 tonnes (approximately 9,500 gallons) of Oseberg crude oil, and the Marginal Ice Zone experiment released 26 m^3 (approximately 6,800 gallons) of Sture blend crude oil (Brandvik et a., 2004). The literature describing these releases does not specify the permitting authority.

4.2 Canada

Canada also has a history of intentional oil releases that date back to the 1970s and 1980s, to both land and water (Hutchinson and Freedman, 1978). Research into bioremediation techniques was conducted through a series of experimental oil spills conducted by the Department of Fisheries and Oceans (DFO) on beaches in Long Cove, Nova Scotia beginning in 1985 (Government of Canada, 2007). Subsequent experiments were conducted in 1999 in St. Croix, Quebec on a freshwater wetland along the St. Lawrence River and in 2000 in a saltwater marsh at Petpeswick Inlet outside Halifax, Nova Scotia (Fisheries and Oceans Canada, 2013).

The lead investigator for these DFO bioremediation studies reported that their approach to gaining permission did not involve a formal government permit, but rather an intensive stakeholder outreach process aimed at fostering community understanding of and support for the research efforts. Community meetings were held to communicate the research value of and need for the experimental oil spills. Results from the 1985 studies in Nova Scotia were used to demonstrate to community members how this type of research could result in significant improvements to oil spill cleanup techniques (Government of Canada, 2007). Other forms of community outreach, including direct mailings to local residents, were also used to disseminate information and foster buy-in. During the experimental releases, local oil spill response organizations were placed on stand-by in case the oil escaped containment. This provided a training and readiness value for local responders in addition to providing an environmental safeguard (K. Lee, personal communication, May 6, 2014).

4.3 United Kingdom

The United Kingdom was reportedly preparing to conduct an intentional release of oil during June 2014. Representatives from Oil Spill Response Limited (OSRL) reported that they were in the process of applying to the Marine Management Organization (MMO) for a permit to discharge a "small volume of oil" as part of a field exercise (P. Foley, personal communication, May 27, 2014).

4.4 Other International Jurisdictions

There have been media reports and anecdotal stories about intentional oil releases and simulant or surrogate releases in other international jurisdictions, but our research efforts did not yield any published sources or firsthand accounts of the permitting requirements. For example, a 2006 exercise in Poland involved a release of 12 m^3 of perlite, a mineral substance used as an "oil simulating substance," but the exercise report does not specify whether any permitting was required or obtained (HELCOM, 2006). In France, the CEDRE spill response organization conducted a series of experimental oil spills during dispersant field trials in the mid-1980s, but permitting is not discussed in the literature (Desmarquest et al, 2985). There have reportedly been intentional oil releases in Denmark and the Netherlands; however, no published sources were located to verify these accounts.

5.0 Permitting Considerations

5.1 Common Requirements

Based on the limited US and international examples identified in this report, we have developed a preliminary list of permitting considerations that reflect the type of information that has been required as a condition of other permit applications and/or identified in the literature as relevant to simulant and/or surrogate-use decision-making. Table 2 describes reoccurring criteria used by permitting entities to grant permission for release in US and foreign jurisdictions.

5.2 Considerations for Oil Simulant Permitting

The criteria listed in Table 2 represent common considerations that could inform a US permitting process for oil simulant and surrogate releases. While it is likely that oil surrogate or simulant permitting could also trigger other federal and state requirements, there has been strong consensus among the work group that addressing the potential for environmental harm should be a primary consideration for any permitting process.

5.3 Parameters for Test Permit[9]

Task 3B of the Oil Simulants project specifies that a test permit would be submitted to attempt to secure federal permission to release a surrogate or simulant as part of a field trial, possibly in the US Arctic Ocean. Originally, this process considered submitting a permit for an actual, planned activity. However, the significant uncertainties around the present permitting system make this option unrealistic, and this component of the project has been set aside until EPA guidance is updated.

[9] Preparing and submitting a federal test permit was removed from this project's Scope of Work due to external circumstances that rendered its completion impossible.

Table 2. Common Permitting Considerations

Considerations	Examples of Evaluation Factors
Environmental Impacts	• Proximity to seabirds • Proximity to other sensitive receptors or environments • Potential to disturb an environment resources • Potential for adverse wildlife impacts
Toxicity	• Published information about environmental toxicity and human health effects (e.g. MSDS) • Concentration of substance in water body • Professional discretion • Naturally-occurring vs. chemically-derived
Volume Released	• Volumetric limits typically established in permit • Minimize total volume released • Set volume limits based on experimental design (release must be of sufficient size to achieve study objectives)
Receiving Environment	• Distance from shoreline • Time and location of release • Permitting body may influence type of water body or location of release (based on jurisdictional authorities, e.g. ADNR permit for streams only) • Water depth • On-scene weather conditions
Purpose	• Scientific research • Credible oil spill risks (e.g. Alaska permit is tied to ongoing oil and gas activities creating spill risk) • Improving oil spill response techniques and technologies • Training value • Demonstration of technology • Economic benefits • Specificity of activities to be conducted and their purpose
Accountability and Oversight	• Ability to remove or collect material released • Notification of potentially impacted parties (e.g. fishing vessels, local residents, etc.) • Notification of authorities not directly involved in permitting • Documentation and reporting • Inclusion of oil spill response organizations • Previous permit approvals • Partner jurisdiction approval

6.0 Next Steps

6.1 Decision-making Guide

The information in this document will provide the foundation for a decision-making guide that could assist potential permit applicants in developing applications to release surrogates or simulants and also inform agency decision-making (Task 4). The decision-making guide would capture international best practices and provide a useful policy reference. Once completed, the decision-making guide will be presented to the National Response Team to foster discussion of the role of simulants in the national response system.

6.1 Permit Application and Field Trials

The ability to develop and submit a permit application for a surrogate release in the US Arctic Ocean will be considered by the work group as this project moves forward.

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Appendix B – Decision-making Guidance

Oil Surrogate or Simulant Release Decision-Making Guide

April 30, 2015

This study was funded by the Bureau of Safety and Environmental Enforcement (BSEE) U.S. Department of the Interior, Washington, D.C., under Contract E13PC00021.

Contents

1 Introduction

Materials that mimic the behavior or properties of oil have been used to improve oil spill response preparedness through controlled field releases to support training, exercises, research and development, and oil spill fate and behavior studies in U.S. waters.

This document compiles information about oil simulants and surrogates to support decision-making for potential releases in U.S. waters.

1.1 How to Use this Document

This document includes:

- Terminology and definitions related to oil simulant and surrogate materials and use.
- Information about materials that may be released to simulate an oil spill to water.
- Decision-making tools to assist a potential user in selecting materials.
- A template for developing a material release use plan.

1.2 How this Document was Developed

Nuka Research and Planning Group, LLC developed this decision-making tool with funding from the Bureau of Safety and Environmental Enforcement (BSEE) as part of the Permitting the Use of Oil Spill Simulants: Identifying Options and Building Consensus (#E13PS00032) project. A work group of oil response experts was convened to provide input on the scope of simulant and surrogate use in the U.S. Workgroup members had expertise in U.S. federal policy on oil spill response preparedness and technologies, mechanical oil spill response technology development, scientific support of spill response, training and exercises, modeling, the National Response Framework, the National Response Team Science and Technology Committee, National Contingency Plan Subpart J, Alaska North Slope operations, and oil spill removal organization training and response needs.

Work group participants met regularly during 2014-2015 and provided technical input and expert review of this document along with more general feedback on oil simulant and surrogate use and policy in the U.S. Workgroup facilitation and technical support was provided by Nuka Research and Planning Group, LLC.

Participating agencies included:

- Association of Petroleum Industry Cooperative Managers (APICOM)
- Bureau of Safety and Environmental Enforcement (BSEE)
- National Oceanic and Atmospheric Administration (NOAA)
- Spill Control Association of America (SCAA)
- U.S. Coast Guard (USCG)

1.3 Definitions

This section explains terminology used throughout this document.

1.3.1 Types of Materials

This document uses the terms *simulant* and *surrogate* to describe two different types of materials that could be released in place of oil for certain purposes.

Oil Simulant

An **oil simulant** is a non-oil substance with physical and/or chemical characteristics that closely mimics the fate and behavior of an oil released to a water body. Oil simulants are not petroleum oil, but may include non-petroleum oils. There is no documented evidence that oil simulants have been released in U.S. waters because available simulants are all considered oils and therefore prohibited for release under the Clean Water Act.

Experimental concept for simulated crude oil

Oil Surrogate

An **oil** surrogate is a substance that does not necessarily share the physical or chemical characteristics of oil but when released into the environment would represent the movement of oil released to a water body. Oil surrogates may be liquid or particle-based, but are more commonly particle-based.

Drift cards released as oil surrogate

Peat moss used as oil surrogate

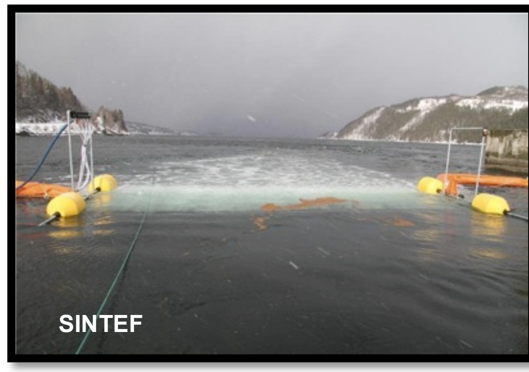
1.3.2 Application or Use of Materials

This document presents decision-making guidance for release of oil simulants or surrogates in the context of three general applications or uses of materials in a water body.

Research and Development

Research and development encompasses all tests or experiments that are performed to evaluate the performance of oil spill response technologies, equipment, or techniques.

Research and development field trials in Norway



Training and Exercises

Training and Exercises are field activities during which practical aspects of oil spill response is exercised to achieve specific objectives related to response techniques, responder proficiency, equipment performance, logistics, or other related topics.

Peat moss released as oil surrogate during protective booming exercise

Oil Spill Fate and Behavior Studies

Oil Spill Fate and Behavior Studies are scientific or practical research projects that aim to improve the understanding of the fate and behavior of oil, including transformation and transport tendencies– both physical and chemical- when spilled into water.

Release of fluorescein dye and drift cards to simulate oil transport.

1.4 Simulant and Surrogate Materials

1.4.1 Surrogate Materials

A range of materials has been used as oil surrogates in the U.S. and other countries. The following surrogate materials have a history of use in the U.S., based on a review of professional literature and information gathered from practitioners. This list is not exhaustive. Section 4 contains material summaries on each material.

Oil Surrogate Materials

- Algae or seaweed (may be ground up into a sludge)
- Bagasse (fibrous remnants of sugarcane or sorghum processing)
- Citrus fruit (oranges are preferred)
- Coir (coconut fibers)
- Cork
- Dog food
- Drift cards
- Dyes
- Evergreen needles
- Hay
- Organic materials (naturally occurring local organic materials)
- Peanut shells
- Peat moss
- Perlite
- Popcorn
- Protein-based foam
- Rice hulls
- Sunflower seeds
- Wood chips

1.4.2 Oils and Oil Simulants

Oils - There is one case where an intentional crude oil release was permitted under U.S. law to study shoreline bioremediation (1994). The professional literature lists canola or rapeseed oil as a potential simulant outside the U.S. There is no history of its use, or of any use of other vegetable oils in U.S. waters in the context of oil spill field studies (SAIC, 2008).

Simulants - There is no documented history of intentional oil simulant release in the U.S. The professional literature lists canola and rapeseed oil as a potential simulant, but there is no history of its use, or of any use of other vegetable oils in U.S. waters in the context of oil spill field studies. A few oil simulant substances have been developed or are being developed, such as a simulated crude oil that was patented but has not been released in U.S. waters (USPTO, 2009). It is not clear whether any simulated oil exists or could be developed that would be not be classified and treated as an oil.

2 Simulant or Surrogate Use Decision-making

Figure 1 shows the basic process used to guide decisions about whether to release an oil simulant or surrogate, which materials are potentially suitable, and considerations for conducting a successful release that minimizes potential adverse environmental impacts.

This section of the document is organized based on the four steps described in the flow chart.

Figure 1. Material release decision-making process

2.1 Step 1: Establishing the Need

Step 1 in the decision-making process is to **Establish the Need** for a release.

The purpose of this step is to help a potential user determine whether a surrogate or simulant release to U.S. waters is necessary. Figure 2 presents a flow chart that presents these considerations in the context of potential material releases.

Considerations include:

What is the purpose of the release?

For decision-making purposes, the intended purpose of releasing oil simulant and surrogate materials are categorized as one of the following (see Definitions in Section 1.2.2):

- Research and development,
- Training and exercises, or
- Oil spill fate and behavior studies.

Have precursor studies been completed?

For decision-making on releases for research and development, it is important to ensure that any foundational studies, such as proof-of-concept trials in controlled environments, are completed prior to a field trial with oil simulant or surrogate release.

What are the objectives of the release?

The objectives of a release must be clearly identified in order to select a suitable material. Objectives will be determined by the purpose of the activity being conducted, and will typically be part of a larger plan (e.g. a research and development project or program, an on-water exercise, or a scientific study). Objectives for the oil simulant or surrogate release should be **specific** and **measurable.**

Some examples of objectives are:

- Simulate the movement of an oil slick to validate model assumptions.
- Train responders in the deployment of effective containment boom.
- Test the recovery rate of a skimming system under field conditions.

Have all viable alternatives to a release been considered?

The decision to pursue a release should be made after careful consideration of alternative methods. If there are other approaches, such as laboratory trials, computer simulants, tank test experiments, or field trials that could be used to achieve the stated objectives, then these alternative approaches should be considered.

Are there net environmental or economic benefits of a release?

Net environmental benefit analysis (NEBA) and net environmental and economic benefit analysis (NEEBA) are approaches that are often applied to decision-making for environmental issues. At its basis, NEEBA provides a framework for examining costs (environmental, economic, or otherwise) against benefits (knowledge gains, oil spill preparedness, technological improvements).

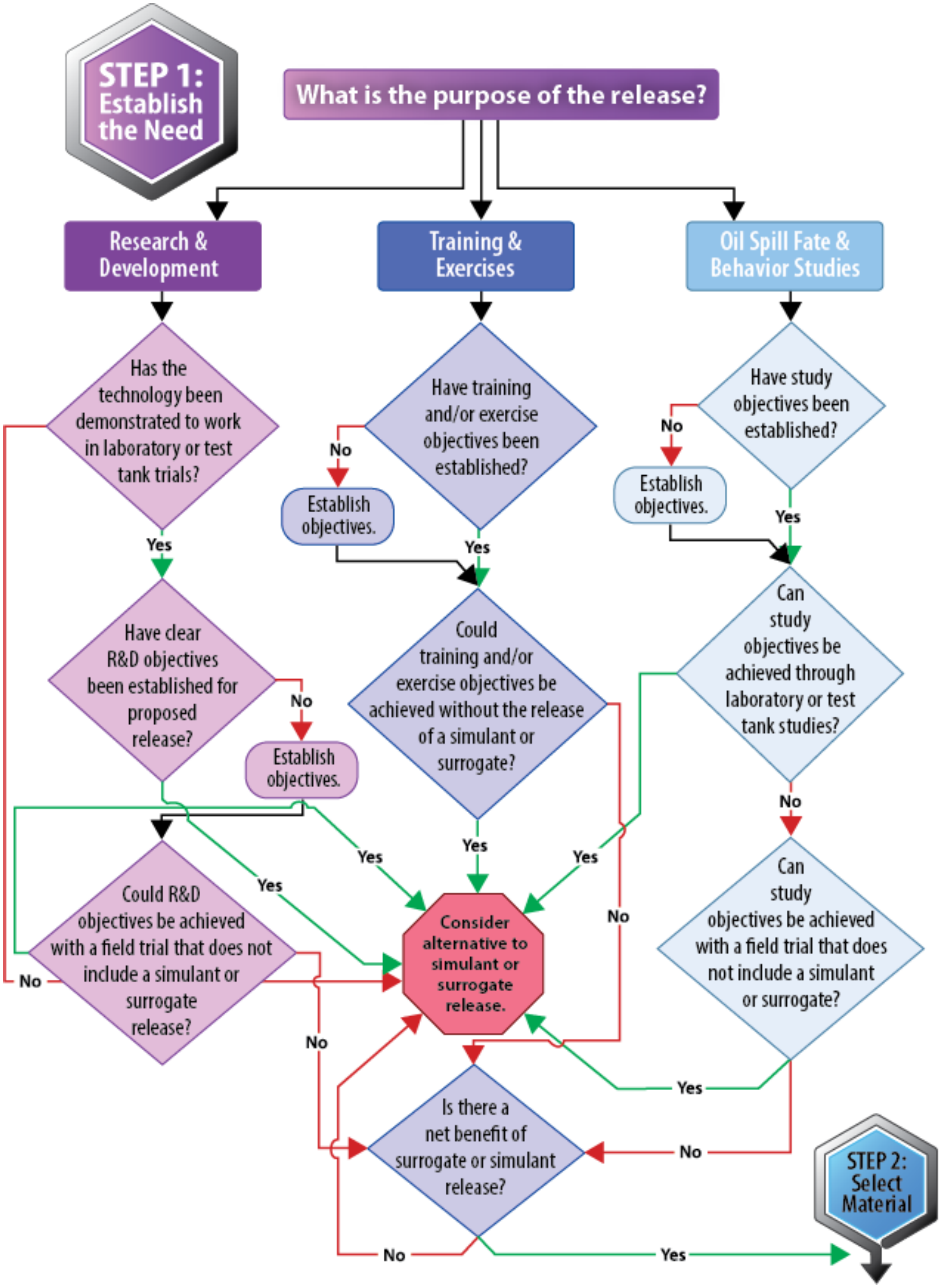


Figure 2. Flow chart showing example of decision-making process to establish the need for a simulant or surrogate release (Step 1)

2.2 Step 2: Select the Material

Step 2 in the decision-making process is to **Select the Material** to be released. Selecting materials for a simulant release requires stepwise consideration of both the **suitability** and **practicality** of the material (See Figure 3).

2.2.1 Suitability

Oil surrogate and simulant materials differ in how they mimic the behavior of oil. The selection of appropriate materials depends upon several considerations:

What is the purpose of the release?

As in Step 1, the first consideration for selecting a suitable material is the purpose of the release. For the purpose of this document, potential oil simulant or surrogate releases are grouped into three main categories: Research and Development, Training and Exercises, and Oil Spill Fate and Behavior Studies.

What are the specific technologies, tactics, or equipment to be applied?

Many of the activities that may involve an oil simulant or surrogate release involve oil spill detection, containment, recovery, or treatment systems. In selecting appropriate materials, it is important to consider how the technologies, tactics, equipment, or systems function.

> For example, an on-water exercise designed to test a containment barrier in a high-current environment would require a floating material that would encounter the boom face and illustrate whether the boom could achieve containment. A research and development trial to assess skimmer performance would require a material that could be encountered, recovered, and pumped through the system in a manner similar to oil.

Liquid or Particle-Based?

For the purpose of simulating an oil spill, the distinction between liquid and particle-based simulant is based on how the material behaves. Determining the desired particle size - whether a material that behaves more or less like a liquid - will help to focus the materials selection process. For some purposes, either material will suffice.

Which oil properties need to be simulated?

"Oil" is not a homogenous substance. There are many different types of oils that may behave very differently under different conditions. Even a single oil displays a range of different types of behavior when spilled to water – it may float or sink, spread or clump, evaporate or disperse, or be physically transported over time and space. Depending upon the objectives of the activity requiring a release, certain aspects of oil properties may be more or less important. Table 1 describes properties of commonly used surrogate and simulant materials.

> For example, if a potential oil simulant or surrogate user was conducting a research and development test of a hypothetical oil spill detection technology, the selected materials must mimic those properties of oil that relate directly to the manner in which the technology detects oil. If the technology senses oil fluorescence, then it will be important to select a material that fluoresces. If the technology senses heat signatures, then the material should mimic the heat signal of an oil slick.

Table 1 summarizes the properties of certain simulant or surrogate materials that may influence their selection. Assessments have been made according to written and anecdotal evidence from industry experts based on previous material releases. Additional information is provided in the material summaries in Appendix A. The properties considered are:

- **Spread:** Spreading describes the property of crude oil or refined petroleum to spread out into a thin film when poured onto a clear water surface. In this context, spreading is determined by how the surrogate mimics the spreading rate and behavior of oil. A yes indicates that the material will spread when released to the water surface. A no indicates that the material would not spread when released.
- **Clump:** Clumping describes the behavior where individual particles of a material may stay together as a mass when released to the water surface, as opposed to moving separately. A yes indicates that the material will clump. A no indicates that the material will not clump. A possibly indicates that the material may clump under certain circumstances, often if the material takes on water.
- **Buoyancy:** Buoyancy describes whether a material is expected to float in seawater, which is typically a function of the density (materials that are less dense than water will float). The density of each substance was measured in units of g/cm3 and then compared to the density of seawater using an online calculator. [1] A yes indicates that the material is expected to float on seawater. A no indicates that the material is not expected to float. Buoyancy may change over time for materials that absorb water.
- **Trajectory:** Trajectory describes the predominant forces that will direct the movement of the material while on the water surface. Wind indicates that the material is most influenced by wind direction. Current indicates that the material is most influenced by current direction. Some materials are affected significantly by wind and current and are noted as both wind and current-driven.
- **Emulsification:** Emulsification describes the formation of a mixture of water and oil, which can be mixed only when energy is applied with higher energy environments (strong wind and waves) making emulsion more likely to occur. In this context, emulsification is determined as the formation of a mixture of water and the surrogate. A yes indicates that the material has the potential to emulsify when released to water. A no indicates that the material is not likely to emulsify. Emulsification tendencies may change over time, and these are noted for some materials.
- **Visibility:** Visibility describes how easily a material can be seen with the human eye on the water surface. High visibility indicates that the material is relatively easy to see with the human eye. A moderate indicates that the material can be seen with the human eye, but not as easily. A low indicates that the material is difficult or impossible to see with the human eye. Materials with low visibility may also be difficult to retrieve.

[1] http://www.aqua-calc.com/

[2] Small refers to surrogates that are liquids, foams, or dusts with particle sizes that measure in microns. Medium refers to surrogates with particles Large refers to surrogates with particles that can be measured as 1 centimeter or greater.

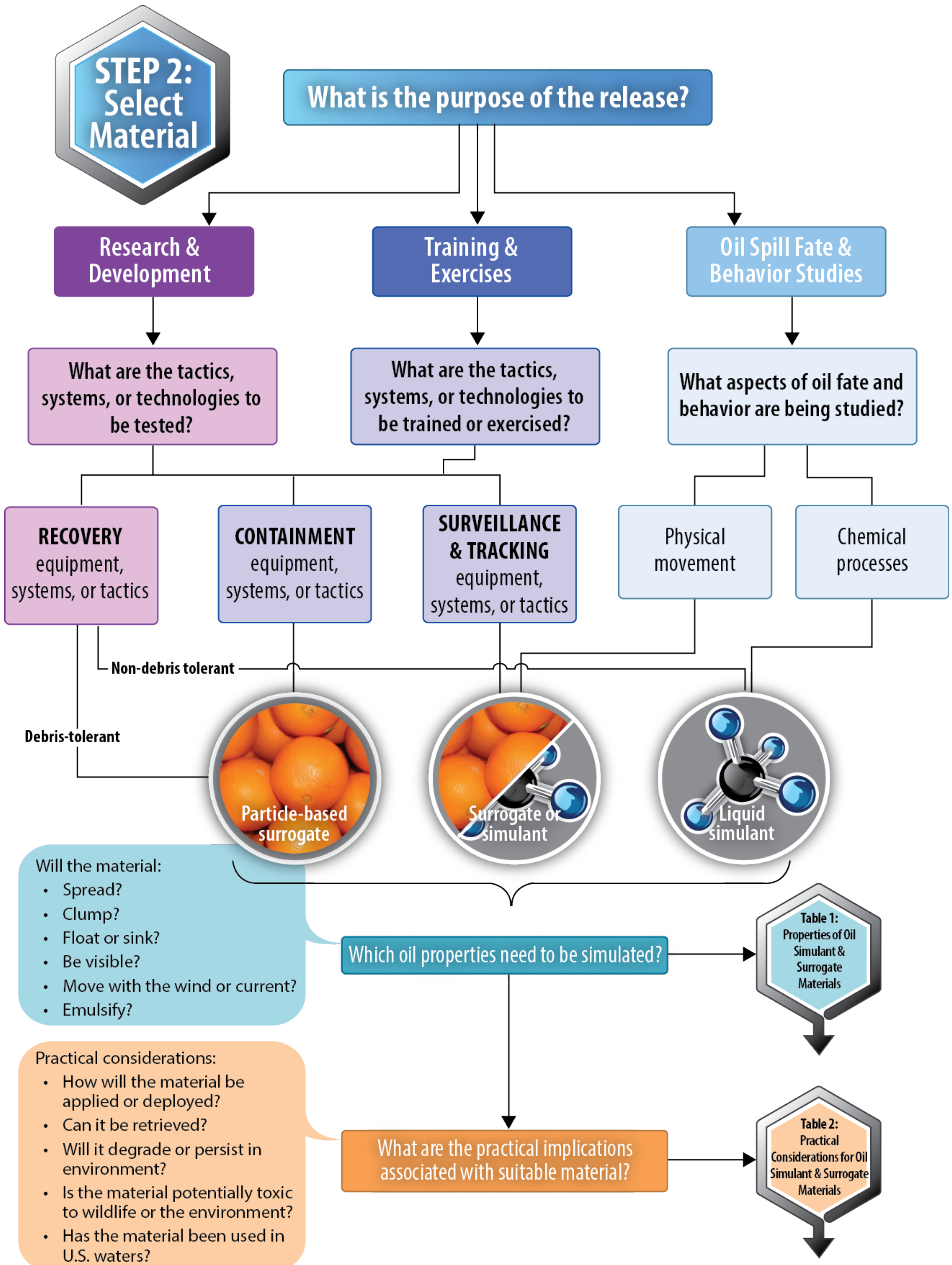


Figure 3. Flow Chart for Selecting Suitable Materials

Table 1. Properties of Oil Surrogate Materials

Material	Properties					
	Spread	Clump	Buoyancy	Trajectory	Emulsi-fication	Visibility
Algae or seaweed	Yes	Possibly	Depends on material	Wind and current	No	Depends
Bagasse	Yes	Possibly	Float	Wind	No	Moderate
Citrus fruit	Yes	No	Float	Wind and current	No	High
Coir (coconut fibers)	Yes	Yes	Float	Current	No	Moderate
Cork	Yes	Yes	Float	Wind	No	High initial
Dog Food	Yes	Not initially	Float	Current	No	Moderate
Drift cards	Yes	No	Float	Current	No	High
Dyes	Yes	No	Mixes in water column	Current	Yes	High
Evergreen needles	Yes	Yes	Float	Current	No	Low
Hay	Yes	Yes	Float	Wind	No	Moderate
Native organic materials	Yes	Possibly	Depends on material	Wind and current	No	Depends
Peanut shells	Yes	Yes	Float	Current	No	Moderate
Peat moss	Yes	Yes	Float	Current	No	Low to Moderate
Perlite	Yes	Yes	Float	Wind	No	High initial
Popcorn	Yes	Maybe	Float	Wind	Not initially	High initial
Protein-based foam	Yes	Maybe	Float	Current	Not initially	High
Rice hulls	Yes	Yes	Float	Current	No	Moderate
Sunflower seeds	Yes	Yes	Float	Current	No	Low to Moderate
Wood chips	Yes	Yes	Float	Current	No	High initial

2.2.2 Practical Considerations

Once suitable materials that will emulate specific properties of spilled oil to suit the purpose of release have been identified, a second set of practical factors may be considered. These hypothetical questions highlight practical and logistical issues related to material release that can affect the user's ultimate selection of a simulant or surrogate. These considerations will help with developing the use plan in Step 3.

The selection of appropriate materials and determination of quantities to be released depends upon several considerations:

How will the material be deployed or applied?

Some materials can be deployed manually, while others may require specialized equipment or machinery. To some extent, this may also be influenced by the quantity of materials to be deployed.

Can it be retrieved?

Some simulant or surrogate materials can be readily recovered or retrieved at the end of the activity, while others will remain in the environment. It is important to consider whether and how a material can be retrieved when selecting the material and determining the quantity to be released.

Will it degrade or persist in the environment?

If a simulant material cannot be retrieved, it is important to consider whether the material will **degrade** or **persist** in the environment.

What is the particle size of the material?

Oil surrogate materials span a continuum from liquid to solid, and particle size is one characteristic that varies along that spectrum. For the purpose of this decision-making tool, liquids are materials with a particle size that can be measured in microns, while particle-based surrogate materials can be measured in millimeters or centimeters. The particle size of the surrogate can affect the intended use (e.g. will it pass through a skimming system?) and desired outcome of a release.

Is material potentially toxic to wildlife or the environment?

Consider whether the material has known or potential toxicity to wildlife or the environment, and specifically the potential risks within the intended receiving environment. Toxicity is referring to chemical properties of a material that can influence a biological habitat as opposed to physical issues encountered by wildlife (i.e. choking, intestinal blockage), although those concerns should be considered based on the substance chosen for deployment and native species that may encounter the material.

Does the material have a known history of past use in U.S. waters?

Consider whether the material has been used in the past for research and development, training and exercises, or fate and behavior studies in U.S. waters. Review information from past events.

Table 2 summarizes the practical considerations for release of certain simulant or surrogate materials that may influence their selection. The characteristics summarized are:

- **Deployment:** Deployment describes the method of release. Manual release can be deployed by hand with no special equipment. Blowers use compressed air to distribute a material. Special equipment includes specialized distribution systems, such as spray nozzles.

- **Retrieval:** Retrieval is characterized as high, moderate, or low based on the relative amounts of material expected to be recovered after release. High retrieval implies a high likelihood that the material can be recovered from the environment, and low implies that relatively low amount of the material can be retrieved from the environment.
- **Degradation:** Degradation characterizes the relative persistence of a substance in the marine environment. It expressed qualitatively based on the length of time the material would be expected to persist in the environment before degrading, with additional information provided as available about specific conditions that would contribute to persistence or degradation.
- **Particle Size:** Particle size is characterized as small (individual particles can be measured in microns), medium (individual particles can be measured in millimeters), or large (particles are typically 1 centimeter or larger), based on the particle size of each material during a release. Materials have multiple sizes indicated if the particle size depends on material processing.
- **Known Toxicity**: Known toxicity describes whether the substance has known toxic effects to the marine environment, wildlife, or humans, specifically referring to chemical properties of a material. Toxicity is characterized as either non-toxic, low, or unknown. This is a qualitative measurement and is not determined by an established benchmark. Clarifying information, if available, is provided in the table and expanded on in the material summaries in Appendix A.
- **Past Use in U.S.:** Past use in the U.S. describes the purpose of known past use based on the categories used in Step 2 of the decision-making process: Fate &Behavior, Research & Development, and Training & Exercises. In cases where no past use has been documented in the U.S., cells state that past use is *unknown.*

Additional information is provided in the material summaries in Appendix A.

What are the opportunity costs of the selected material?

Surrogate materials vary considerably in terms of economic cost, availability, and general acceptance by regulators and the public. In selecting a material, consider:

- How much will the release materials cost?
- How long is permitting process estimated to take?
- Does the material have a history of past permitted use in the state or region?
- How expensive is the projected estimated clean up? Will professional services be required?

Table 2. Practical Considerations for Oil Simulant and Surrogate Materials

Material	Practical Considerations					
	Deploy-ment	Retrieval	Degrad-ation	Particle Size[2]	Known Toxicity	Past Use in U.S.
Algae or seaweed	Manual	Low	Degrade after week	Large. Can be ground to small or medium	Non-toxic (if local)	Unknown
Bagasse	Manual	Low	Degrade	Medium (individual fibers)	Unknown	Training & Exercises
Citrus fruit	Manual	Moderate	Degrade after weeks	Large	Low, potential pesticide residue	Training & Exercises; Fate & Behavior
Coir (coconut fibers)	Manual	Low	Persist	Medium (individual fibers)	Low, possible phytotoxin	Unknown
Cork	Manual	Moderate	Persist	Small, Medium, or Large (depends on processing)	Non-toxic/None indicated	Unknown
Dog Food	Manual	Moderate	Degrade after days	Medium or Large	Non-toxic, May have preservatives	Training & Exercises; Fate & Behavior
Drift cards	Manual	High	Persist	Large	Non-toxic paint	Training & Exercises; Fate & Behavior
Dyes	Manual or special equipment	Low	Dissolves into the water column	Small	Varies by material	Training & Exercises; Research & Development; Fate & Behavior
Evergreen needles	Manual	Low	Persist	Medium or Large length, Small width	Sometimes, possible mycotoxin	Training & Exercises
Hay	Manual	Low	Persist	Medium (individual fibers)	Non-toxic	Training & Exercises
Native organic materials	Manual	Varies	Degrade after weeks	Small, Medium or Large (depends on material and processing)	Typically non-toxic if locally derived	Unknown
Peanut shells	Manual	Low	Persist if heat-treated	Medium or Large (can be processed to small)	Sometimes, possible mycotoxin	Unknown
Peat moss	Manual or blowers	Low	Persist	Medium or large	Non-toxic/No data	Training & Exercises; Fate & Behavior

[2] Small refers to surrogates that are liquids, foams, or dusts with particle sizes that measure in microns. Medium refers to surrogates with particles Large refers to surrogates with particles that can be measured as 1 centimeter or greater.

Material	Practical Considerations					
	Deploy-ment	Retrieval	Degrad-ation	Particle Size[2]	Known Toxicity	Past Use in U.S.
Perlite	Manual or blowers	Low	Persist	Small, Medium, or Large (depends on processing)	Non-toxic/No data	Training & Exercises; Fate & Behavior
Popcorn	Manual or blowers	Low	Degrade after days	Medium	Non-toxic	Research & Development; Training &Exercises
Protein-based foam	Special equipment	Low	Degrade	Small	Low, may include animal protein	Research & Development; Fate & Behavior
Rice hulls	Manual	Low	Persist if heat-treated	Small or Medium	Non-toxic	Training & Exercises
Sunflower seeds	Manual	Low	Persist	Medium	Toxic if ingested in large quantities	Unknown
Wood chips	Manual	Moderate	Persist	Medium or Large (depends on processing)	Non-toxic	Training & Exercises; Fate & Behavior

2.3 Step 3: Develop Oil Simulant or Surrogate Use Plan

Once a material has been selected for the oil simulant or surrogate release, an Oil Simulant or Surrogate Use Plan may be developed. The Use Plan serves several purposes:

- Summarizes the parameters for the intended release
- Describes the decision-making process used to select simulant material
- Provides a worksheet to consider logistical and practical aspects of the release
- May facilitate permit application process

A User Plan Template is included in Section 3 of this document.

2.4 Step 4: Obtain Permission

The release of oil simulant or surrogate materials in U.S. waters may require federal, state, and/or local permits or permissions.

3 Oil Simulant or Surrogate Use Plan Template

The Use Plan Template is provided as a planning tool to assist with the decision-making process associated with a simulant or surrogate release. It provides a fill-in-the-blank form that may be used to compile and organize information specific to the intended release, and is intended for use during the **planning stages.**

Note: This form is not a regulatory requirement and is not associated with any federal or state permitting agencies. There are no requirements to use or submit this form.

3.1 Basic Information

Name of activity/proposed release:	
Date:	
Lead organization:	Other Organization(s) involved:
Location of release:	Jurisdictional authorities: (Specify federal, state, local)
Type of waterbody:	Distance from nearest shoreline:
Material intended for release:	Type of material ☐ Simulant ☐ Surrogate
Source of material:	Intended release volume:
Map or sketch of release area:	

3.2 Purpose

What is the purpose of this release? (Check all that apply) ☐ Research & Development ☐ Fate & Behavior Study ☐ Drill and/or Exercise
What are the study objectives? (Please list all objectives, and be clear about how they will be evaluated)
Have alternatives to simulant or surrogate release been considered? If so, explain.
How will simulant or surrogate release contribute to study objectives?
Identify any precursor work that is relevant to the proposed release.
Based on the net environmental benefit analysis (NEBA) or net environmental and economic benefit analysis (NEEBA) method, how are the costs of a release justified by the benefits?

3.3 Suitability of Selected Material

Describe the activities to be evaluated. (Check all that apply) ☐ Systems ☐ Technologies ☐ Tactics
Additional details. (Attach sketches, specification sheets, etc. as appropriate)
Which oil properties will the material mimic? (Check all that apply) ☐ Spreading ☐ Clumping ☐ Buoyancy ☐ Trajectory ☐ Emulsification ☐ Visibility
Explain how the properties of the selected simulant/surrogate material are suited to the study objectives as well as the technologies, tactics, or systems involved.

3.4 Practical Considerations

3.4.1 Deployment and Recovery

What is the deployment method? (Manual, blower, etc.)
What equipment is required for deployment, if applicable?
Justification for intended release volume:

Describe any monitoring activities that are planned to track the volume released, its movement, and potential recovery? (i.e. Aerial, visual, remote sensing)		
Particle Size ☐ Large (1 cm or more) ☐ Medium (mm to 1 cm) ☐ Small (microns)	Recoverability of material ☐ High ☐ Moderate ☐ Low	Degradability of material ☐ High ☐ Moderate ☐ Low
Describe primary plan for recovery, if applicable.		
What volume or quantity of material must be recovered to satisfy recovery plan?		
Describe the method used to account for total amount of material recovered.		
For materials that will not be recovered, describe the short- and long-term persistence of material (on surface & in water column), potential for shoreline stranding, and other considerations with long-term fate.		

3.5 Environmental and Wildlife Considerations

Is material organic or synthetic?
Is material naturally present in the local environment?
Cite published references on environmental or eco-toxicity, and provide documentation.
Published information on human health effects. (e.g. SDS, toxicity assays, etc.)
Describe receiving environment. (Type of water body, climate zone, water depth and sea conditions, etc.)
Distance and estimated travel time from release site to shoreline:
Identify other sensitive receptors or environments that are within the proposed release area.

List any seasonal considerations for the proposed release. (e.g. Presence of migratory wildlife, sensitive life stages, etc.)
List all wildlife that could come into contact with material and potential adverse impacts. (e.g., Sea birds, marine mammals, finfish or shellfish)
Identify any threatened or endangered species that may be present in the area at the time of release.
Describe measures that will be taken to protect sensitive wildlife or environments from potential adverse impacts from release.

3.6 Permit Considerations

3.6.1 Past Use in U.S. waters

Has material been deployed in U.S. waters before? ☐ Yes ☐ No ☐ Unknown	Was the release permitted? ☐ Yes ☐ No ☐ Unknown

Provide any additional information available about releases of this material in U.S. (e.g. Release details, permitting authority, contact details for lead investigators)

3.6.2 Considerations for Permitting Release

Identify all relevant permitting authorities. (List jurisdictional authorities – local, state, federal, tribal, other)
Applicable statutes and regulations:
Estimated time to complete permit application:

What documentation must be provided prior to the release, and to whom?
What documentation must be provided after the release, and to whom, if applicable?

3.6.3 Opportunity Cost

How much will the release materials cost?
What is the estimated clean up cost?
Has the time estimated for the permitting process been incorporated into the project budget? If so, what amount? How much time can this amount afford to buy?

4 Oil Surrogate Material Summaries

Surrogate material summaries have been developed for the following surrogates, which have some history of reported use in U.S. waters or other jurisdictions.

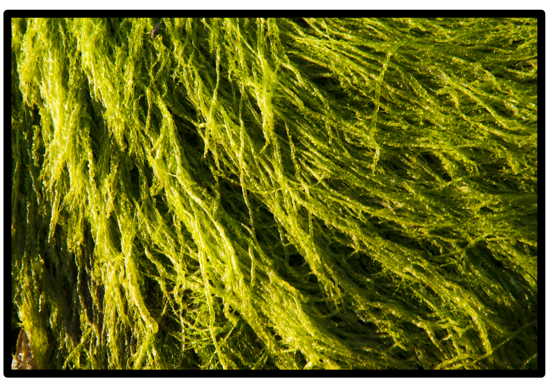
- Algae or Seaweed
- Bagasse
- Coir
- Cork
- Dog Food
- Drift Cards
- Dye
- Evergreen Needles
- Hay
- Native Organic Materials
- Peanut Shells
- Peat Moss
- Perlite
- Popcorn
- Protein-based Foam
- Rice Hulls
- Sunflower Seeds
- Wood Chips

4.1 Algae/Seaweed

Algae and seaweed are a particle-based oil surrogate and do not have a recorded history of use as surrogates in U.S. waters. Since this material is naturally-occurring in marine environments, it has the potential benefits of being readily available and benign under most circumstances. Seaweed or algae may be deployed in fresh or dried form, or may be ground up into a sludge, which may approximate the behavior of a fluid more than solid leaves or plants.

Properties

Properties	Algae	Seaweed
Spreading	Yes	Yes
Clumping	Possibly, but unknown	Possibly, but unknown
Buoyancy	Floats - Density: Varies by species	Floats - Density: Varies by species (raw kelp is 0.34 g/cm3)
Trajectory	Affected by wind and current	Affected by wind and current
Emulsi-fication	Will not emulsify	Will not emulsify
Visibility	Depends on the color	Depends on the color



Examples of algae (left) and seaweed (right), which both naturally occur in marine environments. The use of green or brown-colored material would determine visibility if released for spill response purposes.

Practical Considerations

Practical Considerations	Algae	Seaweed
Deployment	Manual; Can be thrown overboard or deployed from shore/dock	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low	Low
Degradation	Varies	Varies
Particle Size	Large. Can be ground into small or medium.	Large. Can be ground into small or medium.
Known Toxicity	Low; Potential for toxicity in high concentrations	Low; Potential for toxicity in high concentrations
Other Information	• Brushes, mops, and belts might pick these materials up, but unclear if wipe systems can clean it off • Unsure about disks and drums being able to recover materials	

History of Use in U.S.

History of Use		Algae	Seaweed
Regions of U.S. where material has been used		Anecdotal reports, undocumented	Anecdotal reports, undocumented
Past Use in U.S. waters	Research & Development	No documented use	No documented use
	Training & Exercises	No documented use	No documented use
	Fate & Behavior	No documented use	No documented use
Lessons Learned from Past Use		Not available	

4.2 Bagasse

Bagasse is a particle-based surrogate and does not have a recorded history of use as a surrogate in U.S. waters. The material is organic, fibrous remnants of sugarcane or sorghum processing. It is used as biofuel, a material to create pulp and other building materials, or considered waste material. If bagasse is ground up, it may approximate the behavior of a fluid more than in raw form.

Properties

Properties	Bagasse
Spreading	Yes
Clumping	Possibly, but unknown
Buoyancy	Floats - Density: 0.12 g/cm3
Trajectory	Affected by wind
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility due to light brown color

Bagasse is shown on the left. The image on the right shows sugarcane before processing.

Practical Considerations

Practical Considerations	Bagasse
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Persists for weeks
Particle Size	Medium (individual fibers)
Known Toxicity	Unknown
Other Information	• Has been suggested as sorbent for spill clean-up

History of Use in U.S.

History of Use		Bagasse
Regions of U.S. where material has been used		Written evidence of use, location undocumented
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Used by NOAA HAZMAT/ERD
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.3 Citrus Fruits

Citrus fruits are a particle-based oil surrogate and have a history of use as a surrogate in U.S. waters. Given that their density approximates that of oil, they are a favorite for conducting Research & Development, executing Training & Exercises, and testing Fate & Behavior. Round-shaped citrus fruits are most commonly used (oranges and grapefruit).

Properties

Properties	Oranges	Grapefruit	Other Citrus
Spreading	Spreads to form monolayer; Bob up and down like tar balls	Spreads to form monolayer; Bob up and down like tar balls	Spreads to form monolayer. Bobs up and down like tar balls. Smaller fruits are less similar to tar balls.
Clumping	Will not clump	Will not clump	Will not clump
Buoyancy	Floats - Density: 0.87 – 0.91 g/cm3	Floats - Density: 0.97 g/cm3	Floats - Varies by fruit
Trajectory	Behave similar to oils of similar density. Sensitive to both current and wind.	Behave similar to oils of similar density. Sensitive to both current and wind.	Varies
Emulsi-fication	Will not emulsify	Will not emulsify	Will not emulsify
Visibility	Very good visibility due to bright color	Very good visibility due to bright color	Visibility linked to color


Oranges (left) and grapefruits (right) are citrus fruits. Oranges are a popular release material; grapefruits are larger and more likely to break on impact.

Practical Considerations

Practical Considerations	Oranges	Grapefruit	Other Citrus
Deployment	Manual; Can be thrown overboard or deployed from shore/dock	Manual; Can be thrown overboard or deployed from shore/dock	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Labor-intensive. Recover with nets or by hand	Labor-intensive. Recover with nets or by hand	Labor-intensive. Recover with nets or by hand
Degradation	Persists for weeks	Persists for weeks	Persists for weeks
Particle Size	Large	Large	Large
Known Toxicity	Low; Potential pesticide residue	Low; Potential pesticide residue	Low; Potential pesticide residue
Other Information	• Oranges are typically the preferred citrus fruit • Easy to deploy and locate • Relatively small quantities can be used for certain purposes	• Grapefruit are more fragile than oranges and may break upon deployment	• Slightly more difficult to obtain in large quantities • Smaller and less visible in the water than oranges or grapefruits • Anecdotal information suggests limes sink

History of Use in U.S.

History of Use		Oranges	Grapefruit	Other Citrus
Regions of U.S. where material has been used		Documented use in AK, CA, MA, ME, MI, & RI. Anecdotal evidence of more widespread use.	Documented use in CA. Anecdotal evidence use in FL.	Anecdotal evidence of occasional use. Anecdotal evidence of lemons released in FL.
Past Use in U.S. waters	Research & Development	No documented use	No documented use	No documented use
	Training & Exercises	Evaluation of boom arrays	Evaluation of boom arrays	Evaluation of boom arrays
	Fate & Behavior	Oil trajectory and surface transport studies	Oil trajectory and surface transport studies	Oil trajectory and surface transport studies
Lessons Learned from Past Use		• Some weirs skimmers have a top plate fixture for support and some large fruits might not be able to get through • Popular choice of surrogate		

4.4 Coir

Coir is the natural fibrous material that comes from coconut shells, technically between the hard internal shell and the outermost layer. It is a particle-based surrogate and does not have a recorded history of use as a surrogate in U.S. waters. Traditionally, it is used to make mats, brushes, mattresses, sacking, netting, or ropes and also for horticulture.

Properties

Properties	Coir
Spreading	Yes; Initial tendency to spread is countered by its low density
Clumping	Yes; Particles may clump together or move as discreet units
Buoyancy	Floats - Density: 0.0013 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility due to light brown color

Coir fibers are shown on the left. The split coconut on the right shows the outer shell, which is the source of coir.

Practical Considerations

Practical Considerations	Coir
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Persists for years
Particle Size	Medium (individual fibers)
Known Toxicity	Low, but possibility of phytotoxin under certain conditions
Other Information	• Has been suggested as sorbent for spill clean-up • There is an existing patent from 2002 for oil spill clean-up method using coir pith

History of Use in U.S.

History of Use		Coir
Regions of U.S. where material has been used		No documented use
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	No documented use
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.5 Cork

Cork is a natural material that comes from the bark of a cork oak tree. It is a particle-based surrogate and does not have a recorded history of use as a surrogate U.S. waters. It is conventionally used to make wine corks, bulletin boards, shoes, building materials, and various other products. This material is organic, but will persist in water and is expensive compared to other surrogate options given recent shortages and its constant popularity for use in consumer goods. Granulated cork would most likely be used for deployment.

Properties

Properties	Cork
Spreading	Yes; Driving force to spread is countered by its low density
Clumping	Yes; Might clump together or move as discreet units depending on its size
Buoyancy	Floats - Density: 0.16 g/cm3 granulated; 0.34 g/cm3 solid
Trajectory	Affected by wind
Emulsi-fication	Will not emulsify
Visibility	High initial visibility due to light color

Cork is a natural material that comes from the bark of a cork oak tree, which are native to southwest Europe and northwest Africa. Granulated cork can be ground into different sizes and densities depending on the purpose.

Practical Considerations

Practical Considerations	Cork
Deployment	Manually unloaded by bulk dumping or bag discharge
Retrieval	Moderate
Degradation	Will persist in water, but organic material
Particle Size	Small, medium, or large (depends on processing)
Known Toxicity	Considered non-toxic
Other Information	Not available

History of Use in U.S.

History of Use		Cork
Regions of U.S. where material has been used		No documented use
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	No documented use
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.6 Dog Food

Dog food (specifically dry dog food as opposed to wet dog food that comes in cans) is considered a particle-based surrogate and has a history of past use as a surrogate in U.S waters. It has a density that approximates to crude oil, making it an optimal choice. Although it is considered non-toxic, selecting a dog food with minimal or no preservatives will ideally minimize environmental impact. This material can be found in large quantities fairly easily.

Properties

Properties	Dog Food
Spreading	Yes; Tendency to spread into a monolayer
Clumping	Not initially
Buoyancy	Floats initially - Density: 0.8 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify, but may clump as it degrades
Visibility	Moderate visibility due to color

Dog food comes in varying shapes, colors, and densities, as pictured in the photos above.

Practical Considerations

Practical Considerations	Dog Food
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Moderate
Degradation	Will take on water and degrade within days
Particle Size	Medium or large
Known Toxicity	Non-toxic, but may have preservatives
Other Information	Not available

History of Use in U.S.

History of Use		Dog Food
Regions of U.S. where material has been used		Written evidence of use in GA
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		• Birds consume dog food while on the water • Attracts sharks • Sheen will form on water after release

4.7 Drift Cards

Drift cards (also called "drifters") are pieces of wood, metal, or plastic painted with a non-toxic paint. They are a particle-based surrogate and have a history of past use as surrogates in U.S. waters. The National Oceanic and Atmospheric Administration (NOAA) have a long history of drift card-like studies to study ocean currents, starting with glass bottle deployment and evolving into modern drift cards. They are normally printed with contact information so people who recover them onshore can report the cards' ultimate destination.

Properties

Properties	Drift Cards
Spreading	No; Will move as discrete units as opposed to spreading like a liquid
Clumping	No
Buoyancy	Floats - Density: 0.38 g/cm3 (wood chips)
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Very good visibility; Painted with bright colors to enhance visibility

Drift cards provide exceptionally high visibility in marine or freshwater environments due to their bright coloring.

Practical Considerations

Practical Considerations	Drift Cards
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	High. Bright colors enable responders to gather painted wood from the water with nets or by hand. Some scientists put contact information on drift cards so people who find them can report the location they were recovered. This helps predict the movement of oil and create awareness for those who find these pieces of equipment.
Degradation	Will persist in the environment
Particle Size	Large
Known Toxicity	Non-toxic paint used during manufacture
Other Information	• Normally 4"x6"x1/8" in size • Drift cards are often used during oil spills as well • National Oceanic and Atmospheric Administration (NOAA) has used drift cards in experiments to track ocean currents since the 1970s and still do today. Historically, NOAA used plastic drift cards and glass bottles to track currents, which have been replaced with eco-friendly alternatives.

History of Use in U.S.

History of Use		Drift Cards
Regions of U.S. where material has been used		Written evidence of use in AK, CA, CT, HI, FL, & WA
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		• Drift cards have been recovered decades after original release in both the U.S. and foreign countries • Deployed during Deepwater Horizon spill (2010) at different depths to help with forecasting

4.8 Dye

Dye is a liquid surrogate and has a history of past use in U.S. waters. It has an established history of use in simulating oil spills as well as tracking ocean currents and effluent plumes. The most commonly used dyes are fluorescein and rhodamine.

Properties

Properties	Dye
Spreading	Yes
Clumping	No
Buoyancy	Not buoyant
Trajectory	Affected by current
Emulsi-fication	Will emulsify
Visibility	High visibility due to bright colors of the dye, normally bright yellow or green

Dye can be used alone for modeling purposes, or together with oranges to simulate tar balls or drift cards to further the ability to track and model potential oil trajectories.

Practical Considerations

Practical Considerations	Dye
Deployment	Manually or mechanically released
Retrieval	Low
Degradation	Will dissolve into the water column
Particle Size	Small
Known Toxicity	Varies by material
Other Information	Not available

History of Use in U.S.

History of Use		Dye
Regions of U.S. where material has been used		Written evidence of use in AK, CA, FL, MI, & NJ
Past Use in U.S. waters	Research & Development	Used to measure how effective oil spill response equipment may be on-water
	Training & Exercises	Used to model potential oil trajectory during exercises
	Fate & Behavior	Used for surveillance and tracking
Lessons Learned from Past Use		• Possible wildlife impacts • Birds have a tendency to sit in the floating dye • Some states have existing pre-approval for dye releases • Does not mimic oil for boom entrainment

4.9 Evergreen Needles

Evergreen needles are the mature leaves of conifer trees, which are native to North America. They are a particle-based surrogate and have a history of use as a surrogate in U.S. waters. Evergreen needles can be found naturally occurring in forested environments or as a waste product from forestry. They are native to North America and have been introduced to environments all around the world.

Properties

Properties	Evergreen Needles
Spreading	Yes; Have an initial tendency to spread
Clumping	Yes; Particles may clump together depending on moisture content
Buoyancy	Floats; May sink after taking on water
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Low visibility due to dark green color

Evergreen needles are considered a waste product from forestry, or can be found on the forest floor after naturally coming off trees. They turn brown after drying out.

Practical Considerations

Practical Considerations	Evergreen Needles
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment
Particle Size	Medium or large length, small width
Known Toxicity	Sometimes, possible mycotoxin (toxic mold that grows on plants)
Other Information	

History of Use in U.S.

History of Use		Evergreen Needles
Regions of U.S. where material has been used		Anecdotal evidence of use in AK
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	No documented use
Lessons Learned from Past Use		• Can be run through a weir skimmer and collected in a fish tote with holes and a fine meshed brailer bag and used again

4.10 Hay

Hay is composed of grass, legumes, or other plans that have been cut, dried, and stored normally for animal consumption. It is a particulate-surrogate and has a history of past use in U.S. waters. Hay is relatively easy and cheap to come by, therefore an inexpensive and non-toxic option for a release material. Hay is also considered a sorbent and was previously suggested for use during the Deepwater Horizon Spill (2010).

Properties

Properties	Hay
Spreading	No
Clumping	Yes; Tendency to stick together
Buoyancy	Floats, but may depend on extend of drying and/or heat treatment for long term flotation - Density: 0.22 g/cm3
Trajectory	Affected by wind
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility due to initial light color

Hay normally is packaged in bales or large rolls. As seen in the picture on the right, hay has also been used as a surrogate during training and response exercises.

Practical Considerations

Practical Considerations	Hay
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment
Particle Size	Medium (individual fibers)
Known Toxicity	Sometimes, possible pesticide residue
Other Information	• Has been used as sorbent during spill clean-up

History of Use in U.S.

History of Use		Hay
Regions of U.S. where material has been used		Written evidence of use in MA
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.11 Native Organic Materials

Native organic materials include any naturally occurring materials that may be locally available for use as an oil surrogate. They are particle-based surrogates and do not have a history of use as surrogates in U.S. waters.

Many of the other materials presented in this tool are organic in nature. Native organic materials are differentiated because they are opportunistically sourced – instead of being procured and transported for release during a field activity, they are collected from the local environment and deployed. They types of materials that may be included in this category include a range of materials. Examples include acorn tops, leaves, and twigs or sticks.

Properties

Properties are variable depending upon the material.

Examples of potential native organic materials (Clockwise: Dried leaves, twigs and sticks, and acorn tops).

Practical Considerations

Practical Considerations	Native Organic Materials
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Depends on material, but most naturally-occurring materials persist for days/weeks
Particle Size	Small, medium, or large (depends on material and processing)
Known Toxicity	Non-toxic, but should consider if the material is toxic in strong concentrations
Other Information	• Native organic materials may ease the permitting requirements since they are naturally-occurring in the environment and will not introduce a non-native species to the environment.

History of Use in U.S.

History of Use		Native Organic Materials
Regions of U.S. where material has been used		No documented use
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	No documented use
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.12 Peanut Shells

Peanut shells are the outer shell of a peanut and are normally considered waste materials after peanuts are processed. They are a particle-based surrogate and do not have a history of past use in U.S. waters.

Properties

Properties	Peanut Shells
Spreading	Yes; Have an initial tendency to spread but this is countered by its low density
Clumping	Yes; Particles may clump together or move in discreet units
Buoyancy	Floats - Density: 0.23 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility due to initial light color


Peanut shells are considered a waste material after the processing of peanuts.

Practical Considerations

Practical Considerations	Peanut Shells
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment if heat treated
Particle Size	Medium or large (can be processed to small)
Known Toxicity	Sometimes, possible mycotoxin (toxic mold that grows on plants)
Other Information	Not available

History of Use in U.S.

History of Use		Peanut Shells
Regions of U.S. where material has been used		No documented use
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	No documented use
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.13 Peat Moss

Peat moss is the decayed and dried form of a moss called sphgnum that is conventionally used as a soil enhancement for gardening given its ability to absorb and retain water. It is a particle-based surrogate and has a history of past use as a surrogate in U.S. waters. Peat moss is popular since it is easy and inexpensive to obtain, typically from gardening centers, and also because it is an organic material.

Properties

Properties	Peat Moss
Spreading	Yes; Will spread to some extent but the driving force to spread will be countered by low density
Clumping	Yes; Particles may clump together
Buoyancy	Floats initially, but will sink if saturated; Depends on extent of drying and heat treatment for long term floatation - Density: 0.10-0.12 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility; Dark color limits distance of detection

Peat moss is dark in color, which limits its visibility, but it mimics the trajectory and spreading of an oil slick very well until it becomes saturated and begins to sink.

Practical Considerations

Practical Considerations	Peat Moss
Deployment	May be blown or released manually; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment
Particle Size	Medium or large
Known Toxicity	Unknown, no data available
Other Information	Not available

History of Use in U.S.

History of Use		Peat Moss
Regions of U.S. where material has been used		Written evidence of use in AK, MA, ME, & MI
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		• When deployed with citrus fruit, the fruit acts like tar balls while the moss mimics the oil trajectory. Provides good visibility and approximate oil movement. • Works well to test booming configurations during exercises. • Popular choice of surrogate

4.14 Perlite

Perlite is an amorphous volcanic glass that occurs naturally and expands when heated, giving it a lightweight after processing. It is a particulate surrogate and does not have a history of use as a surrogate in U.S. waters, although it has been released in other countries. It is conventionally used for soil enhancement or building materials. Perlite can be ground into different size particles, namely coarse, medium, and fine.

Properties

Properties	Perlite
Spreading	Yes; Have an initial tendency to spread but this is countered by its low density
Clumping	Yes; Particles may clump together
Buoyancy	Floats - Density: 0.11 – 0.14 g/cm3
Trajectory	Affected by wind
Emulsi-fication	Will not emulsify
Visibility	Good initial visibility due to light color

Perlite ore (left) can be ground into different size particles, pending on the purpose it's intended for. Medium or fine would be best for releasing into the environment as an oil surrogate.

Practical Considerations

Practical Considerations	Perlite
Deployment	May be blown or released manually; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment, resists microbial breakdown. Small particle size.
Particle Size	Small, medium, or large (depends on processing)
Known Toxicity	No data available, considered inert
Other Information	Not available

History of Use in U.S.

History of Use		Perlite
Regions of U.S. where material has been used		No documented use in U.S. waters. Released in Poland (2006).
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		• Blends in with sea foam and decreases visibility; colored perlite has been suggested for future releases

4.15 Popcorn

Popcorn is the popped product of dried corn kernels. It is a particle-based surrogate and has a history of use as a surrogate in U.S. and foreign waters. It is produced commercially for consumption, and its low cost and abundant availability make it an optimal choice for a surrogate.

Properties

Properties	Popcorn
Spreading	Yes; Have an initial tendency to spread but will be countered by the low initial bulk density
Clumping	Particles may clump together
Buoyancy	Floats; Once it takes on water, it will float lower in the water but will still remain floating - Density: 0.024 g/cm3
Trajectory	Affected by wind
Emulsi-fication	Will not emulsify; Will turn into a lumpy paste as it takes on water
Visibility	Good initial visibility

Popped popcorn (left), as opposed to popcorn kernels, would be used as a surrogate. On the right, popcorn is being contained and recovered with a belt skimmer during a boom deployment exercise.

Practical Considerations

Practical Considerations	Popcorn
Deployment	May be blown or released manually; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will degrade after days
Particle Size	Medium
Known Toxicity	Non-toxic if plain; Should be unsalted and without butter to prevent contamination of the environment
Other Information	• May be controversial since popcorn is a food product and might be considered waste

History of Use in U.S.

History of Use		Popcorn
Regions of U.S. where material has been used		Written evidence of use in AK, IL, & ME. Released in Brazil (2010).
Past Use in U.S. waters	Research & Development	Evaluation of skimmer efficiency
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	No documented use
Lessons Learned from Past Use		• Popular choice of surrogate • Do not provide accurate interaction with oil spill equipment

4.16 Protein-based Foam

Protein-based foam, typically used in fire-fighting, is stable mass of small air-filled bubbles, which have a lower density than oil, gasoline, or water. It is a particle-based surrogate and does not have a history of use as a surrogate in U.S. waters. Protein-based foams are biodegradable (synthetic foams are not).

Properties

Properties	Protein-based Foam
Spreading	Yes; Low density of the foam, which will negatively affect the spreading, will be offset by the ability of the foam to affect surface tension of the water
Clumping	Maybe
Buoyancy	Floats
Trajectory	Affected by current
Emulsi-fication	Not initially, but eventually while on water
Visibility	Good visibility

Protein-based foam is often used to suffocate fires or combat chemical or oil spills.

Practical Considerations

Practical Considerations	Protein-based Foam
Deployment	Mixed and then ejected using specialized equipment
Retrieval	Low
Degradation	Will degrade after days
Particle Size	Small
Known Toxicity	Low toxicity; may include animal protein
Other Information	Not available

History of Use in U.S.

History of Use		Protein-based Foam
Regions of U.S. where material has been used		Written evidence of use, location undocumented
Past Use in U.S. waters	Research & Development	Used to measure how effective oil spill response equipment may be on-water
	Training & Exercises	No documented use
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		Not available

4.17 Rice Hulls

Rice hulls, or rice husks, are the hard outer shells that protect grains of rice as they grow. They are a particle-based surrogate and have a history of use as a surrogate in U.S. waters. Conventionally, rice hulls are used for fertilizer, building materials, insulation material, or fuel although in the U.S. they are mostly considered a waste product of food processing.

Properties

Properties	Rice Hulls
Spreading	Yes; Initial tendency to spread is countered by its low density
Clumping	Yes; May clump together or move in discreet units
Buoyancy	Floats
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Moderate visibility due to variable brown color

During the milling process, rice hulls are removed
to reveal whole brown rice grains.

Practical Considerations

Practical Considerations	Rice Hulls
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment if initially heat treated
Particle Size	Small or medium
Known Toxicity	Non-toxic
Other Information	Not available

History of Use in U.S.

History of Use		Rice Hulls
Regions of U.S. where material has been used		Written evidence of use in CA, LA, & ME
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	No documented use
Lessons Learned from Past Use		• Do not provide accurate interaction with oil spill equipment

4.18 Sunflower Seeds

Sunflower seeds are the fruit of a sunflower. They are a particle-based surrogate and do not have a history of use as a surrogate in U.S. waters. Their hard shell is black and white and the edible remainder inside the shell is called the kernel. The seeds can be pressed for oil, or the entire product is produced as a food.

Properties

Properties	Sunflower Seeds
Spreading	Yes; Will spread to some extent
Clumping	Yes; May clump together or move in discreet units
Buoyancy	Floats - Density: 0.75 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Fair visibility due to mix of dark and light color will limit distance of detection compared to other identified simulants

Sunflower seeds are primarily considered a food product and can be found in most grocery and convenience stores.

Practical Considerations

Practical Considerations	Sunflower Seeds
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Low
Degradation	Will persist in the environment
Particle Size	Medium
Known Toxicity	Parts of sunflower plant identified as slightly toxic if large quantities are ingested by wildlife
Other Information	• Sheen from sunflower oil may develop on water after release

History of Use in U.S.

History of Use		Sunflower Seeds
Regions of U.S. where material has been used		Written evidence of use, location undocumented
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	No documented use
	Fate & Behavior	No documented use
Lessons Learned from Past Use		Not available

4.19 Wood Chips

Wood chips are a solid material produced from cutting or chipping larger pieces of wood. They are a particle-based surrogate and have a history of use as a surrogate in U.S. waters. They are a byproduct of logging and timber industry and may be plentiful in regions such as the Pacific Northwest. Wood chips are used for a wide range of purposes, from gardening and landscaping to cage lining for small pet rodents.

Properties

Properties	Wood Chips
Spreading	Yes; Will spread to some extent
Clumping	Yes; May clump together or move in discreet units depending on particle size
Buoyancy	Floats; Long term buoyancy may depend on extent of drying and/or heat treatment - Density: 0.38 g/cm3
Trajectory	Affected by current
Emulsi-fication	Will not emulsify
Visibility	Good initial visibility

Wood chips come in a variety of shapes, sizes, and colors depending on the wood used and method of processing.

Practical Considerations

Practical Considerations	Wood Chips
Deployment	Manual; Can be thrown overboard or deployed from shore/dock
Retrieval	Moderate; Can be retrieved by nets
Degradation	Will persist in the environment
Particle Size	Medium or large (depends on processing)
Known Toxicity	Generally non-toxic
Other Information	• Inexpensive • Has been suggested as sorbent for spill clean-up • There is an existing patent from 1989 for oil spill clean-up method using wood chips

History of Use in U.S.

History of Use		Wood Chips
Regions of U.S. where material has been used		Written evidence of use, location undocumented
Past Use in U.S. waters	Research & Development	No documented use
	Training & Exercises	Evaluation of boom arrays
	Fate & Behavior	Model potential oil trajectory for observers
Lessons Learned from Past Use		Not available

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Appendix C – Resource List

Relevant Programs and Organizations

Arctic Tracer Release Experiment (ARCTREX): Applications for Mapping Spilled Oil in Arctic Waters
Link: http://www.ims.uaf.edu/artlab/projects/ARCTREX/
The project's goal is to simulate a small oil spill in the Chukchi Sea in order to test the ability of currently available observational technologies and web-based GIS tools to provide real time data and maps to response agencies. The dye release cruise began as of September 2014.

BSEE Oil Spill Response Research (OSRR) Program
Link: http://www.bsee.gov/Technology-and-Research/Oil-Spill-Response-Research/index/
The project's objective is to advance the understanding of spill responders and the scientific community on how submerged oil plumes and floating slicks are transported in aquatic environments. The goal is to do that without the risk of harming the environment and associated ecosystems.

Interagency Coordinating Committee on Oil Pollution Research (ICCOPR)
Link: http://www.uscg.mil/iccopr/
Title VII of the Oil Pollution Act of 1990 (Section 7001) established the fourteen-member Interagency Coordinating Committee on Oil Pollution Research, the Interagency Committee, to "coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations, as appropriate, and shall foster cost-effective research mechanisms, including the joint funding of the research."

US National Response Team (US NRT)
Link: http://www.nrt.org/
The U.S. National Response Team (NRT) is an organization of 15 federal departments and agencies responsible for coordinating emergency preparedness and response to oil and hazardous substance pollution incidents.

Relevant Resources

Application for EPA Permits to Discharge Oil for Research Purposes: Revised Interim Guidelines (March 2001)
Link: http://www.epa.gov/OEM/docs/oil/fss/fss04/nichols_04.pdf
The U.S. Environmental Protection Agency (EPA or the Agency) has prepared these revised guidelines on discharging oil into U.S. waters to assist research efforts on the prevention, preparedness and response to oil pollution that cannot be conducted in a laboratory, test tank, or other facility. The revised guidelines update the 1971 guidelines developed for the same purpose.

Behavior of Oil Spills in Ice and Implications for Arctic Spill Response, Arctic Technology Conference (February 2011)
Link: http://www.arcticresponsetechnology.org/wp-content/uploads/2012/11/Dickins-Review-Paper.pdf
The paper reviewed the history of research into the behavior spills in ice covered waters and documents our current state of knowledge, drawing on the findings from a number of milestone field experiments conducted over the past 40 years. In particular the paper focuses on the unique aspects of spill behavior in different ice regimes that can both hinder and benefit spill response, depending on the timing and type of release.

Conmy, R. Environmentally Benign Oil Simulants to Mimic the Behavior of Oil Droplets in the Ocean (2015)
Link: http://www.bsee.gov/Technology-and-Research/Oil-Spill-Response-Research/Projects/Project1029/
Robyn Conmy of the Environmental Protection Agency (EPA) is conducting this project for the Bureau of Scientific and Environmental Enforcement (BSEE). The objective of this project is to advance the understanding of spill responders and the scientific community on how submerged oil plumes and floating slicks are transported in aquatic environments. To do this, a synthetic material that behaves like oil but is environmentally benign.

Fingas, M. Vegetable Oil Spills: Oil Properties and Behavior (2013).
This document describes instances of spilled vegetable oil and the data gathered from these instances. These spills have "resulted in environmental concerns equivalent to petroleum oil spills". Behavior tests are also reported for several oils, including canola, soy bean, olive, castor, and corn oils.

National Commission on Deepwater Spill: Response Cleanup/Technology Research & Development (January 2011)
Link:
http://cybercemetery.unt.edu/archive/oilspill/20121211011839/http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Response%20RD%20Working%20Paper.pdf
This paper explores criticism after the Deepwater Horizon Spill that claimed oil spill response was not as effective as it could have been because clean up technology has not kept up with advances in exploration technology.

Non-Toxic, Biodegradable Fluids for the Simulation of Crude Oil Behavior in Oil Spill Environments (August 2012)
Link: http://www.ibridgenetwork.org/utah/non-toxic-biodegradable-fluids-for-the-simulation-of-crude-oi_1
This website provides information on an oil simulant developed at the University of Utah, including an invention summary, market applications, description of features and benefits, and contact information to request more information.

Oil Spill Simulation Materials Review, SAIC 2008 (November 2008)
Link: http://www.pwsrcac.org/wp-content/uploads/filebase/programs/oil_spill_response_operations/oil_spill_simulation_materials_review.pdf
The Oil Spill Simulation Materials Review was presented by the Prince William Sound Regional Citizens' Advisory Council to SAIC Canada in November 2008.

Oil Spill Simulants Materials Workshop (March 2013), Clean Gulf Conference in Tampa, Florida
Nuka Research's Elise DeCola and Mark Swanson presented "Oil Spill Simulants Materials Workshop: Project Highlights and Next Steps for Permitting an Oil Simulant in the U.S." during the 2013 Clean Gulf Conference in Tampa, Florida.

Patent for Non-Emulsion Based Oil Simulant (May 2009)
Link: http://simulants.nukaresearch.com/files/OilSimulant.pdf
In addition to the simulant's patent, there is more information available on this invention from Technology & Venture Commercialization, The University of Utah (**http://www.tvc.utah.edu/techpublisher/energy_environment/3355.php).**

PWSRCAC Oil Spill Simulants Workshop Final Report (May 2013)
Link: http://www.pwsrcac.org/wp-content/uploads/filebase/programs/oil_spill_response_operations/oil_simulants/Oil%20Simulants%20Workshop%20Proceedings.pdf
The Prince William Sound Regional Citizen's Advisory Council (PWSRCAC) previously contracted Nuka Research and Planning Group to convene a high level workgroup of spill response and marine environmental experts from Alaska and around the U.S. to identify preferred substances for use as simulants in on-water oil spill response training and exercises.

PWSRCAC Oil Spill Simulants Workshop Briefing Document (January 2013)
Link: http://simulants.nukaresearch.com/files/130129_SimulantsWhitePaper_v4.pdf
This is the briefing document provided to work group members at the start of the Prince William Sounds Regional Citizen's Advisory Council oil simulants project.

Statement from Perth (Australia) Petroleum Services, Oil & Chemical Spill Equipment (2014)
Link: http://perthpetroleum.com.au/2014-05-12-03-31-27/news/117-using-simulants-during-an-oil-spill-exercise
After pointing out the value of using simulants for recovery exercises and lack of clear permitting process in the US, Perth Petroleum Services states that, "(we) feel there may be a need to combine relevant departments under one authority, to enable organizations to apply for a permit to use simulants during spill exercises and testing". They also mention that, "this may be a step too far for Australian people at present".

Permit Examples

Domestic

An experimental oil spill: The distribution of aromatic hydrocarbons in the water, sediment, and animal tissues within a shrimp pond (Texas) (1973)
Link: http://www.ioscproceedings.org/doi/pdf/10.7901/2169-3358-1975-1-607
This paper describes an experiment to test the resilience of shrimp to oil exposure. The researchers felt more work should be dedicated to studying biological and chemical changed that occur after a spill in the environment.

The abstract of the paper starts with: "A common practice in the mariculture of shrimp on the Texas coast is the application of fuel oil on the surface of the pond. This thin oil layer serves to eliminate large aquatic insects, which are predators of the small juvenile shrimp. Ordinarily, a common diesel fuel is used and it is removed from the pond after one day's treatment. In this experimental spill study, a high aromatic (38%) #2 fuel oil was utilized in higher quantity than normal and the residue was not removed."

Bioremediation study of spilled crude oil on Fowler Beach, Delaware (1995)
Link: http://www.ioscproceedings.org/doi/pdf/10.7901/2169-3358-1995-1-889
This paper describes the most recent crude oil release in the US permitted under the Environmental Protection Agency for the study of bioremediation of marine shoreline.

Ecological effects of experimental oil spills on Eastern Coastal Plain estuarine ecosystems (Virginia) (1975)
Link: http://www.ioscproceedings.org/doi/pdf/10.7901/2169-3358-1977-1-505
This paper describes an experiment during which isolated plots of marsh along York River, Virginia were doused in South Louisiana crude oil to study the ecological impact on the habitat.

Final USCG Great Lakes Demonstration 2 Report (June 2012)
Link:
http://www.uscg.mil/iccopr/files/Great%20Lakes%20Demonstration%202%20Report.pdf
This is the final report from an oil in ice exercise in Michigan that involved release of oranges and peat moss as surrogates. Appendix E is a letter of permissions for material release from the State of Michigan's Department of Environmental Quality.

Final USCG Great Lakes Exercise Report (July 2011)
Link: www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA551023
This is the final report from an oil in ice exercise in Michigan. It explicitly recommends "further demonstrations and exercises should be planned during the ice season with oil surrogates to better demonstrate and evaluate the equipment and techniques shown during this project". It also recommends "research the use of oil or surrogates such as rice hulls, oranges, or other environmentally benign materials to help evaluate containment and collection abilities of the equipment being deployed."

Maine GRS Deployment Tests (2011-2012)
Link: http://www.nukaresearch.com/projects/megrp/index.html
This website hosts all information related to Geographic Response System testing in Maine. Oranges and peat moss have been used as surrogates, which is permitted by the state's statue that allows certain material releases for science.

Meiofauna responses to an experimental oil spill in a Louisiana salt marsh (1983)
Link: http://www.int-res.com/articles/meps/11/m011p257.pdf
This paper describes a release of crude oil in Louisiana to study potential impact of oil on salt marsh meiofauna.

Microbial responses after two experimental oil spills in an Eastern Coastal Plain estuarine ecosystem (Virginia) (1977)
Link: http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-1977-1-517
This paper describes oil being released into a tidal salt marsh in southeastern Virginia to study the effects of spillage on microbial populations.

State of Alaska, Department of Fish and Game: Fish Habitat Permit FG92-III-0212 Amendment #7 (2011)
This permit allowed dye to be released in a fish habitat for an oil spill response exercise between the Canning/Staines River and Chukchi Sea coast south to Point Hope.

State of Alaska, Department of Fish and Game, Letter Re: Fish Habitat Permit FG92-III-0212 and Summer Oil Spill Containment and Recovery Training Activities (1992)
This letter allowed dye to be released for oil spill containment and recovery training activities in fish-bearing waters within the North Slope oil fields.

Use of Natural Oil Seeps for Evaluation of Dispersant Application and Monitoring Techniques (California) (2005)
Link: http://ioscproceedings.org/doi/abs/10.7901/2169-3358-2005-1-241
This paper explains the permitting process used in California to allow dispersants to be released on natural oil seeps for research and training purposes. After the natural oil seeps were deemed unresponsive to dispersants in laboratory tests and the project was called off, researchers considered applying to permit for an intentional release of oil in Alaska to conduct the same research. Their preliminary 2-year project proposal, which allocated an entire year to securing permits for an oil release, was not selected because the financial risk involved for a potentially unsuccessful permit.

International

Fisheries and Oceans Canada. BIO research helps nature clean up oil spills (2013)
Link: http://www.dfo-mpo.gc.ca/science/Publications/article/2007/26-11-2007-eng.htm
Marine oil-spill bioremediation techniques are spreading internationally, with much of the impetus coming from Dr. Kenneth Lee of the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Lee has taken part in collaborative field trials in Canada, the United Kingdom, France, Norway, and the Netherlands. Overall, he and colleagues have

documented the efficiency of various bioremediation techniques in particularly vulnerable coast environments: beaches, cobble shorelines, mudflats, freshwater wetlands, and tidal marshes.

Government of Canada. Bioremediation video (2007)
Link: http://www.science.gc.ca/default.asp?Lang=En&n=F8DA49B5-1
Following the 1989 Exxon Valdez oil spill, a bioremediation strategy based on nutrient enrichment was used to clean up over 100 kilometres of contaminated shoreline. The development and evaluation of bioremediation strategies for oiled wetlands is now the focus of a joint study by DFO and the US Environmental Protection Agency.

NOFO Report from Oil on Water 2014 (June 2014)
Link:
http://www.nofo.no/Documents/%C3%98velser/Rapport%20OPV%202014%2028nov2014-%20engelsk.pdf
Oil-on-Water 2014 took place in Norway during the period 16 – 22 June. The Norwegian Environmental Agency issued an oil discharge permit in a letter of 21 May 2014 for all eight trials. The letter set conditions for the trials and required reporting of all trials – including activities without dedicated discharges.

NOFO Oil Spill Response Exercise Report: Oil on Water 2013 (June 2013)
Link:
http://www.nofo.no/Documents/%C3%98velser/OPV2013/OPV%20rapport_Engelsk_2013_1.pdf
Oil-on-Water 2013 took place on the Frigg field (Norway) during the period 10 – 14 June. The purpose of releasing free-floating oil emulsion was to verify newly developed oil spill response equipment under realistic conditions and possibly identify weaknesses. Conventional oil recovery systems were used as back up behind the prototypes.

The Report of the Exercise Evaluation Team (EET) from Balex Delta 2006 Exercise in Gdynia, Poland. (November 2006)
Link: https://portal.helcom.fi/Archive/archive2/RESPONSE%208_2007_8_1_BALEX.pdf
The results of this exercise report are mentioned in the SAIC 2008 report; perlite was released.

SINTEF Final Report and Whitepaper: Potential Components of a Research Program Including Full-Scale Experimental Oil Releases in the Barents Sea Marginal Ice Zone (2002)
Link: http://www.bsee.gov/Technology-and-Research/Technology-Assessment-Programs/Projects/Project-453/
This project failed to come to fruition due to lack of global oil spill response funding and waning interest from industry, but the report was published with hopes to inform future projects that make similar proposals to release oil.

News Articles

Edge, Josh. "ARCTREX Tests Arctic Oil Spill Tracking Techniques." Alaska Public Media. 23 January 2015.
Link: http://www.alaskapublic.org/2015/01/23/arctrex-tests-arctic-oil-spill-tracking-techniques/
The Arctic Tracer Release Experiment - or ARCTREX - released red non-toxic dye in the US Arctic Ocean to understand how oil and other contaminants would spread in the ocean.

CARTHE Program. "Tracking the Last Mile Before Oil Meets the Beach." Gulf of Mexico Research Initiative. 17 January 2015.
Link: http://gulfresearchinitiative.org/tracking-last-mile-oil-meets-beach/?utm_source=GoMRI+eNews+Subscribers&utm_campaign=ac03d0a0b6-GoMRI_eNews&utm_medium=email&utm_term=0_03075965d8-ac03d0a0b6-263613409
Researchers studied the mechanisms that bring contaminants to shore using an EPA-approved red dye along with tracking devices in Florida.

Wells, Carlie Kollath. "Fake oil spill to be conducted Wednesday in Lake Pontchartrain." The Times-Picayune (New Orleans, LA). 27 August 2014.
Link: http://www.nola.com/environment/index.ssf/2014/08/fake_oil_spill_pontchartrain.html
Officials staged a fake oil spill in Lake Pontchartrain, Louisiana. The drill was part of the annual conference for the Alliance of Hazardous Materials Professionals, held in New Orleans during the last week of August. No liquids were "spilled" or put into the water during the simulation; instead responders pretended there was oil and used standard practices to contain it.

The Huffington Post B.C. "Oil Spill Simulated on B.C.'s Fraser River, Burrard Inlet." HuffPost British Columbia. 27 August 2014.
Link: http://www.huffingtonpost.ca/2014/08/27/oil-spill-fraser-river_n_5719085.html
Researchers dumped hundreds of bright yellow cards into B.C.'s Fraser River and Burrard Inlet to simulate how far a potential oil spill from the Trans Canada pipeline would spread.

Caffrey, Michelle. "N.J. criminal justice department investigates Washington Township oil spill with green dye." South Jersey Times (NJ). 18 July 2014.
Link: http://www.nj.com/washington-township-times/index.ssf/2014/07/nj_dept_of_criminal_justice_in.html
Washington Township's fire department assisted with an investigation into the dumping of more than 2,700 gallons of cutting oil into a local small pond and lake by injecting a non-toxic green dye into an upstream storm drain.

"BSEE Researcher Highlights Current Research Projects." Occupational Health & Safety. 18 July 2014.
Link: http://ohsonline.com/articles/2014/07/18/bsee-researcher-highlights-current-research-projects.aspx
Kristi McKinney, a research specialist in BSEE's Oil Spill Response Division, went to Bergen, Norway, to speak at the annual international seminar hosted by the Norwegian Oil Spill Control Association. McKinney highlighted current research within the Oil Spill Response Division and explained BSEE's and operators' requirements for oil spill planning and preparedness in U.S. territorial waters. She also observed the 2014 Oil on Water Exercise offshore at the Frigg oil field in the North Sea.

Coleman, Dash. "'Oil Spill' cleaned up during demo on Savannah River". Savannah Morning News. 7 May 2014.
Link: http://savannahnow.com/exchange/2014-05-07/oil-spill-cleaned-during-demo-savannah-river
This article mentions the used of "not-so-disastrous dog food" during an on-water oil spill response during IOSC 2014 in Savannah, Georgia.

Woody, Todd. "How scientists are using drones to fight the next big oil spill." Grist. 3 December 2013.
Link: http://grist.org/climate-energy/how-scientists-are-using-drones-to-fight-the-next-big-oil-spill/
This article details efforts to predict the path of potential future oil spills in the Gulf of Mexico using drone technology and surface and seabed sensors to track colored dye moving with the ocean current. This project illustrates simulants being used for spill response research purposes.

Helton, Doug. "From Rubber Ducks to Dog Food, Spilling Everything but Oil." NOAA's Office of Response and Restoration Blog. 22 March 2013.
Link: https://usresponserestoration.wordpress.com/2013/03/22/from-rubber-ducks-to-dog-food-spilling-everything-but-oil/
This article ties together seemingly random objects, such as rubber ducks, dog food, oranges, and wood chips, as the materials used to mimic the movement of oil in water that are currently used during oil spill simulations. It highlights the "need for materials that both realistically mimic oil behavior and are safe for use in the environment" to sufficiently test computer forecasting software and on-water spill response tactics.

Pow, Helen. "Historic plastic drift card washes up on Alaskan beach after 33 year sea voyage." UK Daily Mail. 11 May 2012.
Link: http://www.dailymail.co.uk/news/article-2142951/Historic-plastic-drift-card-washes-Alaskan-beach-33-year-sea-voyage.html
This article details how a young boy in Alaska found a drift card released by NOAA during an ocean current study after 33 years at sea.

Messenger, Stephen. "Oil workers scramble to clean a giant popcorn spill." www.treehugger.com. 5 December 2010.
Link: http://www.treehugger.com/corporate-responsibility/oil-workers-scramble-to-clean-a-giant-popcorn-spill.html
During an oil spill response drill, unsalted popcorn was released into the Amazon River in

Brazil to prepare for a potential disaster given drilling deep in the Amazon rainforest. Oil company Petrobras, along with the Brazilian navy, carried out the exercise.

Reed, Mack. "Slick Response: Mock Oil Spill Near Santa Barbara Tests Clean Up Crews' Readiness". Los Angeles Times. 15 April 1993.
Link: http://articles.latimes.com/1993-04-15/news/mn-23077_1_santa-barbara-spill
This article highlights the use of rice hulls as a surrogate for oil in California. It mentions that researchers expected the rice hulls to "sink and become fish food" and that rice hulls "are not a perfect simulation of floating oil", but add a realistic element to the drill.