# Bureau of Safety and Environmental Enforcement
# Oil Spill Preparedness Division

# Research to Support Analysis of Oil Spill Response Plans (OSRP) for Spills on Snow and Solid Ice

Final Report - REVISED

August 31, 2023


## ARCTOS Alaska, a Division of *NORTECH*, Inc., BSEE Oil Spill Preparedness Division, Alaska Department of Environmental Conservation's Prevention and Preparedness and Response Program



**US Department of the Interior**
**Bureau of Safety and Environmental Enforcement**
**Oil Spill Preparedness Division**

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Final Report - REVISED

OSRR # 1142

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**US Department of the Interior**
**Bureau of Safety and Environmental Enforcement**
**Oil Spill Preparedness Division**

# DISCLAIMER

**Contracts:**

Study concept, oversight, and funding were provided by the US Department of the Interior (DOI), Bureau of Safety and Environmental Enforcement (BSEE), Oil Spill Preparedness Division (OSPD), Sterling, Virginia, under Contract Number 140E0122F0017. This report has been technically reviewed by BSEE, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the US Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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| Bureau of Safety and Environmental Enforcement (BSEE) | Project Number – 1142 | https://www.bsee.gov/research-to-support-analysis-of-oil-spill-response-plans-for-spills-on-snow-and-solid-ice |
| U.S. Department of the Interior Library | Research to Support Analysis of Oil Spill Response Plans (OSRP) for Spills on Snow and Solid Ice | https://library.doi.gov/uhtbin/cgisirsi/?ps=8L0mpW5uPV/SIRSI/X/60/495/X |
| National Technical Reports Library | Research to Support Analysis of Oil Spill Response Plans (OSRP) for Spills on Snow and Solid Ice | https://ntrl.ntis.gov/NTRL/ |

Sources: a) BSEE (2019), b) DOI [2021], c) National Technical Information Service (2021)

# CITATION

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# ABOUT THE COVER

*Infographic image prepared by **NORTECH**, Inc.*

The infographic depicts the concept of the Recovery of Oil on Snow and Ice (ROSI) Calculator used for calculating the amount of heavy equipment needed for a planned response to a worst-case discharge (WCD) using specific contaminated snow and ice removal tactics from the Alaska Clean Seas' Technical Manual. Using the formulas included in the tactics, ROSI calculates the planned amount of material to remove (snow and ice), and heavy equipment (dump trucks, loaders) needed when planning oil spill recovery operations in winter conditions.

# ACKNOWLEDGEMENTS

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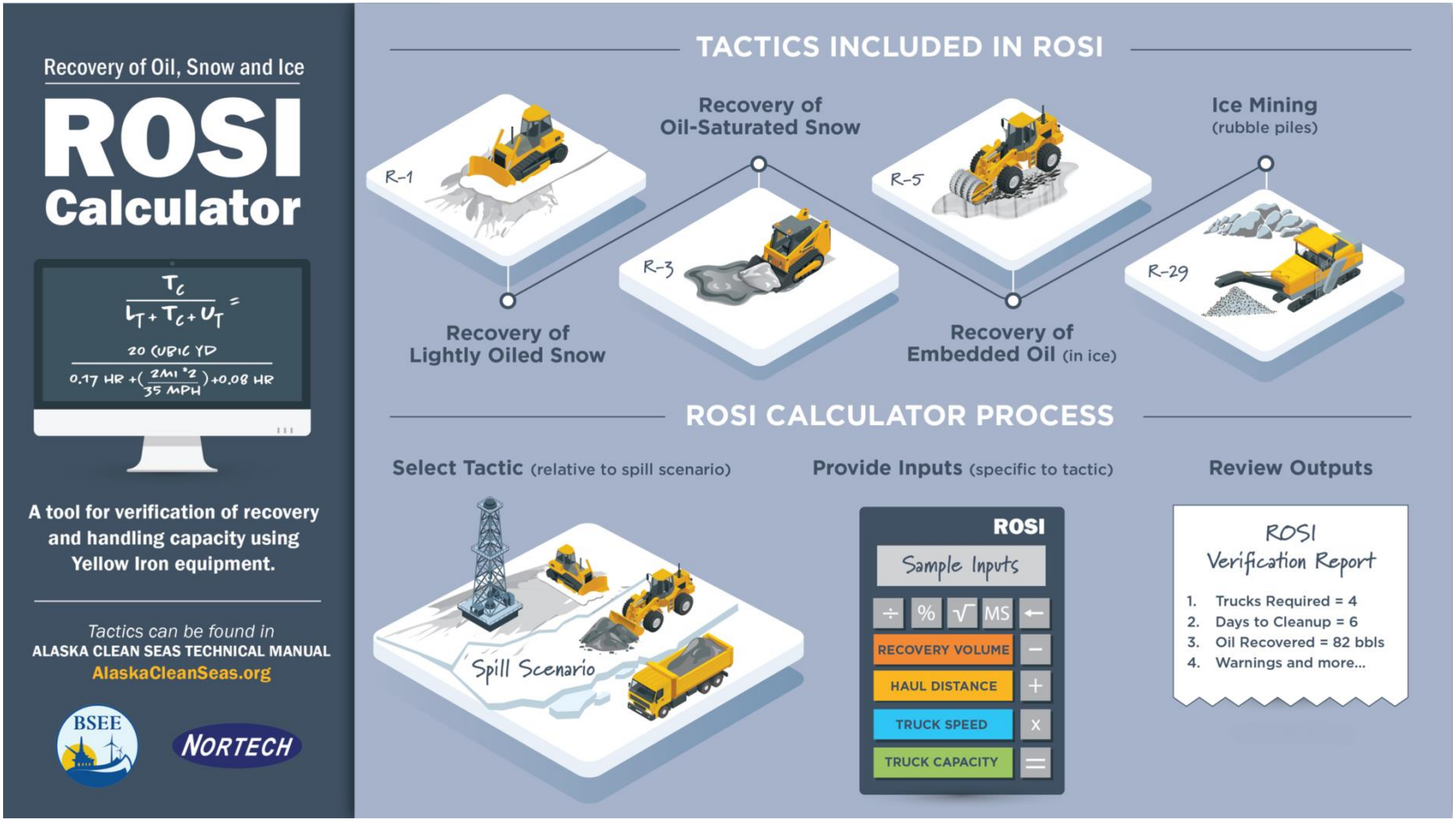
- Alaska Clean Seas' (ACS) entire management team, especially: Fred McAdams and Ken Linderman (Operations Managers), John Pulis and Chris Hall (Planning Managers, for providing thoughtful, concise, written answers to our interview questions and a virtual follow-up interview to answer additional questions. Also, to Jared Edgar, President and General Manager, for providing us with permission to use their copyrighted document (ACS Technical Manual) in our project publications.
- The Alaska Department of Environmental Conservation (ADEC)'s Prevention Preparedness and Response (PPRP) Program for allowing us to include their Scientific Support Coordinator, Mike Donnellan, in the project team, and Mike for his valuable contributions.
- Interviewees in addition to ACS for their time and attention to detail in providing responses to our questions regarding the project: Steve Potter, Vice President and Director, S.L. Ross, Research Limited, Ontario, Canada; Christy Bohl, BSEE OSPD (Alaska), Retired.
- Subject matter experts who provided expert opinions and published research studies that were included in the project: Alan A. Allen, Spiltec, and Dave Dickins, DF Dickins Associates LLC.
- The assistance of Mr. Dickins, S. Potter and Mikkel Foltmar, Professional Engineer (a former member of the project team), all spill response and metric system experts who provided answers to our metric questions, and, for testing the metric version of the calculator. Mr. Dickins also provided advisories regarding ice thickness and truck speed.
- The Reference Librarians at the Alaska Resource Library and Information Services (ARLIS) library who were most helpful with our research effort by pulling reports, conference proceedings and other guides found via their library search engine that are available only in hard copy in preparation for our visits to their library in Anchorage, Alaska. Also, many thanks for pulling additional related information to review, cited articles found while we were reviewing them in the library. It was an exceptional real-live, pre-internet, library experience.

Graphical Abstract

## GRAPHICAL ABSTRACT



# EXECUTIVE SUMMARY

This report has been developed to describe the project entitled Bureau of Safety and Environmental Enforcement (BSEE) Project 1142: "Research to Support Analysis of Oil Spill Response Plans (OSRP) for Spills on Snow and Solid Ice" to guide stakeholders in the development and analysis of OSRPs for facilities located offshore in the frozen Alaska Beaufort Sea during the winter months using "yellow gear" or "yellow iron" tactics presented in the Alaska Clean Seas' (ACS) Technical Manual (TM). The revised version of the report was issued after the metric equivalent version of the project was completed.

The project had two primary objectives:

- Develop the **Recovery of Oil on Snow and Ice (ROSI)** calculator to facilitate development and assessment of an operator's OSRP for a well blowout, tank failure, pipeline leak, or other oil spill that occurs during winter months and results in recovery operations on snow and solid ice using yellow iron equipment as described in the Alaska Clean Seas (ACS) Technical Manual (TM). This calculator could be used by:
    - BSEE oil spill preparedness division (OSPD) analysts to facilitate their review of OSRPs
    - Owners/Operators/Plan Holders/interested parties to assist them when developing OSRP spill response scenarios
- Provide recommendations for research and/or testing activities that should be conducted to reassess, verify, and potentially update the formulas used to calculate oil spill recovery rates that may then be incorporated into a future version of the ROSI calculator

The ROSI calculator was designed using the ACS TM's yellow iron spill response planning tactics designated as R-1, R-3, R-5 (ice only) and R-29. These tactics, comprised primarily of front-end loaders, dump trucks, ice trimmers and bulldozers, were selected as they typically constitute the most extensive and potentially limiting part of a winter oil spill response scenario across the North Slope. The various combinations of these yellow iron assets represent different systems, and the number of systems needed to recover oiled snow and ice prior to breakup represents the primary limitation of the use of these response tactics when planning a spill response in the Arctic.

The ACS planning tactics examined include formulas for determining the amount of yellow iron equipment needed to meet a given spill response scenario based on the spill volume and distances to storage or processing areas. To develop or evaluate an OSRP scenario, the user enters into ROSI the amount of contaminated material (snow, ice) in cubic yards along with the selected tactic(s), less the amount of free oil recovered using other tactics. ROSI then calculates the number of systems the plan holder needs to respond to the hypothetical discharge and the amount of time it will take to clean up the spill.

ARCTOS Alaska, a Division of ***NORTECH***, Inc. (ARCTOS), was selected to fulfil this project. They had previously developed their own calculator that they used to develop OSRPs for plan holders (and Oil Discharge Prevention and Contingency Plans (ODPCP) required by the Alaska Department of Environmental Conservation's (ADEC) statutes and regulations) and were thus

highly experienced in this type of development. Their calculator calculates the number of systems needed to recover oiled snow and ice in the event of a discharge. The project's workgroup, consisting of selected members of BSEE, ADEC, and ARCTOS/***NORTECH***, revised the ARCTOS calculator to make it more user friendly, suitable for a web-based application, and functional for the target audience. ROSI will be available on the BSEE.gov website for use by interested parties.

The existing formulas presented in the ACS tactics were reviewed and analyzed in light of any research studies or testing that had been conducted since the 1980s. Interviews with recognized experts in Arctic spill response were conducted to determine how the formulas were originally developed. The formulas were evaluated to assess their current applicability to anticipated oils, snow volumes, snow sorptive capacity (the amount of oil a cubic yard of snow might contain), ice, weather conditions, and available yellow iron equipment inventory. Recommendations for any research or testing that should be conducted to reassess and potentially update the formulas used in ROSI are provided in this report. A metric version of the calculator was developed after BSEE recognized the value of the calculator once the United States Customary Units (USCU) version was completed.

Actual follow-up research and any resulting ROSI updates and/or "future proofing" of ROSI would be conducted via a separate project(s). Suggested topics for additional research are included in the "Additional Research" section of this report.

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# 1 Introduction

This report has been developed to describe the project entitled BSEE Project 1142: "Research to Support Analysis of Oil Spill Response Plans (OSRP) for Spills on Snow and Solid Ice" to guide stakeholders in the development and analysis of OSRPs for facilities located offshore in the frozen Alaska Beaufort Sea during the winter months using "yellow gear" or "yellow iron" tactics presented in the Alaska Clean Seas' (ACS) Technical Manual (TM).

The project had two primary objectives:

- Develop the **Recovery of Oil on Snow and Ice (ROSI)** calculator to facilitate development and assessment of an operator's OSRP for a well blowout, tank failure, pipeline leak, or other spill that occurs during winter months and results in recovery operations on snow and solid ice using yellow iron equipment as described in the ACS TM. This calculator could be used by:
    - BSEE oil spill preparedness division (OSPD) analysts to facilitate their review of OSRPs.
    - Owners/Operators/Plan Holders/interested parties to assist them when developing OSRP spill response scenarios.
- Provide recommendations for research and/or testing activities that should be conducted to reassess, verify, and potentially update the formulas used to calculate oil spill recovery rates incorporated into a future version of the ROSI calculator.

Once ROSI was completed using USCU, the decision was made by BSEE management to expand the calculator to include a metric equivalent version. This would be useful for BSEE's global equivalent organizations and be available for use by anyone who might need to calculate similar volumes using metric units.

The ROSI calculator was designed using the ACS TM's yellow iron spill response planning tactics described as follows:

- R-1, Mechanical Recovery of Lightly Oiled Snow
- R-3, Recovery of Oil Saturated Snow
- R-5 (ice only), Recovery of Embedded Oil, and,
- R-29, Ice Mining

These tactics, comprised primarily of front-end loaders, dump trucks, ice trimmers and bulldozers, were selected as they typically constitute the most extensive and potentially limiting part of a winter oil spill response scenario across the North Slope. The various combinations of these yellow iron assets represent different systems, and the number of systems needed to recover oiled snow and ice prior to breakup represents the primary limitation of the use of these response tactics when planning a spill response in the Arctic.

Free oil recovery tactics, such as the use of vacuum trucks, were excluded from the project as their use, based on the aerial extent of an oil well blowout that represents the worst case discharge (WCD) for most OSRPs, were not deemed to represent as great of a limiting factor when compared with the volume of contaminated snow and ice that needs to be accounted for during oil spill recovery efforts when using dump trucks, loaders and other yellow iron. This project did not examine broken ice oil spill response techniques, tactics or technologies.

The ACS tactics examined include formulas in USCU for determining the amount of yellow iron equipment needed to meet a given OSRP spill scenario based on the spill volume and distances to storage or processing areas. To develop or analyze an OSRP/ODPCP scenario, the user enters into ROSI the amount of contaminated material (snow, ice) in cubic yards along with the selected tactic(s), less the amount of free oil recovered using other tactics. ROSI then calculates the number of systems the plan holder needs to respond to the hypothetical discharge and the amount of time it will take to clean up the spill originally only in USCU. The formulas in the ACS tactics provide no metric equivalents. A simple conversion of USCU to metric was not readily evident since the metric volume of the oil-to-snow ratio as given in the ACS tactics of barrels of oil to cubic yards of snow in the ACS formulas was not found in the literature reviewed (see Appendix B).

ROSI can be used to develop or assess an operator's response plan for a well blowout, tank failure, pipeline leak, or other spill that occurs during the winter months in the arctic using ACS tactics. ROSI does this by quantifying the amount of equipment the operator should plan on having available through their response contractor(s) to conduct recovery operations on snow and solid ice of sufficient strength to support the equipment typically used during an arctic spill response in winter. The selected tactics use equipment such as bulldozers, front-end loaders, bobcats, ice-trimmers, and dump trucks to recover oiled snow and ice. ROSI incorporates the use of the existing planning capacity formulas of the selected tactics as specified in the ACS TM, which were developed in the 1990s.

ARCTOS Alaska, a Division of ***NORTECH***, Inc. (ARCTOS), was selected to fulfil this project. They had previously developed their own calculator that they used to develop OSRP/ODPCPs for plan holders and were thus highly experienced developing and using a fundamental version of ROSI. Their tool calculates the number of systems needed to recover oiled snow and ice in the event of a discharge after calculating the extent (area, thickness, spreading) of an oil well blowout. The project's workgroup, consisting of selected members of BSEE, ADEC, and ARCTOS/***NORTECH***, revised the existing ARCTOS tool to make it more user friendly, web-based, and functional for the target audience. ROSI will be available on the BSEE.gov website for use by interested parties.

The existing formulas presented in the ACS tactics were reviewed and analyzed in light of any research studies or testing that has been conducted since the 1980s. Interviews with recognized experts in Arctic spill response were conducted to determine how the formulas were originally developed. The formulas were evaluated to assess their current applicability to anticipated oils, snow volumes, ice, weather conditions, and available yellow iron equipment inventory. Recommendations for any research or testing that should be conducted to reassess and potentially update the formulas used in the calculator tool are provided in this report. Case studies and international standards for oil spill terminology were examined for metric equivalent expressions and few were found. Those that were found did not result in any conclusive evidence for a "standard" or consistent expression of the oil-to-snow volume ratio.

Follow-up research and any resulting ROSI updates and/or 'future proofing' of ROSI would be conducted via a separate project(s). Suggested topics for additional research are included in the "Additional Research" section of this report.

# 2 Methods, Timing and Process

The scope of the project was largely defined by the Request for Quote (RFQ) issued by BSEE in 2021. It was narrowly focused on North Slope Alaska offshore exploration and production facilities located in shallow waters of the Beaufort Sea. In this area of BSEE jurisdiction, exploration is often conducted using ice islands in the winter while year-round oil and gas production is typically conducted from gravel islands. During the winter months these locations are surrounded by solid ice of sufficient strength to support heavy equipment that is used for logistical support of exploration and production operations. This also includes any required winter oil spill response activities using equipment such as bulldozers, dump trucks, front end loaders, bobcats, ice trimmers, graders, vacuum trucks and other equipment of substantial size and weight. Some equipment available to North Slope operators includes equipment that is heavy enough to be used in road building or mining operations, such as Maxi-hauls, that are not typically permitted for use in areas of “normal” operations on regular roads. The gross tonnage of the equipment has not been deemed a limiting factor in the use of the calculator tool for calculating response capabilities, although warnings regarding speed limits have been added based on expert advice provided during the metric expansion.

Operators develop, and OSPD analysts assess, oil spill response plans that are developed to demonstrate that an operator’s oil spill response capabilities can be met when planning a spill response. Tools that make this process easier benefit the entire spill response planning community. Early in the project it was deemed advantageous to invite the ADEC’s Scientific Support Coordinator to the workgroup. This provided the team access to the combined knowledge and experience of ADEC staff and the added benefit of developing a tool that would also be of use to ADEC when evaluating ODPCPs.

## 2.1 Essential Variables

The identification of the essential variables to be entered into a calculator in order to obtain the desired output was one of the first steps addressed by the project workgroup. ARCTOS proposed using their existing calculator tool that uses the formulas included in the ACS TM, providing a ready framework to initiate the ROSI development process for the desired outcome.

ROSI’s parameters needed to be well defined in scope to meet the yellow iron threshold of the tactics described in the ACS TM. Seven ACS oil spill recovery tactics fall under the “winter only” tactics designation, but several do not apply to snow and ice recovery conducted by heavy equipment, such as Tactic R-13 “Cutting Ice Slots for Recovery.”

Since the scope focused on yellow iron tactics, the tactics representing manual and snow machine (snowmobile) recovery methods identified as: Tactic R-1A, Use of Snow Blower to Remove Lightly Misted Snow; and, Tactic R-2, Manual Recovery of Lightly Oiled Snow, were also excluded from this round of ROSI development (see Appendix D for detailed tactic descriptions). These two tactics are typically used in the outer-reaches of an oil discharge deposition plume to recover the lightly oiled snow surface – essentially “skimming” the upper portion of the snow depth using brooms and shovels to recover a minimum amount of contaminated material to reduce the overall bulk of oiled snow in a planned spill response, often averaged as an inch of snow depth.

Additionally, these manual tactics address a relatively small percentage of the total amount of oil spilled, typically 10%-20% of the total misted oil volume estimated to result from an oil well blowout. The calculations in tactics R-1A and R-2 address the manual recovery rates for the lightly oiled snow but are not included in the yellow iron calculations as part of ROSI. Data entry into ROSI can instead be manipulated to consider the volume of snow recovered in areas where this tactic is employed in a scenario to achieve a similar result. Including these tactics in a future version of ROSI can be considered to further refine the response planning calculation capabilities of ROSI if "future proofing" is warranted and funded (also see Sections 2.9.4 "Future Proofing ROSI" and 3.4.2 "Expand ROSI to Include Manual Recovery Methods").

## 2.2 Project Requirements and the existing ARCTOS Calculator

An early project task was to develop a Requirements Document for the project. This document was to specify all requirements associated with the ROSI calculator. However, because ARCTOS already had a working version of the calculator in a Microsoft Excel Workbook, a finalized Requirements Document was deemed unnecessary prior to beginning the development of ROSI. This Document was completed during the course of the project for documentation purposes. The existing ARCTOS calculator included features that were more extensive than specified in the project scope, and one of the workgroup's tasks was to reach a consensus on the necessary information to be included in the ROSI calculator.

### 2.2.1 Definition of Project Scope and Timing

The core group (See Appendix A) met monthly, and breakout groups were formed to tackle various tasks, such as the specific tactics to be included in ROSI to best meet the needs of the stakeholders, how ROSI should perform, and how to facilitate the interviews.

During a series of meetings in February and March 2022, the project timing, tactics to be incorporated into ROSI, research goals, the literature review, and interviews were more precisely defined. The specific tactics included are:

- R-1 – Mechanical Recovery of Lightly Oiled Snow
- R-3 – Recovery of Oil-Saturated Snow
- R-5 – Recovery of Embedded Oil (*ice only*)
    - Note that R-5 contains information regarding both ice and gravel, so only the portion relating to ice is to be used
- R-29 – Ice Mining

These specific tactics also cross-reference other tactics in the ACS TM, such as L-3, Deployment Strategies (travel times using various forms of transportation), and R-6, Recovery by Direct Suction. During the metric addition, one of the experts raised their concerns about vehicle speed limits on floating ice that would need to be considered during the operational phase of an oil spill response using the tactics incorporated into ROSI. A careful examination of the ACS TM reveals that while the construction of an ice road is included in some of the tactics' "Deployment Capacities and Limitations," floating ice roads and their operational limitations are not discussed.

The project timing was further affected by the Department of the Interior's protocols and The Paperwork Reduction Act, which required the review and vetting of the interview questions and the number of interviewees. As the interviews were delayed into April, it was agreed that the completion of the interviews would likely overlap with other project deliverable deadlines. With the initial tool substantially completed by the end of March 2022, the team agreed the interviews and research would be more appropriately included in the Draft/Final Reports as they were not needed to revise the ARCTOS calculator tool as it already used the existing formulas in the ACS TM.

The project progressed along the agreed upon timeline with some minor variations to accommodate various personnel's other projects, leave schedules and the holidays.

## 2.3 ROSI Calculator Development

The formulas used in the ROSI calculator as indicated in the applicable tactics are provided in Table 1:

**Table 1: Formulas Used**

| Function of Formula | Applicable ACS Tactic(s) | Formula |
|---|---|---|
| Dump Truck Cycle Time *(hours (hr))* | R-1, R-3 | $\text{CycleTime} = \frac{2 * \text{Distance}}{\text{Truck Speed}} + \text{LoadTime} + \text{DumpTime}$ |
| Snow Ice recovery rate ($yd^3/hr$ *or* cubic metres/hr ($m^3/hr$)) | R-1, R-3 | $\text{Rate} = \frac{\text{TruckCapacity}}{\text{CycleTime}}$ |
| Calculated days to cleanup (*days*) | Calculated by ROSI | $\text{CleanupDays} = \frac{\text{EstSnowVolume}}{\text{HandlingCapacity}}$ |
| Actual Volume of snow removed ($yd^3$ *or* $m^3$) | Calculated by ROSI | ActSnowVolume = HandlingCapacity * NumDays |
| Dump Trucks needed (*Qty*) | Calculated by ROSI | $\frac{\text{EstSnowVolume}}{\text{NumDays} * \text{OperatingHrsPerDay} * \text{Rate}}$ |
| Oil Barrels Recovered (Qty bbl or $m^3$) | R-1, R-3 and T-7[1] | OilRecovered = ActSnowVolume * OilSnowSaturation |
| Max Trucks per Loader | R-1, R-3[2] | $\text{TrucksPerLoader} = \frac{\text{CycleTime}}{\text{LoadTime}}$ |

Notes:

1: While ACS Tactic T-7 Spill Volume Estimation was not examined, the quantity of oil per $yd^3$ of snow (lightly oiled, heavily oiled) is provided as a response planning assumption that applies to all applicable tactics. For the metric addition, this is expressed from a direct conversion from barrels (oil) to $m^3$, and, $yd^3$ to $m^3$ (snow).

2: "Max Trucks per Loader" is based on the formulas provided in the tactics and not the assumptions provided in the tactic about the $yd^3/hr$ that a loader can handle, e.g., 120 $yd^3/hr$ vs. 500 $yd^3/hr$.

3: Optional basic formulas, such as for the area and volume calculations and USCU-to-metric conversions, not included in this table.

### 2.3.1 ROSI Calculator Inputs and Outputs

ROSI will deliver outputs based on the available data. The data should be included in the OSRP's scenarios. If data presented in the plan is insufficient, the analyst will need to ask for it in a Request for Additional Information (RFAI).

ROSI has defined units for each input. Data should be converted to the appropriate unit before use in ROSI (all inputs/outputs are in U.S. customary system units). Some inputs may be optional or have default inputs depending on the outputs required.

For each individual tactic deployed at a recovery area, the following inputs in USCU or metric units are needed for complete calculator operation:

- Spill Response Tactic
- Number of Dedicated Dump Trucks
- Dump Truck Capacity
- Haul Distance
- Average Transit Speed
- System Loading Time
- System Unloading Time
- Volume of Material to be Recovered (Oil/Snow)
- Targeted Cleanup Time
- Days Allocated in Plan to Spill Recovery Tactic
- Recovery Rate per system provided by plan
- Total handling capacity provided by plan

In the final form of ROSI, most of the above inputs are mandatory, and some have been provided with optional default values. A screenshot of the mandatory ROSI inputs is shown in Figure 2. Note that only one (1) dump truck is indicated in the figure to prompt ROSI to provide the warning that more dump trucks are required to meet the required 30 days for the WCD (see ROSI Verification Report in Figure 3).

Final outputs provided by ROSI include:

- Actual recovery rate for one dump truck
- Maximum number of dump trucks that can operate congruently per loader
- Total Handling Capacity
- Actual volume of snow/liquid recovered
- Days to achieve cleanup
- Actual barrels of oil recovered
- Number of dump trucks and loaders needed to clean up within the targeted cleanup time
- Warnings regarding speed, number of trucks, etc., exceeding or being insufficient to meet the desired or stated timeline

Outputs from multiple recovery tactics or task forces can be combined to verify and compared to total calculated cleanup numbers. As ROSI does not address free oil recovery, this volume of oil should be included (subtracted from the total) in the final comparison by the analysts. It is possible to recover more contaminated material (snow) than was impacted. The analyst should limit oil recovery volumes to the maximum amount deposited in a recovery zone (less any free oil recovered separately). When precise data is not known, ROSI will provide estimates based on assumptions included in the tactics. An example output report is shown in Figure 3.

OSPD analysts requested a way to verify the amount of material that would need to be removed from an oil well blowout. Thus a snow volume calculator was built into ROSI for this purpose. An optional basic area calculator was included so the analyst/reviewer can calculate the amount of material (snow) that would need to be planned to be removed from a hypothetical oil well blowout discharge plume. The size (dimensions) of a blowout plume is usually provided in the OSRP spill response scenario. The calculated area of the blowout is then used along with the depth of the oil in the snow in inches so then the amount of snow and ice that needs to be planned for removal from a blowout can then be calculated in cubic yards ($yd^3$) or cubic metres ($m^3$) (see Figure 1). ROSI does not provide a means to perform the calculations of the size and the areal extent of a discharge plume. Expanding ROSI to include a blowout calculator is suggested as a means of Future Proofing ROSI, see Sections 2.9.4 and 3.4.2 of this report. See the ROSI User Manual for details on how to use the calculator.

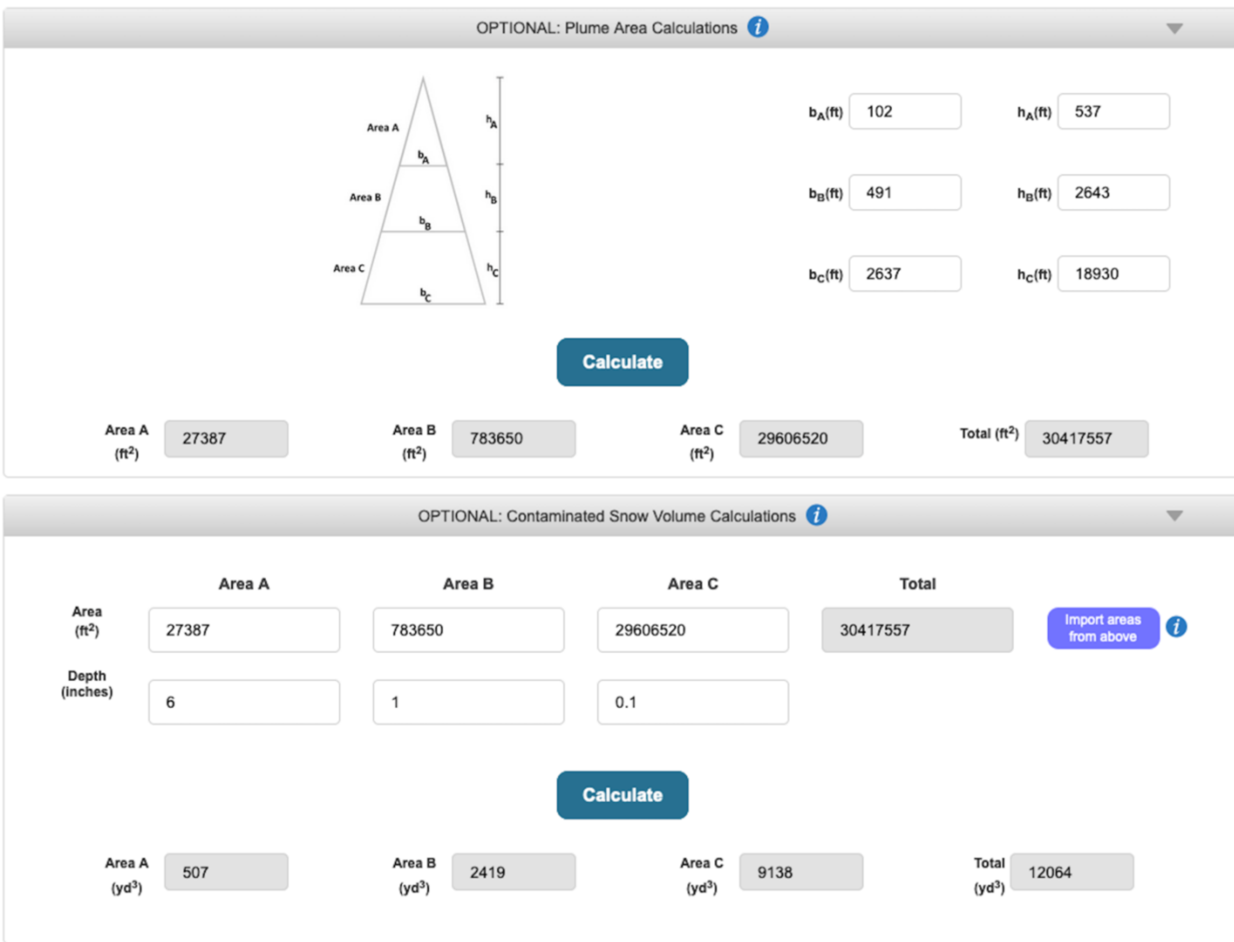


**Figure 1: ROSI Optional Plume and Volume Calculator Screenshot**
Screenshot of Plume Area and Contaminated Volume calculator using USCU units from a hypothetical blowout scenario plume as presented in an unnamed, historical spill response plan

#### 2.3.1.1 Metric Addition:

The formulas used in ROSI (see Table 1) are mostly not unit-dependent. Most of them have direct correlations to the USCU variables used in the first version of ROSI, such as square feet ($ft^2$) to $m^2$ for area, $yd^3$ to $m^3$ for volume, etc. that are converted directly using USCU-to-metric equations. The one variable that required some thought and research was barrels (bbl) per $yd^3$ for the oil-to-snow ratio. The team determined that $m^3$ oil/$m^3$ snow/ice represented the best way to express the ratio based on research and input from the experts consulted. See the Research section of this report for further discussion on how these units were selected for ROSI. Since most of the formulas remain unchanged except for oil-to-snow ratio for the optional area calculator, the team focused mostly on the graphical user interface (GUI). ROSI dynamically updates the unit labels and default values in the inputs based on the unit system chosen. The formulas that required conversion factors include snow depth or oil volume.

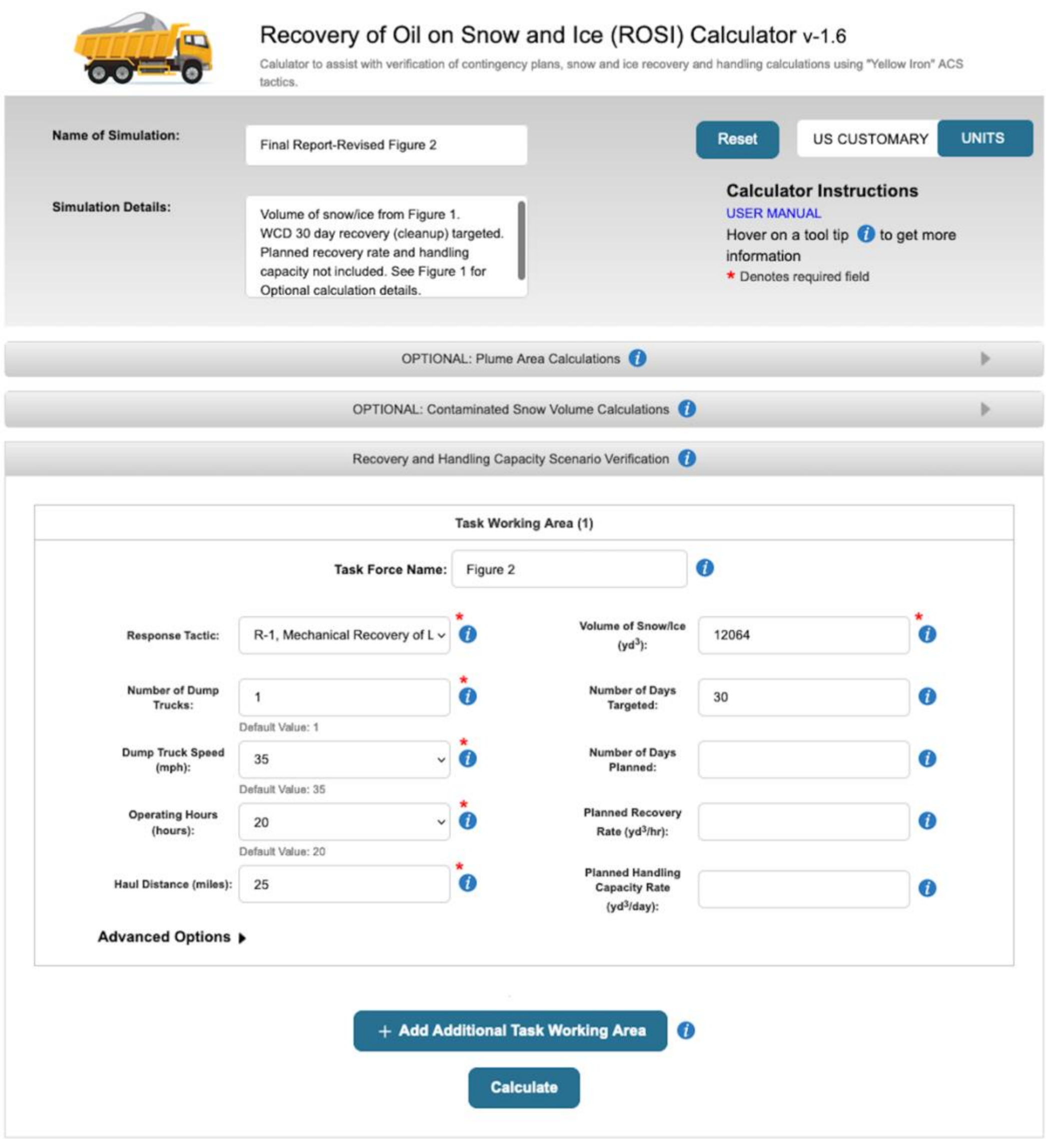


**Figure 2: ROSI Mandatory Inputs Screenshot**
Screenshot of ROSI Mandatory Inputs in USCU with example numbers from Figure 1.

**Recovery of Oil on Snow and Ice (ROSI) Calculator**

Recovery and Handling capacity Verification Report Download PDF

ROSI Recovery and Handling Capacity Verification Report
Program Version 1.6
Analysis Completed: 2023/08/31 10:59:38 Alaskan Standard Time

| | |
|---|---|
| **Simulation Name:** | Final Report-Revised Figure 2 |
| **Simulation Details:** | Volume of snow/ice from Figure 1. WCD 30 day recovery (cleanup) targeted. Planned recovery rate and handling capacity not included. See Figure 1 for Optional calculation details. |
| **Unit System:** | US Customary |

**Task Working Area (1): Figure 2**

**User Input**

| | | | |
|---|---|---|---|
| **Response Tactic:** | R-1 | **Number of Days Planned:** | 0 |
| **Number of Dump Trucks:** | 1 | **Planned Recovery Rate ($yd^3$/hr):** | 0 |
| **Dump Truck Speed (mph):** | 35 | **Handling Capacity ($yd^3$/day):** | 0 |
| **Operating Hours (hours):** | 20 | **Dump Truck Capacity ($yd^3$):** | 20 |
| **Haul Distance (miles):** | 25 | **Oil Saturation (bbl/$yd^3$):** | 0.3 |
| **Volume of Snow/ice ($yd^3$):** | 12064 | **Load Time (min):** | 10 |
| **Number of Days Targeted:** | 30 | **Unload Time (min):** | 5 |

| Equipment Verification | Results |
|---|---|
| Dump Trucks Required | 2 |
| Loaders Required | 1 |
| Max Dump Trucks Per Loader | 10.07 |
| Recovery Rate ($yd^3$/hr) | 11.91 |

| Handling and Recovery Verification Results | Plan Based | Need Based |
|---|---|---|
| Total Handling Capacity ($yd^3$/day) | 238.2 | 476.4 |
| Actual Volume Snow Recovered ($yd^3$) | 12064.83 | 14292 |
| Calculated Days to Cleanup | 50.7 | 25.3 |
| Estimated Barrels of Oil Recovered | 3619 | 4288 |

**Warnings: First Task Working Area - Figure 2**

More dump trucks required than shown in plan, consider increasing the number of days targeted (Planned: 1 trucks Needed: 2 trucks)

Check if sufficient days/trucks allocated to tactic (Planned: 0 days Needed: 50.7 days)

Difference between planned/needed recovery rate capacity exceeds 5% (Planned: 0 ($yd^3$/hr) Needed: 11.91 ($yd^3$/hr) )

Difference between planned/needed handling capacity exceeds 5% (Planned: 0 ($yd^3$/hr) Needed: 238.2 ($yd^3$/hr) )

**Figure 3: ROSI Verification Report Screenshot**
Results from ROSI calculator in USCU using numbers from figures 1 and 2

### 2.3.2 Graphical User Interface (GUI)

The GUI includes all of the described inputs and outputs as shown in Figures 2 and 3. The BSEE Estimated Recovery System Potential (ESRP) calculator GUI was used as a guide for its appearance (see: https://www.bsee.gov/sites/bsee.gov/files/mechrecovery-cal.html).

To provide support for scenario development and assessment, a snow volume calculator was built into ROSI (i.e., the area of a plume in square feet and the depth of snow (in inches) to be recovered using the specified tactic to calculate overall volume in cubic feet, using drop-down webpage features denoted as "optional". Note: these inputs presume the size of the overall discharge area (plume) is accurately presented in the scenario, and that the plume area is typically estimated using Tactic T-6 Blowout Modeling). See Figure 1.

#### 2.3.2.1 Metric Changes to the GUI

To address web-based language and graphical requirements, a new, separate GUI was developed for the use of metric system units. A "toggle switch" was added to the top of the GUI to allow the user to select either USCU or metric. The reset button's function was expanded to include resetting the fields and the calculator to USCU since it is US based. A "Download PDF" button was also added to generate output reports in both USCU and metric that print with clean page breaks from the text, boxes and tables instead of random page breaks inherent with webpage-based printing.

## 2.4 User's Manual Development

The BSEE ESRP User's Manual (UM) was used as a guide for the content and appearance of the ROSI UM (https://www.bsee.gov/sites/bsee.gov/files/mechrecovery-cal.html). A draft guide identifying assumptions, limitations, inputs, outputs, instructions, and a glossary was developed for the several rounds of stakeholder testing.

The UM is accessible through a link included on the ROSI webpage; the manual can be viewed in the user's browser or downloaded to their computer. Hovering on the tooltip, which is denoted by an *"i"* in a blue circle, provides a short description of the input variable; clicking on the "More Information" link embedded the tooltip opens a new browser tab displaying the relevant section of the web-based version of the UM (also see figures 1, 2 and 3). The UM should be referenced for more detailed instructions on the formulas used and how to use ROSI.

#### 2.4.1.1 Metric Changes to the UM

The revisions to ROSI involved including the metric units selected by the project team. Simple USCU-to-metric conversion equations were used to convert the units from USCU to metric once the variables for the inputs were selected. The decision was made to leave the scenario example in the UM in USCU since the formulas did not change.

## 2.5 ROSI Testing

Testing of ROSI was performed in several stages:

- Initial presentation of the ARCTOS calculator at the Kickoff meeting to verify its capability to meet the needs of the project.
- Internal testing of multiple versions of the "Initial High-Level Calculator" in Excel format over several months to verify functionality of the equations.
    - Instructions were provided on how to use the calculator.
    - Several scenarios from OSRPs/ODPCPs specified in the RFQ were obtained and provided for testing.

    - Work sessions were scheduled, with some being conducted upon request, to go over the functionality of the calculator, the formulas, inputs, and outputs.
- Testing of a "Revised Calculator" (RC) also in Excel format, by a select set of stakeholders including ACS and other plan development experts.
    - The Excel tool was revised in format and appearance to appear similar to the proposed Graphical User Interface (GUI).
    - A draft UM without illustrations was provided to assist the testers.
    - A single historical scenario with identifying information removed was provided for testing.
    - Testers were encouraged to use other scenarios from other OSRPs/ODPCPs they were familiar with.
    - Comments were received and incorporated into the refinement of the calculator.
- Testing of an "Operational Calculator" conducted "live" on the web via a sub-domain hosted by ARCTOS's web developer.
    - The GUI was presented as a fill-in form on a website.
    - "Tool Tips" were added to the GUI.
    - Links to the relevant pages of the UM were provided in the GUI via the Tool Tips.
    - Default values from the formulas were provided within the calculator.
    - A "reset" (clear all) button was provided.
    - The same scenario used in the RC Testing was provided upon request.
    - The same stakeholders that were invited to the RC testing were asked to test the Operational Calculator, inviting them to share the tool with other potentially interested parties (ADEC invited individuals from Alyeska Pipeline to the testing pool).
    - The Operational Calculator was further refined based on input received from all parties who submitted comments.
- Once all testing was complete, substantive comments and minor errors were addressed to update ROSI and the UM.
- Final ROSI and UM in USCU was provided to BSEE to host on their website.
- The metric version was tested over the course of the extended contract period by the project team and two arctic oil spill response experts.
- The UM was revised to include the metric units. The creation of an additional, separate "Example Scenario" using only metric units was deemed duplicative and so one was not created.

By including tool tips and links to the UM, we think ROSI provides functional improvements on the platform as compared with the 2021 version of the ESRP calculator and its UM. Additionally, since ROSI addresses the recovery of what is essentially bulk material, the tool has the potential to be used to calculate material removal for other projects, such as contaminated site excavation, land farming, grain or mining tailing spills – any spill of bulk materials best addressed using yellow iron, although the user is advised that it is not fully functional for this purpose in the UM.

It is critical to note that ROSI is designed to present information to allow analysis of oil spill response scenarios, not to specify exact performance during an actual spill event. Therefore, we do not represent ROSI as providing performance-based results, nor should it be used during an actual spill response. Certain physical factors are not accounted for in the calculator, such as load bearing capacity of ice roads on floating ice. This is discussed further in the Literature Review section that follows.

## 2.6 Research/Literature Review

Research was conducted to find any studies presented in peer-reviewed literature that used yellow iron for spill response in snow and ice conducted since 1980, including some select papers from the 1970s. The Convention du Metre (The Metre Convention) of 1875 was also reviewed for direction on the use of the metric system. Scenarios in existing, current and historical OSRPs and ODPCPs were analyzed.

### 2.6.1 Literature Review

The literature review was performed using available search engines on the internet and scholarly literature repositories such as Google, Google Scholar, Duck Duck Go, the Transportation Research Board via the National Academies of Science, Engineering and Medicine (among others), The Arctic Marine Oilspill Programme (AMOP), International Oil Spill Conference Proceedings, the Arctic Oil Spill Response Joint Industry Programme, the Federal Aviation Administration (FAA), the Northeast Chapter of the American Association of Airport Executives (NEC/AAAE), the Heavy Equipment Forum, Volvo, Caterpillar, the Department of Interior's library, the Alaska Resource Library and Information Service (ARLIS), the International Standards Organization (ISO) and many others. These sources were queried using applicable search terms for information on the research conducted to establish snow and ice removal methodologies, efficiencies, capacities, and other yellow iron-related information.

Studies on the sorptive capacity of snow were also researched. The precise search terms used and the various websites, organizations, other entities, individual sources and peer-reviewed studies are identified in the Research Table in Appendix B. All electronic copies of the research documents available were obtained and filed with the project file provided to BSEE at the end of the project. A handful of documents were available only in hard copy. Hard-copy articles deemed relevant to the project were scanned and added to the electronic record. Those are also referenced in the Research Table. Appendix B serves as the substantive bibliography for this research report.

### 2.6.2 OSRP and ODPCP – Analysis of Historical and Current

North Slope OSRP and ODPCP scenarios specified in the RFQ were analyzed and run through the ARCTOS calculator. These included OSRP/ODPCP scenarios from Hilcorp, Harvest AK, and Eni to establish the functionality of the initial calculator. Most of the plans were found to have spills too small to generate the output BSEE required from ROSI. Others were found to have insufficient, unspecified, or inaccurate input data to provide adequate output from ROSI. Furthermore, in those plans that did include all required data in the scenario, it became clear that the analyst needed to look beyond the "Recovery Tables" presented by the plan writers that included the project's specified ACS recovery tactics. The entire scenario had to be reviewed to verify that all data presented in the plan was accurate to extract usable data points for entry into ROSI. The OSRP/ODPCP Analysis that was performed is included in the project files.

While the initial ARCTOS tool worked adequately on the plans that were included in the scope for analysis, it was determined that larger spill volumes were preferred to be included in the capabilities of ROSI. Historical or past ODPCPs that were approved by the ADEC under their Prevention, Preparedness and Response Program (PPRP) were obtained so the larger response planning standard (RPS) scenarios (5,500 bopd/82,500 bbl over the course of 15 days) presented in those plans could be used in the development and testing of ROSI. Testing ROSI also provided a means for stakeholders to review the scenarios and learn what questions or 'requests for additional information' might need to be included as part of the analysis of a snow and ice scenario.

### 2.6.3 Blowout Calculator

The team also examined ARCTOS' full "Blowout Calculator." This multi-spreadsheet workbook in Microsoft Excel uses information extrapolated from the 1998 SL Ross Blowout model, also presented in ACS's Tactic T-6 (see Appendix D). The SL Ross model is codified in the State of Alaska's Oil Pollution Prevention Regulations in Title 18 Alaska Administrative Code Chapter 75 (18 AAC 75) to be used for oil well blowout spill response scenario development as part of ADEC's ODPCP requirements. ODPCPs are similar to OSRPs and are often combined into a single plan with a cross-reference table for submittal to both ADEC and BSEE by plan holders for review and approval by the agencies prior to oil exploration (and other oil production) activities. These plans identify the planned oil discharge response strategies (e.g., Contingency Plans). ARCTOS' Excel blowout calculator is used to calculate the size (length, width, depth) and deposition of a hypothetical discharge plume for scenario development when ARCTOS writes ODPCP/OSRP scenarios for client plan holders.

During the development and testing of ROSI, many of the workgroup members commented on the need to calculate the area, depth and ultimately the number of cubic yards of material (oiled snow) that would be generated by the hypothetical discharge proposed, based on the gas-to-oil ratio. As a result of this examination, a limited snow volume calculator was added to ROSI to assist the plan authors or plan analysts with their assessments of the planned response capabilities. The snow volume calculator can verify the volume of material (snow, ice) based on the size of a blowout plume provided by a plan's author, and hence the number of systems required to move the material. This area and volume calculator cannot, however, verify the accuracy of the size of the modeled plume developed by the author of the plan. See Figure 1.

### 2.6.4 SL Ross Blowout Model and ACS Tactic T-6

The SL Ross Model Ross paper was presented in the AMOP Proceedings of 1998. It is incorporated into ACS' Tactic T-6 - Blowout Modeling, and is required to be used when developing ODPCP response plans to meet ADEC regulatory requirements. The SL Ross Blowout Model was reviewed as a "matter of course" for this project as part of ARCTOS' ongoing work using the ARCTOS Blowout Model when developing and writing oil spill response scenarios for clients.

The 1998 paper provides tables that can be used to estimate a gas-to-oil ratio (GOR), and it is these tables that are presented in ACS Tactic T-6. The GOR is then used with the exponentially-scaled charts of oil fallout percent versus distance for several different diameters of drill casings. These tables are then used to provide estimates of the width, distance and amount of oil that might be deposited in various areas of a blowout. The Optional area and volume features of ROSI can then be used to verify if the numbers presented in an OSRP/ODPCP scenario are similar.

As of the writing of this paper, ACS has engaged SL Ross to review and update the model. Also see the “Additional Research” section of this report.

### 2.6.5 Mechanical Recovery with Burning

1972, T.J. McMinn, United States Coast Guard (USCG), concludes “the apparent primary oil recovery techniques are rapid burning and/or mechanical recovery.” Rapid burning means that the oil must be fresh (less than 24 hours old) with mechanical recovery of oil in snow ultimately remaining the best method for recovery/cleanup after this point. Ultimately we interpret McMinn as rating burning second as a cleanup technique as it creates other problems with the need to mechanically recover what he characterized as “mulch” (snow with the burned oil residue), along with the smoke and air pollution issues. While McMinn’s article is outside of the scope of the project’s stated research date (prior to 1980), it is cited repeatedly in the literature reviewed.

Research performed as part of this project found only a few scholarly articles about recovering oiled ice and snow after McMinn’s field experiments. This seems to be the point when mechanical recovery became generally accepted as one of the preferred and most thorough methods for the removal of oiled snow from about 1972 forward. It is worth noting that experts interviewed, and those who declined interviews, during the project asserted that the best method to deal with very large quantities (e.g., 91,000 bopd for 30 days) in the shortest possible time would probably be burning following up with mechanical recovery of the ““mulch”.

### 2.6.6 Mechanical Recovery Research and Experiments

Specific research using yellow iron for oil spill cleanup has been very limited. A review of the literature and studies performed show that while a handful of references are made regarding the effectiveness of using snow as a sorbent to clean up spilled oil, quantifiable, peer-reviewed studies have not been issued. ACS cites in their TM “field experience and data from actual spills” (ref. Tactic T-7, Spill Volume Estimation), but does not cite any peer-reviewed studies nor has ACS presented any that quantify the recovery volumes and rates (ACS has a history of submitting technical, scientific and case study papers that have been presented at various symposia, conferences, etc.) based on field experience that could be found in the literature. Interviews with experienced ACS personnel did not reveal any other “white papers” that ACS might have conducted that might have been missed in the literature review that present quantified data on this topic.

### 2.6.7 Caterpillar, Inc. “Performance Guide”

The most useful document for developing ROSI was the Caterpillar, Inc. “Performance Guide” where the formulas for loading a dump truck with a front-end loader was used in conjunction with the information provided by the ACS Tactics R-1, R-3, R-5 (ice only) and R-29.

Close examination of the formulas ACS Tactics R-1 and R-3 was required by the workgroup during the development of ROSI. Loading and unloading assumptions presented in the ACS Tactics do not match for tactics R-1 and R-3. For example, there is an assertion that a loader can move 500 cubic yards per hour ($yd^3yd^3$/hr). While this could indeed be the case, the tactics also state that it takes 10 minutes to load a 20 $yd^3yd^3$ dump truck. This means that only 120 $yd^3$/hr can be moved by a loader or only six dump trucks per hour can be loaded. With 10 minutes to load each truck at 20 cubic yards this equals 120 $yd^3$/hr functional loader-loading capacity. Therefore, the 120 $yd^3$/hr loading rate is what was used for development of ROSI as the 500 $yd^3$/hr could not be verified without field experiments but the Caterpillar Performance Guide and the basic math do support the 120 $yd^3$/hr loading rate.

It is important to emphasize that the formulas provided in the ACS TM are for *planning purposes only*. There are many elements that can affect the formulas that cannot be easily captured in a tactic. For example, loaders collecting oiled snow in an open area will be able to operate more quickly and efficiently than loaders collecting oiled snow around the confined areas of a drilling rig or pipeline. The times provided in the ACS tactics are therefore more general in nature; in any given response, it is reasonable expect the actual times to differ (faster and/or slower).

### 2.6.8 Metric Addition

USCU conversion to metric units formulas are generally accepted formulas presenting a straightforward means to change the expression of length, area, volume and speed for the purposes of ROSI's variables. However, the generally accepted expression of the oil-to-snow ratio represented a challenge for the team so additional research was conducted to find how this ratio was presented in the peer reviewed literature – whether an international standard exists. Based on the research conducted (see Appendix B for literature/sources that were cited and obtained in 2023), no generally accepted standard was found.

Using the same internet search techniques and referenced sources discussed previously, additional case studies, standardization guides, proposals, the Metre Convention of 1875, and, The International System of Units (SI) were reviewed for a oil-to-snow ratio expression in the literature. The Warwick Lake Spill of 1983 expressed the spill volume in litres, and the oiled-snow volume in "15-20 snowmobile trailer loads" with no indication of the volume capacity(s) of the trailers. Other literature discusses the percentage of oil-to-snow, or, percentage of oil-to-water once melted. One of the Canadian spill response experts consulted about the oil-to-snow ratio expression stated that while there had been other spills in Canada that were documented using metric units, they were not documented nearly as well as the Warwick Lake spill. Other studies examined used percentage, cubic centimetres, and some others used a mixture of USCU and metric. No standard for expressing the oil-to-snow ratio was found in the literature reviewed, including the ISO standard 16165 – "Ships and marine technology - Marine environment protection -Vocabulary relating to oil spill response." See Appendix B for details on the documents examined for the expression of this ratio that were reviewed in 2023.

In order to maintain a global appeal and functionality of ROSI, the spelling of the metric terms used also needed to be addressed. One expert consulted stated that the proper spelling of metre is the French spelling. This is verified by the Metre Convention and the other governing bodies of the metric system, such as the SI system spellings presented in the International System of Units Brochure, and as presented by the Bureau International de Poids et Mesures (BIPM). "Meter" is the American English spelling in common use in the US. The expert also pointed out that a "meter" is something used to measure something, like a speedometer, a thermometer, micrometer, etc.

Therefore, the project team decided to use the global spelling standards provided by the governing bodies for the metric units used.

## 2.7 Interviews

### 2.7.1 Interviews Summary

In addition to the literature review, individuals and organizations, such as ACS, were interviewed. Some experts in Arctic spill response declined the interviews as they did not consider themselves qualified to speak to the specific matter of using yellow iron in oil spill recovery because they did not personally conduct any research exclusively on the topic. These experts did conduct extensive research on oil spill techniques in the arctic on topics such as broken ice oil spill recovery and the oil-sorptive capacity of snow, among others. Their research reviewed as part of this project is also captured in Appendix B and the electronic research files. These individuals also offered opinions about the effectiveness of burning versus mechanical recovery for extremely large volumes of material that are discussed in this report. At least one of the experts who declined to be interviewed regarding the yellow iron recovery portion of the project did provide input on the metric conversion, and provided cautionary information regarding the load bearing capacity and speed limits that should be considered for ice roads constructed on floating ice.

### 2.7.2 Interview Process

In order to satisfy the requirements of the Paperwork Reduction Act, a limited number of interviewees were identified, a list of questions was developed, and both were vetted by DOI.

Choices for interview candidates were made based on those known to be experts in various aspects of arctic spill response based on the project teams' collective knowledge of arctic oil spill response researchers and associated authorities.

There were two tiers of interview candidates identified. The first tier were those persons considered the most likely to be: 1) able to provide applicable information for this project, and 2) available for an interview. The second tier was made up of alternates (such as retired ACS personnel) with similar qualifications to be considered if the first tier were unavailable or refused.

We reached out to experts in spill response methodology who have published peer reviewed articles, research, and textbooks, and, those with extensive actual spill response experience using the selected tactics to interview them on the development of the tactics (ACS).

Recognizing this project's very narrow focus on the use of yellow iron to recover oil on snow and ice, some of the experts indicated their areas of expertise were more focused on other recovery methods, such as broken ice, and other topics, such as the sorptive capacity of snow in its many different states (wet, dry, fresh, old, etc.). Nonetheless, it is worth noting that thanks to their extensive contributions over many years of research and oil spill response in the arctic, their research articles were reviewed for this project. Additionally, they provided input via personal communications that burning is likely the best response method, especially when very large amounts of oil need to be removed in a limited amount of time. Burning is discussed in Sections 2.9.1 and 2.9.2.

#### 2.7.3 Metric Addition

Questions were drafted for the experts consulted for the metric addition, see Appendix C for details. These questions were sent via electronic mail to the selected experts and two responded. While formal interviews were not conducted for this portion of the project, their answers and guidance are included with the Interview Summaries that follow.

#### 2.7.4 Interview Summaries

##### 2.7.4.1 Minerals Management Service (precursor to BSEE)

Most of BSEE's prior work with the TM was focused on the categories of 'oil in water' and 'oil in broken ice'. We were advised that all of ACS' land-based tactics were created before significant work was conducted with MMS/BSEE. Prior OSRP analysis was driven primarily by Shell's efforts in the early-to-mid 2000's to initiate exploratory drilling in the offshore areas of the Chukchi and Beaufort Seas. Shell's drilling plan was to only conduct drilling during ice-free periods as they were using drilling ships. As a result, the tactics pertaining to materials handling and storage as they related to Shell's planned on-water operations were the ones analyzed. Yellow iron tactics were not part of the review.

##### 2.7.4.2 SL Ross Environmental Research Ltd.

SL Ross indicated they had no input into the development of the tactics in the ACS TM and could not speak to their real-world accuracy. They did, however, weigh in on the metric addition regarding the units used, how to express the oil-to-snow ratio, and, the generally accepted spelling of the terms used. While litres per cubic metre was suggested to eliminate decimal points, since ROSI was designed for WCD volumes, the project team settled on $m^3/m^3$ for the expression of this ratio.

##### 2.7.4.3 Alaska Clean Seas

The Planning and Operations Managers of ACS engaged their entire supervisory staff to ensure a comprehensive and supportive written response to our list of questions (initial inquiry). Their written response was followed with an interactive Question and Answer interview over the Microsoft Teams (MS Teams) video conferencing platform. As their response was prepared in writing, it is included in Appendix C.

The information obtained from the ACS personnel provided significant guidance in some of the choices made in developing the calculator. The information obtained validated the reliance on the default values provided in the ACS tactics for equipment capacities, percentage of oil in snow, and loading/offloading times. They clearly possess a full understanding of the broad list of variables that could potentially affect any given response, such as the snow oil-sorptive capacities of dry versus wet snow, compaction, "blending" contaminated snow with clean snow, travel times and other factors that that affected the choice of the default values presented in the ACS tactics. They additionally stressed that the tactics in the TM are for planning purposes only; actual times for any given tactical activity can be expected to vary from the written tactic based upon the specific circumstances of each response.

### 2.7.5 DF Dickins Associates LLC

Dickins provided valuable input on the units expression, guiding the project team towards the adoption of $m^3/m^3$ for the snow to oil ratio. In addition, for cautioning the team regarding speed and deceleration of the dump trucks in certain ice zones over floating ice ("critical speed zones"). In particular:

- **Dump Truck Speed (mandatory; default: 35 mph)** *The average speed for the dump truck to transit from the recovery area to the offload area. Unless stated otherwise in the plan, this speed is set to 35 miles per hour as specified in the ACS TM.* I am concerned that this speed doesn't recognize the need to avoid the resonant speed for moving heavy loads on floating ice sheets as a function of water depth. While not a factor in deeper water or very shallow water where the ice is grounded, decelerating through the critical speed zone (typ. 12-15 mph) in certain water depths can cause sudden buckling failure of the ice sheet and major damage to the ice road. This should be factored into transit times, with appropriate speed restrictions along certain sections of the route. There is a lot of published material on this phenomenon which, although not a significant issue for light vehicles like crew cabs, can become a major factor for moving heavy vehicles like tandem dumps and loaders. Safe parking times is another factor that would come into play within the active loading area for heavy vehicles waiting to load or in the process of loading. Two classic references are: (1) Nevel (1970) https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/5750/1/CRREL-Research-Report-261.pdf; and (2) Vaudrey (1977) https://ui.adsabs.harvard.edu/abs/1977navy.rept.....V/abstract

Since ROSI is designed as a planning tool, and not an operational tool, engineering principles regarding the construction and use of ice roads would need to be addressed in real-time to safely respond to a discharge. Other tools and means are available to engineer and design floating ice roads. Including this capability is outside of the scope of the ROSI project. The project team instead included warnings in the ROSI output reports along with advisories in the UM and this report.

### 2.7.6 Interviews Conclusion

Overall, interviewees tended to favor the ignition of oil to reduce the overall impacts and on-water (in broken ice) physical recovery for large oil spills, especially if they occurred late in the season and away from infrastructure that would be damaged by burning. In general, the use of yellow iron to recover oil on snow and ice is acknowledged as a viable option but no real attention to the quantitative details of such recovery methods is provided in the literature beyond vague comments to the effect of 'work with the local responders for best results.'

The interview and metric addition questions are included in Appendix C.

## 2.8 Research, Interviews and OSRP/ODPCP Findings Summary

One of the major findings of the research is that we were unable to find any studies or experiments presented in a peer-reviewed format on the specific subject of oil spill cleanup/recovery of oiled snow and ice using the yellow iron tactics examined or any other yellow iron tactics. While the research did reveal a considerable amount of research on the topic of oil spill recovery on water in broken ice or freshly forming ice, no research on the specific topic of using yellow iron was found in the literature review over the course of our extended searches. Scholarly articles were reviewed briefly, in depth, or their citations were examined to determine if they had cited any such yellow iron research, and none was found. The notable exception to the research into mechanical recovery was the conclusion made by McMinn in 1972 recommending burning as a cleanup method followed by mechanical recovery.

The Caterpillar Performance Catalogue proved to be the most valuable reference for verifying the formulas used in the calculator (e.g., regarding the volumes of loader buckets and dump trucks), regardless of the units used. The manufacturer's information is presented to address the transport of bulk material with no regard to oil content. While technically not scientific peer-reviewed research, as manufacturers stated capacities the information presented by Caterpillar in their Performance Catalogue must meet the stringent requirements of consumer protection laws (Truth in Advertising). Therefore, we consider their information equivalent to scientific field studies for the purposes of this report.

We note that since the ACS tactics examined are intended to meet planning requirements and not performance requirements (also known as planning vs. performance standard in ADEC vernacular), the need to conduct additional research into the actual performance standard of yellow iron recovery of actual oiled snow may be moot in regard to future research requirements unless a performance requirement (standard) is adopted. Since research into the sorptive capacities of snow is well documented and included as part of the formulas in the ACS Tactics, along with blending techniques, the need for additional research or experiments actually moving snow with various levels of oil content may be unnecessary to support the planning requirements used. This presumes also that all free-oil is removed from a hypothetical spill response scenario using other means, e.g., vacuum trucks. Free oil removal was excluded from the scope of this project.

## 2.9 Research and Interviews Combined Conclusions

### 2.9.1 Burning with Mechanical Recovery

Research and interviews did reveal an apparent consensus that burning may be the most useful means to consider when responding to some oil spills in snow and ice, especially when copious amounts of spilled oil are taken into consideration. Factors such as infrastructure (oil pipelines, processing facilities, camps, etc.) would need to be taken into account, in addition to response timelines, such as late-winter/early-spring season spills when targeting maximum cleanup volumes prior to broken ice season. These factors would mean that only a few scenarios could practically consider burning, such as an exploration drill site far from infrastructure. Regardless, as a planned method of spill response, proposing burning is impractical for reasons addressed in the discussions that follow.

After burning, yellow iron can then be used to clean up any residuals ("mulch") or unburned oil, as stated by McMinn, reiterated over several papers, cited extensively, and as expressed by one of the experts we spoke with, but did not interview. McMinn's conclusion supporting burning as the most effective form of initial spill response is included from his 1972 report as follows:

> Burning offers the easiest and fastest solution for partial removal of freshly spilled oil from a winter snow or ice surface. With a fresh spill (less than 24 hours old) there is no difficulty involved in igniting the oil by placing fuel soaked rags along the upwind edge of the oil spill. The rags provide a heat and wicking source sufficient for ignition and

sustained burning of the crude. Once ignited, the oil gives off an intense flame (Figure 20) accompanied by thick black smoke. The smoke, however, does not leave any ash immediately down wind of the burn and is quickly dissipated. The most effective burns were achieved when the oil was at least 1/4" thick and the wind was blowing between 0 and 14 knots. The temperature of the oil or air did not appear to affect the intensity or efficiency of the burn, however, winds over 14 knots tended to knock the flames down and blow loose snow onto the oil cooling it below ignition temperature. (McMinn, 1972)

FIGURE 20 - Oil burning on a snow surface; air temperature @ -25F.

**Figure 4: Text and Photo from McMinn, 1972**
McMinn Report, 1972 - Test burn of oil in actual field condition on snow, North Slope, Alaska (Text and Photo: McMinn, 1972)

### 2.9.2 Planning for Burning - 49 CFR 194; National and Area Contingency Plans

Planning for in-situ burning (ISB), creates another set of issues regarding air quality permitting requirements, especially when the extensive requirements of the ADEC ISB spill planning regulations are considered as they would need to be addressed for BSEE OSRPs via the National Contingency Plan (NCP) and the Arctic & Western Alaska Area Contingency Plan (A&WAACP) the applicable Area Contingency Plan (ACP) review and approval processes. These NCP and ACP documents reference the Alaska Regional Contingency Plan (Alaska RCP). The Alaska RCP includes four Alaska ACPs, including the A&WAACP (formerly known as Sub-Area Contingency Plans).

BSEE plan approvals must be consistent with the NCP and the ACP per 49 CFR 194.107(b). ADEC requirements would need to be considered as per the NCP and ACP process. The Alaska RCP (https://alaskarrt.org/PublicFiles/Alaska_RCP_V2_2022FEB.pdf) states:

> There are no current preauthorization agreements in Alaska region for ISB. If a chemical agent, such as a burning or herding agent is required for the burn, per the NCP, the Federal On Scene Coordinator (FOSC) must receive concurrence from the Environmental Protection Agency (EPA) and State of Alaska representative to the Alaska Regional Response Team (ARRT).

Burning as an active *response* measure, not as a *planned* response measure, can be allowed via the Unified Command process when the NCP and Alaska RCP are activated during a spill response. Mechanical recovery as a planning tool remains the OSRP planning requirement in the Alaskan Arctic as burning cannot be pre-approved via the OSRP review and approval process by BSEE unless there are preauthorization agreements in place. If in-situ burning is the *planned* response method in an OSRP/ODPCP, all of the extensive, applicable air quality regulatory requirements would need to be met by the plan holder prior to OSRP/ODPCP approval.

### 2.9.3 Mechanical Recovery Analysis for Spill Planning with ROSI

For spill response planning in Alaska under 30 CFR 254, and under 18 AAC 75, mechanical methods must be proposed as part of the oil spill response plan unless proposed in-situ burning as the planned response method undergoes the review and approval process required by the Clean Air Act. ROSI has been developed to assist plan holders and analysts with the development and analysis of their oil spill response scenarios using mechanical recovery methods.

### 2.9.4 Future Proofing ROSI

ROSI was developed to address yellow iron tactics, methods and volumes. Plan holders also use other snow and ice recovery tactics that are more refined when planning for large volume spills to minimize the bulk material limitations of graders, loaders and dump trucks. In particular, Tactic R-2, Manual Recovery of Lightly Oiled Snow, focuses on removing a minimum amount of oiled snow using manual methods such as personnel lightly “skimming” the snow’s surface with shovels and/or brooms, collecting the materials in bins towed by snow machines (snowmobiles) to a central collection point. It is at this point where heavy equipment then removes the collected material in bulk along with the other materials collected using other yellow iron. As stated previously, Tactic R-2 was considered out-of-scope for this project as the material collection is performed manually with the bulk material handing completed by heavy equipment.

Expanding ROSI to include tools to provide indisputable estimates of the size and extent of blowout plumes used to calculate the extent of a planned spill response should be considered to expand its capabilities. Another consideration would be including tactics R-1A, Use of Snow Blower to Remove Lightly Misted Snow, and R-2, Manual Recovery of Lightly Oiled Snow, into ROSI. These types of refinements to ROSI could provide clear, irrefutable calculations of oil spill response planning estimates such as the number of snow machines (snowmobiles), the number of personnel required to implement the tactics at the necessary scale, in addition to the volume estimates already addressed for yellow iron.

Increasing ROSI's capabilities to provide a calculator that can unarguably address all the parameters of a spill response scenario to be used by plan writers and analysts when sizing a blowout to comprehensively calculate the size of the discharge plume so it can more accurately estimate the amount of ice and snow that needs to be managed in a hypothetical spill response scenario would benefit BSEE, ADEC, industry and the general public. The more detailed the calculator can be made to address known variables in spill response planning could provide a potentially less contentious and smoother, shorter review process to benefit the general public, industry and analysts.

# 3 Additional and Future Research

Based on the research and interviews it is apparent that there is an incredible amount of knowledge and experience responding to oil spills in the arctic, but little peer-reviewed research or field experiments published on the specific topic of using yellow iron for oil spill response recovery.

The recommendations for additional research that follow are based on interviews, the extensive expertise and experience of the project team, the research reviewed, and the research/studies not found to support the project's goals and findings:

## 3.1 ADEC Database and Historical Records Review

Research into the historical ADEC spills database and records may provide factual information and data regarding recovery rates that could replace the need for any field experiments. A detailed review of the records collected during actual spills would consist of examining information in the ADEC oil spill case files that may include data that could reveal the cleanup rates for tactics employed. For example, given the size and date of the Gathering Center (GC)-2 spill of 2006, it is highly likely the tactics relevant to this project were employed in addition to other tactics. A thorough examination of records, field notes and other information in these files could be performed to determine if sufficient information already exists or whether further research or experimentation is warranted to support the original premise of this project.

Available by a *Public Record Request*, information in ADEC spill files that may be relevant to future research include the following: reports and work plans, clean up actions, interim and final reports. Please note, some information related to ongoing investigations or open cases may not be available for a public records request. General information about spills including spill date, location, responsible party, spilled substance, and spilled volume is available from the publicly accessible ADEC Spills Database Search:
***https://dec.alaska.gov/Applications/SPAR/PublicMVC/PERP/SpillSearch***.

Note that for spill cleanup case records, the ADEC retention policy is "*Retain case files in office for 20 years after case closed, barring any legal hold on records, or historical significance*." There is an exception for "first and final spills cases," where the retention is two years, and on the other end of the spectrum the ADEC Spill Prevention and Response (SPAR) director may determine which documents are of historical significance and retained permanently, such as the GC-2 Pipeline discharge that occurred in the winter of 2006. The number of historical spill records that are still available for review would be the first step to determine if this avenue of research could be examined further.

We would suggest that based on the records retention policy of ADEC that if additional research is warranted to verify the planning formulas that this records review and analysis should be done as soon as possible.

## 3.2 Spill(s) of Opportunity

If there is an oil discharge in the arctic winter conditions that would employ the mechanical recovery tactics of this project as a "spill of opportunity" it could be studied. Parameters to test such a “spill of opportunity” could be developed and provided to ACS and/or another arctic response contractor that employs similar tactics, or who would be willing to employ the specific ACS tactics, which could be used for data collection. The field study(s) could be implemented when the selected tactics are next employed in a spill response of a minimum agreed upon volume or extent. Tactics could be timed and the formulas in the tactics could be tested and verified. This might be the most cost-effective means to test recovery rates using actual oiled snow and ice.

## 3.3 Spill Tested in Field Conditions

A field location could potentially be established to test the tactics under actual field conditions. The amount of oil and associated saturation rates needed to conduct an experiment that would adequately test the tactics would need to be established. Permits to discharge oil would be required. It is worth noting that such permits have rarely been issued in Alaska since the 1970s. A test facility such as Poker Flat near Fairbanks, Alaska, could be potentially used for such tests.

Significant logistical requirements for personnel, equipment, cleanup, disposal and decontamination would need to be met. This research would require intensive effort and planning to be performed. It would likely be expensive and potentially controversial. Given that the tactics provided by ACS are for “planning purposes only” and are not meant to meet performance requirements, the value of such an effort needs to be carefully evaluated.

## 3.4 Expand ROSI

### 3.4.1 Include Blowout Modeling

The ROSI calculator does not include blowout modeling. However, the ARCTOS’ existing Blowout Modeling Calculator (BMC) could be expanded and incorporated into ROSI. The current BMC meets the modeling requirements of ADEC’s “default” RPS of 5,500 bopd. However, it could be revised to model the area of discharge for WCDs of greater than 10,000 barrels of oil per day.

#### 3.4.1.1 Description of a Blowout Modeling Calculator

The BMC first provides the gas-to-oil ratio (GOR) when the user inputs the volume of oil and the accompanying gas pressure. The BMC also calculates the total size of the affected area in square feet, and then calculates the cubic yards of material that needs to be planned for removal. The BMC can be manipulated to include additional affected areas should the wind data for the location indicate that the plan writer should account for changes in wind direction over the duration of the planning period, typically 15 days for ADEC and 30 days for BSEE.

Even though the SL Ross model indicates 10% of the aerosolized oil remains aloft, this increment is added back into the BMC to ensure the plan holder demonstrates plans to remove the entire RPS or WCD volume from the snow/ice surface using mechanical methods. The calculator also accounts for spreading of oil near the source when large quantities are hypothetically deposited. The volumes of free-oil, oil-saturated snow, and lightly-oiled snow are then designated by the plan writer based on the extent of the plume(s), calculated oil thickness and other factors such as pad size and geological or man-made features, such as bluffs and containment areas.

Additional refinement of the full BMC for use by BSEE OSPD analysts was outside the scope of this project. Funding an effort to expand the capabilities of the Blowout Calculator would provide analysts a means to verify plume (affected area) size and snow volumes to be recovered.

### 3.4.2 Expand ROSI to Include Manual Recovery Methods

To provide more detailed and refined calculations of the amount of resources that may need to be deployed to respond to a discharge ROSI could be expanded to include manual recovery methods. The formulas in ACS tactics R-1A, Use of Snow Blower to Remove Lightly Misted Snow, and, R-2, Use of Snow Blower to Remove Lightly Misted Snow, could be included in ROSI's framework. These tactics are often described in the spill response scenarios since while they cover a large area, they represent a smaller amount of the total calculated discharge volume. Using manual tactics the scenarios plan to minimize the amount of snow and ice volumes that need to be addressed by the overall recovery operation. Expanding ROSI to include these tactics would assist industry, analysts and the general public with a more realistic amount of material and yellow iron that should be planned for when developing an OSRP or ODPCP.

## 3.5 SL Ross Model Procurement

Procurement or re-programming a version of the SL Ross computer model cited by Belore, et. al., should be considered if analysts are to rely on the referenced model in Tactic T-6 when analyzing plans. While the tables presented in ACS Tactic T-6 are used to extrapolate GOR, plume length and width to estimate these factors, they are based on exponential scales and are of a published size that potentially leaves too much room for debate. They are also limited to five (5) pipe diameters. Improved resources to provide a plan writer to prepare an oil spill scenario, and, for regulatory reviewers to analyze the scenario, should be considered. A BMC that provides consistent results means there is less controversy when developing and analyzing scenarios to meet regulatory requirements. Currently, using the exponential scales in the tables potentially introduces differences of interpretation of plume sizes, especially when very large spill sizes outside of the ranges covered by the tables might need to be modeled. Procurement of the computer model from SL Ross, if still available, or the re-engineering the computer model, would be an important component to remove potential disagreements as to the extent of plume sizes between analysts and plan holders. This would improve the review process for all involved parties.

The computer model should be available to all potentially interested parties to develop response scenarios and could be used to double-check the ARCTOS BMC and verify the blowout size estimates in proposed OSRPs and ODPCPs. Regulatory requirements in both state and federal rulemaking require references to be available to the public when cited or used. The lack of references in the SL Ross computer model in regulation or by proxy could potentially be considered a non-compliance condition on the part of the governments' use of the SL Ross model.

ADEC was informed late in the project that ACS has granted a contract to SL Ross in December 2022 to modernize the model. ACS has asked SL Ross to update the documentation on the original model, review more recent studies to see if further updates are warranted and create a Microsoft Excel spreadsheet that would take the place of the charts in the current Tactic T-6. If the spreadsheet is made available to the analysts and general public this could address any concerns regarding the use of the model in the public domain for regulatory requirements. It is not known if the model will be of sufficient capacity to address potentially very large blowouts. The ultimate capacity of the model to meet BSEE's current needs will need to be monitored and evaluated should the model become available to BSEE analysts and the general public.

## 3.6 Propose International Standard for Oil-to-Snow Ratio Expression

Many forums for oil spill technology and case studies exist globally such as: AMOP, the International Oil Spill Conference (IOSC), Spillcon (Australian Institute of Petroleum (AIP) and the Australian Marine Oil Spill Centre (AMOSC)), Interspill (Europe), among others. In addition, there are many scientific journals, the BIPM, NIST, ISO, and other entities who govern standards of measure and terminology. We suggest BSEE or another scientist propose a standard measure for the oil-to-snow ratio and recovery of solid materials (e.g., oiled gravel, sand) so that in the days forward a standard measuring methodology in the future literature would provide a better "apples to apples" means to compare any future research associated with the recovery of ice and snow in Arctic and Antarctic regions, and potentially for other bulk material recovery studies, cases or methods.

# 4 Conclusion

In summary, despite the incredible amount of knowledge that exists around oil spill response methods in the arctic, the handful of studies and field experiments conducted and documented over the years at best obliquely references the use of yellow iron for spill response recovery/cleanup tactics. We conclude that currently the best source of information regarding the yellow iron tactics that this project focused on are the people who use them regularly, the experts in arctic spill response at ACS.

It's noteworthy that other arctic spill response authorities around the world cite ACS and the ACS TM in their research or response plans. ACS's formulas are unsurprisingly consistent with the Caterpillar performance guide and provide reasonable planning formulas for oil spill recovery of oiled ice and snow during winter conditions in the arctic and other frozen environments. These in turn provided sufficient information to generate ROSI, and to provide a basis for consideration of additional expansion of ROSI to include the development of a blowout modeling calculator that would be available to BSEE, stakeholders and the general public.

A standard for the expression of the oil-to-snow ratio, instead of the free-for-all that now exists, would provide for an easier means to quantify recovered oiled material. We suggest proposing to the appropriate governing entities that $m^3/m^3$ should be established for metric, and $bbl/yd^3$ for USCU, as has been used in the development of ROSI. Smaller quantities of oil and snow, such as those typically used in bench-laboratory or small scale field studies, could use the inherent and intuitive units of the metric system, such as centi, deci, etc. For smaller quantities expressed in USCU, gallons per cubic foot could be used ($gal/ft^3$), however, anything less than that (such as for bench or other small scale studies) should consider the use of the metric system in the scientific literature.

Additional field studies to establish performance criteria in lieu of the current planning requirements demonstrated by the ACS TM is unwarranted at this time. While future changes in regulation may provide impetus for such research, it worth remembering that a performance requirement is only valid for the elements that it incorporates and catalogues – in real-life spill responses there will always be elements and variables that are not included or that cannot be measured or fully anticipated. Use of the planning requirements model is the currently the best approach for now and into the foreseeable future.

## 4.1 Citations in Report (also see Appendix B, Research)

Alaska Clean Seas. 2021. Revision 15, Alaska Clean Seas Technical Manual, Volume 1, Tactics Descriptions.

Belore, McHale & Chapple. 1998. Oil Deposition Modeling for Surface Oil Well Blowouts. 1998. Arctic and Marine Oilspill Technical Program, Environment Canada.

Caterpillar, Inc., Peoria, Illinois. 2019. 49th Caterpillar Performance Handbook.

Dickins, David F. Personal communication with G. C. LeBeau, ARCTOS Project Team Interviewer. May 12, 2022.

ISO Standard 16165. 2020. Ships and marine technology – Marine environment protection – Vocabulary relating to oil spill response. Third edition. International Standards Organization.

McMinn, Trevor J. 1972. Oil Spill Behavior in a Winter Arctic Environment. United States Coast Guard.

Detailed research citations – See Appendix B of this report.

Interviewees – See Appendix C of this report.

# Appendices

# Appendix A:  Technical Summary

REPORT TITLE: Research to Support Analysis of OSRPs in Snow and Solid Ice
CONTRACT NUMBER(S): 140E0122F0017
FISCAL YEARS(S) OF PROJECT FUNDING: FY 2022 and FY 2023
CUMULATIVE PROJECT COST: $248,134.80
COMPLETION DATE OF REPORT: 31 August 2023
BSEE COR(S): Kristi McKinney
BSEE CO(S): Jennifer Hershberger
PROJECT MANAGER(S):Kirsten Ballard
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KEY WORDS: Arctic, Oil Spill, Mechanical Recovery, Alaska Clean Seas Tactics, Calculator

* The affiliation of the Principal Investigators(s) may be different than that listed for Project Manager(s).

# Appendix B:  Research Summary Table

Search Terms, articles reviewed, and whether they were used in this project are detailed and summarized in an extensive spreadsheet.

**Table of Research**

| Date | Source | Date2 | Website/Source | Document | Summary | Purpose/Use |
|---|---|---|---|---|---|---|
| 1/20/22 | ADEC | | Division of Spill Prevention and Response (alaska.gov) | ENI North Slope og ep ODPCP | ENI Cplan | CPlan Review |
| 1/20/22 | ADEC | | Division of Spill Prevention and Response (alaska.gov) | HAK North Slope Production ODPCP | HAK Cplan | CPlan Review |
| 1/20/22 | ADEC | | Division of Spill Prevention and Response (alaska.gov) | Harvest North Slope ODPCP | Harvest Cplan | CPlan Review |
| 1/20/22 | BOEM | | https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Alaska-Region/Leasing-and-Plans/Plans/Vol-1-Liberty-FEIS.pdf | Vol-1-Liberty-EIS | Liberty EIS | CPlan Review |
| 1/21/22 | ACS | Jun-21 | Volume-1-Tactics-Description_Rev_15-1.pdf (alaskacleanseas.org) | ACS Tactics Volume 1, Rev. 15 | Includes Tactics R1-R3, R-5, R-29, T-7 + | Existing Calculators |
| 1/25/22 | FAA | 24-Sep-14 | https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5220-20 | AC 150/5220-20A - Airport Snow and Ice Control Equipment | Airport snow and ice control equipment documentation | Existing Calculators |
| 5/11/22 | EPPR | 2017 | https://oaarchive.arctic-council.org/bitstream/handle/11374/2100/EPPR_Field_Guide_2nd_Edition_2017.pdf?sequence=12 | EPPR Field Guide 2017 | Field guide of Arctic response Guide | Examine for snow and ice response tactics/information - very limited and not useful |
| 5/11/22 | NOAA | 25-Oct-13 | https://response.restoration.noaa.gov/about/media/above-under-and-through-ice-demonstrating-technologies-oil-spill-response-arctic.html | story about arctic response | Story about UAV and underwater technology. Not relevant - no yellow iron | Reviewed, not useful |
| 5/11/22 | IOSC | May-14 | https://www.researchgate.net/profile/Kurt-Hansen-2/publication/286170275_Responding_to_Oil_Spills_in_Ice/links/566ed89408aea0892c52acee/Responding-to-Oil-Spills-in-Ice.pdf?origin=publication_detail | International Oil Spill Conference Presentation - Responding to Oil Spills in Ice | Compliation of various exercises and studies primarily about the operation of boom, skimmers, vessels, barges, UAV's and other equipment in arctic conditions in broken ice conditions. No yellow iron | Research |
| 5/12/22 | ADOT | 2022 (website) | https://dot.alaska.gov/stwdmno/ | Maintenance & Operations; Emerging Practices in Winter Highway Maintenance | summary of practices in snow removal on highways | Research |
| 5/12/22 | MnDOT and LRRB | Oct-12 | https://www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf | Minnesota Snow and Ice Control Field Handbook for Snowplow Operators, Second Revision | Snow removal guide; Bibliography source of information | Research |
| 5/12/22 | Clear Roads.org | 2022 (website) | https://clearroads.org/research-by-topic/ | Research by Topic Website | Research by Topic website for road clearing | Research |
| 5/12/22 | Clear Roads.org | 2019 | https://nap.nationalacademies.org/cart/download.cgi?record_id=25410 | Performance Measures in Snow and Ice Control Operations, 2019 | Performance Measures in Snow and Ice Control Operations presents approaches for monitoring the performance of snow and ice control activities by public agencies and proposes a core set of performance measures that can be customized and used by agencies to meet their snow and ice control objectives. | Research |
| 5/12/22 | NCAR/RAL | 2022 (website) | https://ral.ucar.edu/solutions/products/maintenance-decision-support-system-mdss | Maintenance Decision Support System (MDSS) | Software to optimize winter maintenance Operations | Research |
| 5/12/22 | TRB | Jun-04 | https://onlinepubs.trb.org/onlinepubs/circulars/ec063.pdf | Sixth International Symposium on Snow Removal and Ice Control Tech, 2004 | Transportation Research Circular of presentations at the symposium with several articles regarding winter maintenance management/decision systems that may be relevant upon further review | Research |
| 5/12/22 | IASS | 2022 (website) | https://www.snowsymposium.org/ | Website of the IASS/NEC/AAAE & the 2022 Symposium | Air Force Snow and Ice Control Management Course; Symposium; other training - possible information source for equipment capacities/capabilities | Research |
| 5/12/22 | Case Const. | 2022 (website) | https://www.casece.com/northamerica/en-us/your-business/snow-removal | Winter Snow Removal Specs, operation calculators, videos, association links | Articles, videos, tips and specs | Research |
| 5/17/22 | Rutgers University | 2022 (website) | http://eckstein.rutgers.edu/beijing07/Tuesday/snow-solutions.pdf | Snow removal calculation homework for Alberta | Formulae for calculating snow removal capacity; not relevant to this project | Research |
| 5/17/22 | Kanata | 23-Feb | https://www.youtube.com/watch?v=1XHzq1S8i5o | Snow Removal Operation Video | Video of snow removal using loader mounted snowblower and dump trucks | Research |
| 5/17/22 | Canadian Tire Center | 11-Feb | https://www.youtube.com/watch?v=pMGTUAxJiDk | Snow Removal Operation Video | Video of loader, loader plow & dump trucks removing snow | Research |
| 17-May | Eric Langlois, APWA | Apr-11 | http://pnsassociation.org/wp-content/uploads/2011-Conference-Presentations/Snow_Dump_Sites.pdf | Snow Dump Site Planning | Planning for a new snow dump site | Research |
| 5/17/22 | APWA | Apr-22 | https://www.apwa.net/2022SNOW/Event_Details.aspx?Event_Tabs=6#Event_Tabs | 2022 Conference Site - use for contacts | Use to contact AKDOT&PF Moderator | Research |
| 5/18/22 | Rutgers University | Nov-21 | https://newbrunswick.rutgers.edu/event/snow-and-ice-removal-municipalities-and-public-grounds | Snow and Ice Removal for Municipalities and Public Grounds | Half-day online course for snow removal; Laws and salt/brine application seem to feature; next offered Nov. 22 | Research |
| 5/18/22 | CPW | Apr-22 | https://www.climate-policy-watcher.org/snow/saturated-or-onephase-flow.html | Saturated or Onephase flow (snow) | Principles of fluid flow through snow | Research |
| 5/18/22 | Donald Mackay, Paul J. Leinonen, John C.K. Overall, and Barry R. Wood | 1975 | https://pubs.aina.ucalgary.ca/arctic/Arctic28-1-9.pdf | The Behaviour of Crude Oil Spilled on Snow, ~1975 | Field and laboratory studies of the behaviour of isothermal and hot oil spills on snow are described | Research |
| 18-May | T.J. McMinn, USCG | 1972 | https://apps.dtic.mil/sti/pdfs/AD0754261.pdf | Crude Oil Behaviour on Arctic Winter Ice, 1972 | Field studies of several oil spill cleanup techniques (dispersants, absorbents, burning) shown to be less effective than mechanical cleanup. Methods of mechanical cleanup discussed very briefly, barely relevant to yellow iron - "Light bulldozers and shoveling can accumulate the oil so that it can be barreled and removed by road or air transportation to a disposal or reclamation facility." | Research |
| 5/18/22 | David Dickens | 2011 | http://www.dfdickins.com/pdf/OTC22126LR.pdf | Behavior of Oil Spills in Ice and Implications for Arctic Spill Response, 2011 | Evaluation of several other papers with a focus on oil 'in' ice/water. Minimal discussion of oil spill cleanup on top of fast ice. Not relevant to yellow iron. | |
| 5/20/22 | Anna Fiolek, Linda Pikula, and Brian Voss | Jul-15 | https://repository.library.noaa.gov/view/noaa/10410 | Resources on Oil Spills, Response, and Restoration A Selected Bibliography | A search of the document for "mechanical", "snow" and "ice" reveals no information relevant to the project. | Research |
| 5/20/22 | OSRI/USARC | Mar-04 | https://www.arlis.org/docs/vol1/60400463.pdf | Advancing Oil Spill Response in Ice Covered Waters | Relates primarily to Broken Ice. Most relevant revelation would be to advance research "Lessons from Past Spills" (p. 12) to perform the research of actual past spills, but this information is sparse and incomplete - a detailed preliminary investigation as to the feasibility of conducting such a study should be considered; however, given the lack of response from ADEC for this information requested as a result of THIS project, shows the difficulties that will likely be encountered. | Research |

Key:

| | |
|---|---|
| BSEE | Bureau of Safety and Environmental Enforcement |
| ADEC | Alaska Department of Environmental Conservation |
| BOEM | Bureau of Ocean Energy Management |
| ACS | Alaska Clean Seas |
| FAA | Federal Aviation Administration |
| EPPR | Emergency Prevention Preparedness and Response |
| NOAA | National Oceanic Atmospheric Administration |
| IOSC | International Oil Spill Conference |
| ADOT | Alaska Department of Transportation & Public Facilities |
| MnDOT | Minnesota Department of Transportation |
| NCAR/RAL | Research Applications Laboratory (sponsored by National Science Foundation) National Center for Atmospheric ResearchNational Center for Atmospheric Research |
| TRB | Transportation Research Board of the National Academies |
| IASS | International Aviation Snow Symposium |
| NEC/AAAE | Northeast Chapter American Association of Airport Executives |
| APWA | American Public Works Association |
| CPW | Climate Policy Watcher |
| USCG | United States Coast Guard |
| OSRI | Prince William Sound Oil Spill Recovery Institute |
| USARC | United States Arctic Research Commission |
| JIP | Joint Industry Programme (Arctic Oil Spill Response Technology) |

| Date | Source | Date2 | Website/Source | Document | Summary | Purpose/Use | | |
|---|---|---|---|---|---|---|---|---|
| 5/24/22 | Buist, Dickens | 1987 | DOI Library acquisition | 1987. Experimental Spills of Crude Oil in Pack Ice. Proceedings 1987 International Oil Spill Conference. American Petroleum Institute. Washington, pp 373-381 | Spill behavior in pack ice. Not relevant to this project. | Research | AMOP | Arctic Marine Oil Programme (Technical Seminar/Proceedings) |
| 5/24/22 | Vandermeulen, J.H., Buckley, D.E. | 1985 | DOI Library acquisition | 1985. The Kurdistan Oil Spill of March 16-17, 1979: Activities and Observations of the Bedford Institute of Oceanography Response Team. Canadian Technical Report of Hydrography and Ocean Sciences No. 35, Bedford Institute of Oceanography, Dartmouth NS. | Spill in pack ice. Not relevant to this project | Research | LRRB | Minnesota Local Road Research Board |
| 25-May | Donald Mackay; Warren Stiver; Peter A. Tebeau | 1983 | https://meridian.allenpress.com/iosc/article/1983/1/331/204390/TESTING-OF-CRUDE-OILS-AND-PETROLEUM-PRODUCTS-FOR | TESTING OF CRUDE OILS AND PETROLEUM PRODUCTS FOR ENVIRONMENTAL PURPOSES | Spill in pack ice. Not relevant to this project | Research | | |
| 5/25/22 | Carl J. Oskins, Dee Bradley | 2005 | https://meridian.allenpress.com/iosc/article/2005/1/521/138575/EXTREME-COLD-WEATHER-OIL-SPILL-RESPONSE-TECHNIQUES?searchresult=1 | "EXTREME" COLD WEATHER OIL SPILL RESPONSE TECHNIQUES & STRATEGIES – ICE & SNOW ENVIRONMENTS | Spill response challenges in extreme cold - PPE, Slotting techniques. Not relevant to this project | Reviewed, not useful | | |
| 5/31/22 | JIP | 2015 | https://www.arcticresponsetechnology.org/wp-content/uploads/2017/09/ACS-Mechanical-Recovery-of-Oil-in-Ice-Feasiblity-Report-Final-1208.pdf | Mechanical Recovery in Ice Summary Report | Mechanical Spill Recovery in broken ice, under ice. Not relevant to this project | Reviewed, not useful | | |
| 5/31/22 | JIP | 2015? | https://www.arcticresponsetechnology.org/wp-content/uploads/2017/08/JIP-IG-Mechanical-Rec.pdf | Mechanical Recovery in Ice - Infographic | Mechanical Spill Recovery in broken ice, under ice. Not relevant to this project | Reviewed, not useful | | |
| 6/8/22 | Nelson, Allen (AMOP Proceedings) | 1982 | DOI Library acquisition | The Physical Interaction and Cleanup of Crude Oil with Slush and Solid First Year Ice | Field experiments of oil under ice and misted/sprayed onto snow-covered ice. Effectiveness of cleanup methods (dozer & truck) relevant for oil sprayed on ice and after burning and weathering (99% effective). Minimal penetration of oil noted | | | |
| 6/13/22 | Goodman, R.H., AG. Holoboff, T.W. Daley, P. Waddell, L.D. Murdock, and M. Fingas | 1987 | https://meridian.allenpress.com/iosc/article/1987/1/395/198608/A-TECHNIQUE-FOR-THE-MEASUREMENT-OF-UNDER-ICE | "A Technique for the Measurement of Under-Ice Roughness to Determine Oil Storage Volumes", in Proceedings of the 1987 International Oil Spill Conference | "The parameter that characterizes this spatial extent is the storage volume, which has units of m3/m2, and is the average oil thickness under the ice." - not relevant to this project | Reviewed, not useful | | |
| 6/13/22 | Tom Coolbaugh | 2021 | https://ohmsett.bsee.gov/scientific/NWOSCC%20Oil%20Properties%20Aug%2023%202021_Final.pdf | Properties, Fate, and Behavior of Spilled Oil - Northwest Oil Spill Control Course, August 23, 2021 | Relates primarily to marine environments, weathering, fate, behavior accordingly. Not relevant to this project | Reviewed, not useful | | |
| 13-Jun | D. G. Wilson and D. Mackay | 1987 | https://www.osti.gov/etdeweb/biblio/6961441 | "The Behaviour of Oil in Freezing Situations", Manuscript Report EE-92, Environment Canada, Ottawa, ON, 65 p | Relates primarily to marine environments, weathering, fate, behavior accordingly. Not relevant to this project | Reviewed, not useful | | |
| 6/13/22 | Tatjana Paulauskiene, Indrė Jucikė, Natalija Juščenko, Dalia Baziukė | 2014 | https://www.researchgate.net/figure/The-maximum-sorption-capacity-of-sorbents-using-crude-oil-and-diesel_tbl1_262487332 | The Use of Natural Sorbents for Spilled Crude Oil and Diesel Cleanup from the Water Surface | Moss, straw, wool, sawdust, and peat are the five natural sorbents evaluated during the experiments. Snow and ice are not examined. Not relevant to this project | Reviewed briefly, not useful | | |
| 6/30/22 | Mohammad A. Alshuqaiq | 2014 | https://web.wpi.edu/Pubs/ETD/Available/etd-050814-133636/unrestricted/ALSHUQAIQ_Oil_combustion_over_snow.pdf | An analysis of Oil Combustion on Snow | The effects of differing Porosity of snow and burning are examined and physically explained with the goal of improving strategies of oil cleanup of spills on snow (Note: Thesis) | Reviewed for references to sorptive capacity of snow | | |
| 6/30/22 | Stroh, Jacob Nathaniel | 2019 | https://scholarworks.alaska.edu/handle/11122/10542 | Data analysis and data assimilation of Arctic Ocean observations | Primarily directed towards various observations (and models) regarding climate change effects in the arctic. Not relevant to this project | Detailed Abstract reviewed | | |
| 7/7/22 | Paul V. Sellmann and Dale R. Hill | 1997 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:1619076/one?qu=GB+2401.+c77+no.+97-14&te=ILS | Ripping Frozen Ground with an Attachment for Dozers | Front-mounted rippers on dozers of various sizes are tested on frozen ground as an alternative to rear-mounted rippers in the event they are unavailable in a combat situation. Limited use for this project as this tactic is not examined. Good resource for the comparative Distribution of Permafrost figure (Bates and Bilello 1966) and the use of the Caterpillar Performance Guide, 1989 | Reviewed, not useful | | |
| 7/7/22 | Mervin F. Fingas, Editor | 2015 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:2391625/one?qu=TD+427+.+p4+h366+2015&te=ILS | Handbook of Oil Spill Science and Technology | Comprehensive textbook-style compendium of oil properties, spill behaviour, spill histories, modeling, effects on wildlife, and many other topics with many well-known scholarly contributors, including Arctic/Antarctic spills, Risk Analysis, etc. Not relevant to this project | Reviewed text of relevant chapter headings/subtopics: Oil Spreading on or in Snow; Oil Spills on Land (briefly - primarily tundra or soils); Cold Region Spills - Arctic and Antarctic Spills - not relevant or useful for this project with the possible exception of Oil Spreading on or in Snow, however, the cited authors have been noted with regard to the sorptive capacity of snow elsewhere. | | |
| 7/7/22 | The Environmental Research Section, Production Development Department, Dome Petroleum Limited | 1980 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:2946935/one?qu=TD+427+.+p4+d645+1980z&te=ILS | Ice is Nice - Oil Spill Research and Countermeasures for the Beaufort Sea | Oil company/Beaufort Sea Leaseholder's summary of oil spill response and drilling program offshore from the MacKenzie River Delta area. Primary focus is summer drilling programs, blowout response under ice/come springtime. Not relevant to this project. | Reviewed, not useful | | |
| 7/7/22 | L. B. Solsberg, M. McGrath, and Canadian Petroleum Association | 1992 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:1645738/one?qu=TD+427+.+p4+s54+1992&te=ILS | Task Force on Oil Spill Preparedness, Technical Report Number 92-02; State of the Art Review: Oil-in-Ice Recovery | Mostly addresses broken ice response equipment available at the time and examines some spill responses in cold weather - most relevant one was the approximately 59,000 L of diesel fuel was spilled to the ground and drained to the snow and ice surface of Warwick Lake. The site was accessible by aircraft only and temperatures during the cleanup ranged from -35 C to -50 C. From late January to late March, contaminated snow was collected and burned on site. Collection trenches were cut into the ice and fuel was recovered and burned. 46,300 L of oil was recovered. Additionally, prior to break-up, a containment boom was sunk into the ice. Pockets of pooled oil were burned off as break-up occurred. | Deslauriers, P.C., Morson, B.J, and EJC Sobey, "Field Manual for Cold-Climate Spills", prepared for USEPA, EPA-3-05-009-8, date unavailable, may be reference worth reviewing. Warwick Lake response cited: Burns, R.C., "Cleanup and Containment of a Diesel Fuel Spill to a Sensitive Water Body at a Remote Site Under Extreme Winter Conditions", Proceedings of the Eleventh Arctic and Marine Oil Spill Program Technical Seminar, Environment Canada, Jun. 1988, pp 209-220, may also be worth reviewing. All other summarized Oil Spill Incidents not relevant | | |
| 7/7/22 | D. F. Dickins Engineering | 1981 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:1154958/ada?qu=Baffin+Island+Oil+Spill+Project+Working+Report&d=ent%3A%2F%2FSD_ILS%2F0%2FSD_ILS%3A1154958%7EILS%7E2&te=ILS | Baffin Island Oil Spill (BIOS) Project : Cape Hatt ice conditions, 86 p., BIOS Working Report 80-8 | Study results of ice conditions off Baffin Island 1980 | Reviewed briefly, not useful | | |
| 7/7/22 | S.L. Ross Environmental Research Ltd. | 1982 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:328935/one?qu=Recovery+of+Oil+in+an+Ice+Environment&te=ILS | Canadian Offshore Oil Spill Research Association, Project Report; Proceedings of a Brainstorming Workshop on Recovery of Oil in an Ice Environment, October 19-20, Calgary, Alberta | Refers to cleanup ideas for oil: amongst large moving ice floes, under solid moving pack ice, and, in brash and pulp ice. Not relevant to this project. | Reviewed Executive Summary - not useful | | |

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| 7/7/22 | Carpenter, Kristin | 2016 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:2927303/one?qu=GC+1552+.P75+E993+2015+RP+15120112C&te=ILS | Legacy of the Exxon Valdez Oil Spill: Mitigating Stormwater Runoff's Chronic Toxicity Through Snow Management in Cordova (Restoration Project 15120112-C), Copper River Watershed Project, Cordova, Alaska. | Stormwater mitigation plan for municipalities and state agencies contribution. Not relevant - no yellow iron | Reviewed abstract - Not useful |
| 7/7/22 | Peter W. Barnes, Erk Reimnitz, Lawerence J. Toimil, Harry R. Hill | 1979 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:1613793/one?qu=Fast-Ice+Thickness+and+Snow+depth+in+relation+to+oil+entrapment+potential&te=ILS | US Geological Survey Open File Report 79-539. Fast-Ice Thickness and Snow Depth in Relation to Oil Entrapment Potential, Prudhoe Bay, Alaska | Examines the undersurface of the sea ice on shallow arctic shelves and compares the thickness of the ice relative to the thickness of snow on top. Not relevant to this project. | Reviewed abstract - Not useful |
| 7/7/22 | Ian Buist, Randy Belore, David Dickins, Dan Hackenberg, Alan Guarino and Zhendi Wang | 2008 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:1234269/one?qu=TN+871+.E5+2008&te=ILS | Empirical Weather Properties of Oil in Ice and Snow. Project Number 1435-01-04-RP-34501. Final Report for USDOI, MMS, Alaska Outer Continental Shelf Region | Four-year study of oil weather with extensive laboratory testing. May be relevant for next project for oiled snow capacity and algorithms and equations that may be useful for the equations in the tool and/or the next project. | Reviewed abstract - Usefulness TBD |
| 7/7/22 | Paul C. Deslauriers, Barbara J. Morson, and Edwin J. Sobey | 1982 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:251938/one?qu=TD+427+P4+P41&te=ILS | Field Manual for Oil Spills in Cold Climates, Prepared for US Environmental Protection Agency, Municipal Environmental Research Lab., Cincinnati, OH, EPA-600/8-82-0011, June 1982 (reproduced by US Department of Commerce, National Technical Information Service) | Most relevant information is in regards to the effectiveness of burning for non-mechanical recovery; a discussion of using heavy equipment (cautiously) and that Ice Removal (p. 88) "In general, the amount of oil in the ice is very small, and the volume of ice required to recover even a slight amount of oil would be very large….Before using this technique, it is important to estimate the amount of oil contained in the ice and the volume of ice being considered for removal." | Reviewed relevant topics; see Summary |
| 7/7/22 | Burns, R.C. | 1988 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/results?qu=GC+1101+A73+1988&te=ILS | "Cleanup and Containment of a Diesel Fuel Spill to a Sensitive Water Body at a Remote Site Under Extreme Winter Conditions", Proceedings of the Eleventh Arctic and Marine Oil Spill Program Technical Seminar, Environment Canada, Jun. 1988, pp 209-220 | Case study of oil (diesel) cleanup in winter using a combination of mechanical recovery (snow machine) and burning; boom left in ice through breakup | Reviewed. May be relevant for next research. 6/26/23 UPDATE: Reviewed in detail. While fuel loss was measured in litres, snow recovery was measured in '15-20 snowmobile trailer loads' which is not useful for the metric units since the size/volume of the trailers was not specified. Consultation w/S. Potter, SL Ross, indicated that other spills in Canada were not documented as well as this one (his suggestion for ROSI (via email) was to use litres oil/cubic metre of snow). |
| 8/2/22 | IOSC - Edward H. Owens, David F. Dickins, and Gary A. Sergy | 2005 | https://meridian.allenpress.com/iosc/article/2005/1/513/138538/THE-BEHAVIOR-AND-DOCUMENTATION-OF-OIL-SPILLED-ON | THE BEHAVIOR AND DOCUMENTATION OF OIL SPILLED ON SNOW- AND ICE-COVERED SHORELINES | The efficient and effective cleanup of oiled snow and ice on shorelines or riverbanks requires an understanding of the likely behavior and fate of the oil. Depending on the snow conditions, oil may remain at or near the surface or drain through the snow or into ice cracks. Much of the oil is often hidden from view. The basic principles of snow and ice and oil behavior are relatively well understood. Equations and models are available to estimate rates of infiltration, spreading, migration, or evaporation for oil in snow. There is, however, limited understanding of the mechanics of oil behaviour or transport pathways in snow. Little knowledge exists regarding how oil migrates through a non-uniform snow cover. As a consequence, it is difficult to estimate where the oil might accumulate, a critical question for responders. The few observations published from spills or field experiments indicate that oil transport and migration mechanisms are likely to be complex, particularly if the structure of the snow is not uniform. Snow thick- ness, snow surface topography, terrain slope, and the presence of ice layers combine with the properties of the oil to create multi- variant scenarios that are not conducive to predictive modeling. Standard techniques that have been developed to systematically describe oiling conditions for shorelines and riverbanks have recently been expanded to take into account situations where oil is spilled on snow- and ice-covered shorelines or riverbanks. This paper presents seven snow and ice categories as an aid to documenting and summarizing shore-zone conditions. | Abstract Reviewed - outside of scope for this project but useful for verification of behavior of oil in snow/ice and past research. - 6/26/23 - UPDATE - Re-reviewed for metric units - m3 (cubic meters) used for measurement of discharge for 1978 diesel spill in Nome, AK and a 1979 spill in Spitzbergen. Spitzbergen spill discusses 'residual oil content in the drained snow through which the oil had migrated varied between 0.6 and 2.8% by volume." "Standard Terms and Definitions for Documentation of Oiling Conditions for Snow and Ice are proposed" but relates to "snow = SNW; frozen swash = FSW; etc." No volumetric measurements proposed. References cited may be useful. |
| 8/2/22 | IOSC - Carl J. Oskins and Dee Bradley | 2005 | https://meridian.allenpress.com/iosc/article/2005/1/521/138575/EXTREME-COLD-WEATHER-OIL-SPILL-RESPONSE-TECHNIQUES | "EXTREME" COLD WEATHER OIL SPILL RESPONSE TECHNIQUES & STRATEGIES - ICE & SNOW ENVIRONMENTS | Emphasis on personnel safety and various techniques, such as slotting, to be used in extreme cold weather. Not relevant to this project. | Reviewed briefly, not useful |
| 8/2/22 | IOSC - Edward H. Owens | 2014 | https://meridian.allenpress.com/iosc/article/2014/1/1186/198373/SHORELINE-PLANNING-AND-RESPONSE-IN-ICE-DOMINATED | SHORELINE PLANNING AND RESPONSE IN ICE-DOMINATED ENVIRONMENTS | Focus is on identification of shoreline types and cleanup methodology based on shoreline/ice types; snow a "minor role" in shore-zone processes. Not relevant to this project. | Reviewed briefly, not useful |
| 8/2/22 | IOSC - Lee Majors, Fred McAdams | 2008 | https://meridian.allenpress.com/iosc/article/2008/1/689/202643/RESPONDING-TO-SPILLS-IN-AN-ARCTIC-OIL-FIELD?searchresult=1 | RESPONDING TO SPILLS IN AN ARCTIC OIL FIELD – LESSONS LEARNED | Valuable lessons learned from actual oil spill events where ACS responded. | Reviewed. Verifies several aspects of ACS Response Tactics. Personnel safety achieved at -50F (GC-2 Pipeline Spill) |
| 8/2/22 | IOSC - Jacqueline Michel, Zach Nixon and Heidi Hinkeldey | 2003 | https://meridian.allenpress.com/iosc/article/2003/1/123/198355/Use-of-In-Situ-Burning-as-an-Oil-Spill-Response | USE OF IN SITU BURNING AS AN OIL SPILL RESPONSE TOOL: FOLLOW-UP OF FOUR CASE STUDIES | Use of in-situ burning shortly after a spill (including winter conditions) shown to be a most effective means of reducing the size, extent and damage of a spill. | Reviewed. May be relevant for next research |
| 8/2/22 | IOSC- Jesse J. Ross, Nancy Kinner, Kai Ziervogel; Susan Saupe | 2021 | https://meridian.allenpress.com/iosc/article/2021/1/667006/473184/Potential-Role-of-Marine-Snow-in-the-Fate-of?searchresult=1 | Potential Role of Marine Snow in the Fate of Spilled Oil in Cook Inlet, Alaska | Refers to "Marine Snow" - the biological/sedimentary 'stuff' that 'snows' down to the seabed. From the article: "Marine snow is the phenomenon of particle aggregates sinking throughout the world's oceans." Not relevant | Reviewed abstract - Not useful |
| 8/2/22 | IOSC-Allen A. Allen, William G. Nelson | 1981 | https://meridian.allenpress.com/iosc/article/1981/1/297/138227/OIL-SPILL-COUNTERMEASURES-IN-LANDFAST-SEA-ICE?searchresult=1 | OIL SPILL COUNTERMEASURES IN LANDFAST SEA ICE | The behavior of crude oil and diesel oil in solid landfast sea ice has been examined under a variety of conditions by scientists in both the United States and the Canadian Arctic. Controlled oil releases under laboratory and actual field conditions have shown that oil spills in the landfast ice zone will tend to remain highly immobilized and achieve relatively thick concentrations. Such spills will encounter natural conditions that encourage accumulation of the oil at or near the ice surface, limit the areal extent of the oil, and help preserve certain physical and chemical characteristics that facilitate its control. A summary of these phenomena for oil in landfast sea ice reveals several important operational considerations for the development of specific Arctic countermeasure techniques. Such techniques for the containment and removal of oil in the landfast ice zone are presented, emphasizing the use of natural materials and conditions for their implementation. > Countermeasures, not recovery measurements, therefore, not relevant except possibly for snow sorptive capacity verification | Reviewed. May be relevant for next research |
| 8/2/22 | Chantal Guenette | 2017 | https://meridian.allenpress.com/iosc/article/2017/1/2017281/197836/Case-Studies-from-a-Canadian-Response-Organization?searchresult=1 | Case Studies from a Canadian Response Organization: 20 Years in Review (Poster) | Reviewed, not relevant | Reviewed briefly, not useful |

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| 8/2/22 | IOSC- William G. Nelson | 1981 | https://meridian.allenpress.com/iosc/article/1981/1/297/138227/OIL-SPILL-COUNTERMEASURES-IN-LANDFAST-SEA-ICE?searchresult=1 | OIL MIGRATION AND MODIFICATION PROCESSES IN SOLID SEA ICE | Abstract: The migration of Prudhoe Bay crude oil and diesel fuel through first year sea ice and the effect of entrained oil on sea ice growth rates were examined. Physical and chemical changes within the oils were examined during and after the entrainment process. Several crude oil and diesel fuel injections beneath solid sea ice were conducted off Prudhoe Bay during the winter of 1979/1980. Oil layers of 2.5, 15, and 30 centimeters (cm) were formed under 15, 30, and approximately 60 cm of sea ice. The sea ice growth under the injected oils was monitored. At the end of the ice growing season the individual oil injection sites were excavated from the ice. Each site was studied to determine the extent of vertical oil migration. The field results are compared to laboratory salt water ice growth experiments with entrained oil layers. The laboratory test results include oil migration as a function of ice temperature and the effect of various oil layer thicknesses upon the ice growth rates. Direct heat flux measurements are included from which the thermal conductivity of oil layers is obtained as a function of the oil layer thickness. These data illustrate the relationships among oil layer thickness, temperature gradient across the oil layer, oil viscosity, and convective motion occurring within the oil layer. Not Relevant | Reviewed briefly. May be relevant for next research or justifies snow sorptive capacities |
| 9/2/2022 & 10/7/22 | M.F. Fingas and B.P. Hollenbone | 1986 | ARLIS interlibrary Loan | Behaviour of Oil in Freezing Environments: A Literature Review | Unpublished summary of many articles that were reviewed on the topics of spreading of oil on ice and oil on snow. | Reviewed briefly. May be relevant for next research; justifies snow sorptive capacities; may be useful for expanding on or refining the spreading factor in the ARCTOS Blowout Model |
| 9/2/22 & 10/7/22 | Peter Kawamura, Donald Mackay, Michael Goral; Environmental Canada, Environmental Protection Directorate, River Road Environmental Technology Centre | 1986 | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:406245/one?qu=Spreading+of+Chemicals+on+Ice+and+Snow.&te=ILS | Spreading of Chemicals in Ice and Snow | Unpublished report of Environment Canada, Environmental Protection Department | Paper indicates over 100 pages of information (including appendices), only first 12 included. Provides documentation that enough snow sorptive capacities of snow and ice studies have most likely completed. Any additional research would be to review this and the previous article to make a definitive declaration to establish that this is indeed the case. |
| 5/9/23 | Platts S&P Global Commodity Insights | Feb-23 | https://www.spglobal.com/commodityinsights/PlattsContent/_assets/_files/en/our-methodology/methodology-specifications/europe-africa-refined-products-methodology.pdf | Specifications Guide: Europe and Africa Refined Oil Products | The following specifications guide contains the primary specifications and methodologies for Platts refined oil products assessments throughout Europe and Africa. All the assessments listed here employ Platts Assessments Methodology, as published at https://www.spglobal.com/platts/plattscontent/_assets/_files/en/our-methodology/methodology-specifications/platts-assessments-methodology-guide.pdf. | Reviewed for units to be used in the Metric version of ROSI, especially the snow-to-oil ratio, as there's some question as to whether it should be litres/metric ton, barrels per metric ton, barrels per cubic meter, etc. Primarily relates to shipping and consumption. Not conclusive for expression of the variable in question. |
| 6/21/23 | Richard A. Garrett, Thomas C. Sharkey, Martha Grabowski, William A. Wallace | Feb-17 | https://www.sciencedirect.com/science/article/abs/pii/S0377221716305604 | Dynamic resource allocation to support oil spill response planning for energy exploration in the Arctic | Abstract: A mixed-integer linear program is proposed to model the dynamic network expansion problem of improving oil spill response capabilities to support energy exploration in the Arctic. Oil spill response operations in this region can be hampered by a lack of existing infrastructure, limited pre-positioned response equipment, and the possibility that response equipment might not arrive in time to mitigate the impact of a spill because of distance and infrastructure limitations. These considerations are modeled by two inter-related constraint sets with the objective of minimized total weighted response time for a set of potential oil spill incidents. One constraint set determines how to dynamically allocate response equipment and improve the infrastructures necessary to stockpile them within a network of response sites. The other set determines how to utilize this stockpile to respond to each task necessary for an incident by scheduling the equipment to complete tasks. These task completion times are subject to deadlines which, if not met, can, instead, require costlier follow-on tasks to be scheduled. The model, its assumptions, and data requirements were assessed by subject matter experts in the United States (U.S.) Coast Guard and a major Oil Spill Response Organization in the context of oil spill response logistics to support energy exploration initiatives in the U.S. Arctic. | Paper and model focuses on response zones and depots for offshore, on water response excluding winter months: "given these considerations, and that the functional form of the solutions for summer and winter seasons were found to be similar, the driver of he model's decisions is the improvement of summer time periods." However, further examination of the model for winter response may provide some additional verification of the ACS formulae used. It is also notable that ACS was interviewed for this paper. |
| 6/22/23 | Anand V. Srinivasa, Wilbert E. Wilhelm | 17-Nov | https://www.sciencedirect.com/science/article/abs/pii/S0377221796002421 | A procedure for optimizing tactical response in oil spill clean up operations | Abstract: The Tactical Decision Problem (TDP) associated with oil spill clean up operations allocates available components to compose response systems so that the clean up requirement for each time period over the entire planning horizon is met. The objective is to minimize total response time to allow for the most effective clean up possible. The TDP is formulated as a general integer program, a problem that is difficult to solve due to its combinatorial nature. In this paper, we develop an optimization procedure that is based on an aggregation scheme and strong cutting plane methods. The solution of the resulting Aggregated Tactical Model is used in reformulating the TDP, in generating a family of facets for the TDP, and in several preprocessing methods. Computational experience in also reported in application to a realistic scenario representing the Galveston Bay Area. | Cited in Garret, et. al. (above). Abstract only reviewed. This approach may also provide further validation of the ACS formulae for future research/application. |
| 22-Jun | National Research Council | 2014 | https://nap.nationalacademies.org/download/18625 | Responding to Oil Spills in the U.S. Arctic Marine Environment | Assess the current state of science and engineering regarding oil spill response and Arctic marine environments, with emphasis on potential impacts in U.S. waters in the Bering Strait and Chukchi and Beaufort Seas. The committee was tasked to review research activities and recommend strategies to advance research and address information gaps, to identify opportunities and constraints for advancing oil spill research, to describe promising new concepts and technologies, and to assess the types of baseline information needed to monitor the impacts of an oil spill and to develop plans for recovery and restoration. | Searched document for the term "winter" and reviewed 52 instances of the term used in the report. Primary focus is on marine environment, under ice, broken ice, 'overwintering' spill responses under ice. One scenario cites the turning over of a diesel tank in winter with purported under-ice impacts. Not relevant. |
| 6/22/23 | Emergency Prevention, Preparedness and Response, a working group of the Arctic Council | Mar-15 | https://oaarchive.arctic-council.org/bitstream/handle/11374/1464/EPPR_SPILLGUIDE_Doc1_Guide_Oil_Ice_Snow_Arctic_Final_Feb_2_2015_AC_SAO_CA04.pdf?sequence=1&isAllowed=y | GUIDE TO OIL SPILL RESPONSE IN SNOW AND ICE CONDITIONS IN THE ARCTIC | "The objective of the Arctic version of the Guide is to identify and describe those aspects of planning and operations that are directly associated with a response to an Arctic oil spill in ice and snow conditions Response strategies to deal with Arctic oil spills in summer open water conditions are not considered in the Guide." The Guide provides a means to 1) plan and prepare for an incident, and 2) the implementation of response strategies. 235 pages. "One summary point deserves special attention for remote Arctic areas: the need to have a rigorous, scientifically defensible, streamlined process in place to rapidly assess the environmental trade-offs and process the necessary approvals related to the use of dispersants and in situ burning. The goal is to maximize all the available options in an emergency, including mechanical recovery, where they are appropriate and effective." | Searched document for the term "snow" and reviewed 395 instances of the term used in the report. "The Guide does not deal with strategies needed to respond to open-water spills in the Arctic summer season." Describes shore features with ice and snow and other fate and characteristics of oil in various ice and snow environments, spreading and weathering of spilled oil in snow, etc. Also reviewed scenarios/Case Studies looking for European equivalents for using ROSI tactics as examples for units to use for metric ROSI - primarily vessel scenarios/cases in broken ice. Verification of snow sorptive capacity provided. Brief discussion of mechanical recovery techniques (pages 167, 172 & 173) notes large volumes of waste, suggest in-situ burning to minimize waste; safety considerations. Also reviewed . Should be required reading for anyone reviewing OSRP's. However, little value for the ACS tactics examined for the BSEE 1142 project for ROSI development w/in scope. |
| 6/26/23 | Carl J. Oskins, DOWCAR Environmental Management, Inc. | 2004? (unclear) | https://archive.epa.gov/emergencies/docs/oil/fss/fss04/web/pdf/c_oskins_04.pdf | "Extreme" Cold Weather Oil Spill Response Course | 119 page PowerPoint (in PDF) of Cold Weather Oil Spill Response course | Reviewed for units of measurement to be used when documenting response - none found. Slotting, chainsaws, trenching techniques primarily. Not relevant for project or metric addition. Good field-hand training guide. |
| 6/26/23 | Ivar Singsaas, Mark Reed - Marine Environmental Technology, SINTEF, Norway | 2021 | https://interspill.org/wp-content/uploads/2021/11/science_spillresponse_doc.pdf | Oil Spill Response in Ice-infested and Arctic Waters - Need for Future Developments | Status of Arctic oil spill-related R&D - Weathering Processes of oil in ice, Mechanical Recovery, In-situ burning, and Modelling of oil in ice processes. | Reviewed, not relevant (broken ice/marine response methodology). No reference to units used (for metric addition) |

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| 6/28/23 | Paul D. Barrette, National Research Council, Ottawa | 2015 | http://conf.tac-atc.ca/english/annualconference/tac2015/s24/barrette.pdf | A review of guidelines on ice roads in Canada: Determination of bearing capacity | An ice road is a winter road that runs mostly on frozen water expanses. A significant number of guidelines (best practices, design codes, handbooks and manuals) currently exist for the construction, maintenance and usage of these structures. They are typically published by provincial jurisdictions, the private sector and some research organizations. They are also found in the scientific literature. These guidelines include various amount of information of different types, notably some background on the nature of the ice cover, how it should be used for transportation purposes and how to determine the maximum load it can safely sustain. For the latter, Gold's formula, or a version thereof, is almost always alluded to. Significant differences are noted in the guidelines' recommendations regarding the strength of white ice relative to clear ice, resulting in a large discrepancy in recommended maximum loads. Although white ice is mechanically weaker than clear ice, the influence of that difference on the bearing capacity has yet to be understood. New empirical data, numerical and analytical studies and physical testing are possibilities to investigate this issue. | Reviewed for discussion points with project team as to future research & future proofing of ROSI in terms of speed limits and/or warnings that need to be discussed as part of the tool. David Dickins brought up the matter. |
| 6/28/23 | D.M. Masterson | 2009 | [https://www.sciencedirect.com/science/article/abs/pii/S0165232X09000706](https://www.sciencedirect.com/science/article/abs/pii/S0165232X09000706) | State of the art of ice bearing capacity and ice construction | ABSTRACT: Ice is an effective and economical means of supporting loads for construction and resource extraction. The main requirement is to have continuous ice of sufficient thickness to support the intended loadings. Ice has been used to support heavy loads, both mobile and stationary and long-term loads such as oil and gas drilling rigs. It has been used to support the installation of offshore pipelines and related facilities. The paper describes the various uses of ice as a load-bearing medium and presents methods for determining required thicknesses.<br>The bending of floating ice under applied load causes flexural stress to be imposed on the ice cross section. Because ice is weak in tension, the critical stress is the maximum tensile stress at the bottom of the ice directly under the load. The paper presents standard methods of calculating the maximum, extreme fibre stress for different types of loads and presents an allowable stress for safe use of the ice as a load-bearing medium. This allowable stress is also instrumental in ensuring that long term, creep deformation does not result in submergence of the ice surface. The paper presents a method of estimating long-term deflection and also presents a method of assessing the effects of dynamic or moving loads.<br>Grounded ice roads require sufficient thickness to spread applied wheel loads and avoid overstressing of the tundra or seabed. A method of assessing the support provided by widely differing subgrade conditions is presented.<br>Construction methods and techniques for ice roads and structures, including the best types of equipment to use, are presented, with photographs. Issues such as snow removal vs. flooding of thick snow are discussed. Durability of the road surface and surface repairs is outlined.<br>During the construction phase of ice structures, the quality control (QC) tasks verify material quantity and material quality as required by the design. An outline of considerations for this task is presented.<br>Failures and anecdotal information related to the design, construction and use of ice roads and structures are presented, with illustrative photographs. | Online available information only reviewed (PDF requires purchase but is available in DOI library). Saved as point of discussion for future proofing. SEE REPEAT ENTRY DATED 8/14/23 |
| 6/28/23 | The Metre Convention | 1875 | [https://www.bipm.org/en/metre-convention](https://www.bipm.org/en/metre-convention) | The Metre Convention/Convention du Mètre (Bureau International des Poids et Mesures | The Convention to "assure the international unification and improvement of the metric system" and its annexed regulations (commonly known as the "Metre Convention"), was signed on 20 May 1875, and amended in 1921. It is an international treaty, the purpose of which was the creation of an international organization called the BIPM.<br><br>It is an example of the efforts made by countries in the second-half of the 19th century to establish new forms of intergovernmental cooperation. Other international organizations created during that period are the Central Commission for the Navigation of the Rhine (CCNR) in 1815, the International Telecommunications Union (ITU) in 1865, the Universal Postal Union (UPU) in 1874.<br><br>Since then, the aim of the BIPM continues to be to facilitate the standardization of measurements world-wide by enabling Member States to act together on matters related to measurement science. | Discusses the establishment of the metre and administrative policies, dues, etc. No information about the International Standard of Units (SI - Systeme Internacional d'unites) for project's purposes |
| 6/28/23 | BIPM - Bureau International de Poids et Mesures | 2019/2022 | [https://www.bipm.org/en/publications/si-brochure/](https://www.bipm.org/en/publications/si-brochure/) | The International System of Units 9th edition (2019) Brochure | Introduction: This brochure presents information on the definition and use of the International System of Units, universally known as the SI (from the French Système international d'unités), for which the General Conference on Weights and Measures (CGPM) has responsibility. In 1960 the 11th CGPM formally defined and established the SI and has subsequently revised it from time to time in response to the requirements of users and advances in science and technology. The most recent and perhaps the most significant revision of the SI since its establishment was made by the 26th CGPM (2018) and is documented in this 9th edition of the SI Brochure. The Metre Convention and its organs, the CGPM, the Comité International des Poids et Mesures (CIPM), the Bureau International des Poids et Mesures (BIPM), and the Consultative Committees are described in the text "The BIPM and the Metre Convention" on page 117. The SI is a consistent system of units for use in all aspects of life, including international trade, manufacturing, security, health and safety, protection of the environment, and in the basic science that underpins all of these. The system of quantities underlying the SI and the equations relating them are based on the present description of nature and are familiar to all scientists, technologists and engineers.<br>The definition of the SI units is established in terms of a set of seven defining constants. The complete system of units can be derived from the fixed values of these defining constants, expressed in the units of the SI. These seven defining constants are the most fundamental feature of the definition of the entire system of units. These particular constants were chosen after having been identified as being the best choice, taking into<br>account the previous definition of the SI, which was based on seven base units, and progress in science. A variety of experimental methods described by the CIPM Consultative Committees may be used to realize the definitions. Descriptions of these realizations are also referred to as<br>"mises en pratique". Realizations may be revised whenever new experiments are developed; for this reason advice on realizing the definitions is not included in this brochure but is available on the BIPM website. | "Quantities that are ratios of quantities of the same kind (for example length ratios and amount fractions) have the option of being expressed with units (m/m, mol/mol) to aid the understanding of the quantity being expressed and also allow the use of SI prefixes, if this is desirable (µm/m, nmol/mol). Quantities relating to counting do not have this option, they are just numbers.<br>The internationally recognized symbol % (per cent) may be used with the SI. When it is used, a space separates the number and the symbol %. The symbol % should be used rather than the name "per cent". In written text, however, the symbol % generally takes the meaning of "parts per hundred". Phrases such as "percentage by mass", "percentage by volume", or "percentage by amount of substance" shall not be used; the extra information<br>on the quantity should instead be conveyed in the description and symbol for the quantity." This language provides a basis, but not a clear international standard, for the units and expressions used in ROSI when discussing the oil/snow ratio. |

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| 6/28/23 | National Institute of Standards and Technology, US Department of Commerce, Office of Weights and Measures | 2023 | https://www.nist.gov/pml/owm/metric-si/si-units | SI Units | The SI rests on a foundation of seven (7) defining constants: the cesium hyperfine splitting frequency, the speed of light in vacuum, the Planck constant, the elementary charge (i.e. the charge on a proton), the Boltzmann constant, the Avogadro constant, and the luminous efficacy of a specified monochromatic source. NIST provides values and a searchable bibliography for the fundamental physical constants. Definitions of all seven (7) SI base units are expressed using an explicit-constant formulation and experimentally realized using a specific mises en pratique<br><br>(practical technique).<br><br>The seven SI base units, which are comprised of:<br><br>Length - meter (m)<br>Time - second (s)<br>Amount of substance - mole (mole)<br>Electric current - ampere (A)<br>Temperature - kelvin (K)<br>Luminous intensity - candela (cd)<br>Mass - kilogram (kg) | Volume measurement for purposes of the metric addition (oil/snow ratio) not useful for metric tonnes (amount of a substance in moles; mass in kg (references that 1000 kg = 1 megagram or 1 metric ton). Additionally, uses American spellings for "meter"). |
| 6/28/23 | E.H. Owens; D.F. Dickins; L.B. Solsberg; O-K Bjerkemo | 2017 | https://meridian.allenpress.com/iosc/article/2017/1/1182/197875/NEW-IMO-EPPR-GUIDES-TO-ARCTIC-OIL-SPILL-RESPONSE?searchresult=1#10487446 | NEW IMO/EPPR GUIDES TO ARCTIC OIL SPILL RESPONSE – STRATEGIC AND OPERATIONAL | ABSTRACT<br><br>In 2015 and 2016, two complementary projects produced both a new strategic guide (in two versions) and an updated operationally oriented guide to assist managers, regulators and responders in responding effectively to oil spills in snow and ice conditions. The objective of the first initiative, which began as a Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) project, a "Guide to Oil Spill Response in Snow and Ice Conditions", was to identify and describe the strategic aspects of planning and operations. This program gained a separate phase through the Emergency Prevention, Preparedness and Response (EPPR) working group of the Arctic Council to adapt the Guide specifically for Arctic waters. The second initiative by EPPR was to update the 1998 "Field Guide for Oil Spill Response in Arctic Waters" while retaining the original operational focus. The 2016 version of the Field Guide incorporates major revisions and updates to sections on strategies and countermeasures, for example the use of herders and burning, dispersants in ice and specialized brush skimmers as well as advances in remote sensing and tracking. In addition, new sections address important topics such as Health and Human Safety, Logistics and Wildlife Response.<br><br>The overall goal was to produce two complementary documents that provide a broad base of essential information to key decision-makers and responders at both the strategic planning level and at the field tactics and operations level.<br><br>These two projects bring together a wide range of new knowledge generated over the past two decades that make many previous manuals and documents out of date. With such a vast amount of recent literature, the new strategic guide and the operational field guide update can only provide a brief summary of the new material but are valuable tools to indicate where the more detailed documents can be found. | Reviewed - not useful for metric units |
| 6/28/23 | E.H. Owens; D.F. Dickins; G.A. Sergy | 2005 | https://meridian.allenpress.com/iosc/article/2005/1/513/138538/THE-BEHAVIOR-AND-DOCUMENTATION-OF-OIL-SPILLED-ON | THE BEHAVIOR AND DOCUMENTATION OF OIL SPILLED ON SNOW- AND ICE-COVERED SHORELINES. | ABSTRACT<br><br>The efficient and effective cleanup of oiled snow and ice on shorelines or riverbanks requires an understanding of the likely behavior and fate of the oil. Depending on the snow conditions, oil may remain at or near the surface or drain through the snow or into ice cracks. Much of the oil is often hidden from view. The basic principles of snow and ice and oil behavior are relatively well understood. Equations and models are available to estimate rates of infiltration, spreading, migration, or evaporation for oil in snow. There is, however, limited understanding of the mechanics of oil behaviour or transport pathways in snow. Little knowledge exists regarding how oil migrates through a non-uniform snow cover. As a consequence, it is difficult to estimate where the oil might accumulate, a critical question for responders. The few observations published from spills or field experiments indicate that oil transport and migration mechanisms are likely to be complex, particularly if the structure of the snow is not uniform. Snow thickness, snow surface topography, terrain slope, and the presence of ice layers combine with the properties of the oil to create multi-variant scenarios that are not conducive to predictive modeling. Standard techniques that have been developed to systematically describe oiling conditions for shorelines and riverbanks have recently been expanded to take into account situations where oil is spilled on snow- and ice-covered shorelines or riverbanks. This paper presents seven snow and ice categories as an aid to documenting and summarizing shore-zone conditions. | Article not available; based on abstract researcher deemed this document as more relevant to SCAT methodology and not likely to contain the snow/oil ratio expression sought for the metric addition. |
| 6/28/23 | International Standards Organization (ISO) | 2020 | https://www.onlinestandardssearch.com/iso-161652020-pdf-download.html | Ships and marine technology — Marine environment protection — Vocabulary relating to oil spill response | ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.<br>The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives). | Primarily relates to liquids (oil, water, seawater, recovery rates of skimmers, encounter rates, among others), with cubic metres is the preferred unit for volumes of liquids. Expression of volume for bulk material recovered in need of disposal not found. |
| 7/13/23 | David G. Wilson, Donald Mackay, University of Toronto, Toronto, Ontario | 1987 | ARLIS | The Behaviour of Oil in Freezing Situations | (Abstract - brief: An experimental study of the behaviour of an oil spill in a developing (Grease) ice field is described. It was found that significant quantities of oil may be entrained within and beneath a grease ice field.... | Oil quantities are described in metric terms for depth (cm), density differences - specific gravity, ppm, percentages, entrainment, spreading. An apparatus was constructed that could agitate a mixture of oils and grease ice/water, and graduated beakers were also used and measured in mL. Droplets were measured in mm. Oil/water mixtures were measured in ration, e.g., 70/30. A 1985 oil spill in the Gulf of St. Lawrence River includes measurements from shore (to compare ice variations) was done in metres. Not useful for initial scope or metric conversion phase. |

| Date | Source | Date2 | Website/Source | Document | Summary | Purpose/Use |
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| 7/13/23 | Emergency Prevention, Preparedness and Response, a Program of the Arctic Council | 1998 | ARLIS | EPPR Field Guide 1998 | Field guide Oil Spill Response in Arctic Waters | Examine for metric measure of recovered oil/water/ice - no discussion of temporary storage or disposal. Tidal range discussed in metres. |
| 7/13/23 | Edward H. Owens, Polaris Applied Sciences, Inc.; Gary A. Sergy, Environment Canada | 2004 | ARLIS | The Arctic SCAT Manual | A Field Guide to the Documentation of Oiled Shorelines in Arctic Regions | Conversion table most useful for "1 barrel = 0.16 (cubic) metres, and, 1 cubic metre = 6.289 barrel" - spelling of litres, metres, kilometre, etc. Superscript is used for cubics - metre3. Method for estimating volumes of oil on a shoreline not found - discussed in percentages. Some case studies provided, not useful. References reviewed for potential other sources - none noted. 3.3.5 Oil on Peat Shorelines notes that "Dry peat can hold large amounts of oil, 1 to 5 kg oil/per kg of dry peat."3.2.1 Snow discusses the specific gravity of fresh snow, granular snow and hard-packed snow, but no discussion of oil carrying capacity of snow. Also see "The development of the SCAT process for the Assessment of oiled shorelines", 2003, Owens and Sergy. |
| 7/13/23 | Edward H. Owens, Polaris Applied Sciences, Inc.; Gary A. Sergy, Environment Canada | 2003 | ARLIS | The development of the SCAT process for the Assessment of oiled shorelines | Discusses the development of the Shoreline Cleanup Assessment Team process | 2.7 includes how the SCAT data can be used to inform the Waste Management Unit "to determine what and how much waste will be generated at each site." and 2.9 how "a waste management system to deal with the materials generated by the work effort" |
| 7/13/23 | M.F. Fingas and C.E. Brown | 2002 | ARLIS | Detection of Oil in and Under Ice, Proceedings of the Twenty -fifth Arctic and Marine Oilspill Program (AMOP) Technical Seminar | Detection technologies for application to oil spills in the Arctic environment, specifically for detecting oil in, with or under ice, are assessed.... | Reviewed - not useful for metric units |
| 7/13/23 | D. Mackay, M.E. Charles and C.R. Phillips, Dept. of Chemical Engineering and Applied Chemistry, University of Toronto | 1974 | ARLIS | Crude Oil Spills on Northern Terrain | Report describes the initial field, laboratory and theoretical studies of the physical aspects of crude oil spill on the terrain of the Mackenzie Valley. Etc. | Section 9.1 discusses the current state of knowledge on oil/snow absorption. 9.2 summarizes study topics and gives oil spill volumes in gallons. 9.3 discusses Laboratory Studies on Oil Flow into Snow, and the Results and Discussion section discusses the rate of flow in cm/min, and the volume of 100 cm3 of snow with a comparison of the cm3 of air (every 100 cm3 of snow 60cm3 is occupied by ice crystals and 40 cm3 of air. After oil contamination about 23 to 30 cm3 of the air is displaced by oil. "The final mixture is thus, by volume, 60% ice, 23-30% oil and 17-10 % air. About 58 to 75% of the original air space is occupied by oil.") cm3 uses superscript. Other experiments are described using cm and cm3. Section 9.4 describes a Beare Road, Ontario, experimental spill that was conducted with volumes expressed in gallons and square feet, and depths in inches. Table 9.1 describes ground flow distance, ground area contaminated, snow volume contaminated and snow contaminated by ground flow as follows: m, m2, m3 and m3, using superscript where needed. Dimension of the melt hold described in m2 and volume by m3, also using superscript. 9.5.2.1 intersperses the use of cm3, m3, gallons. Useful for metric version of expression of volume of oil |
| 7/17/23 | European Commission, Directorate General XI; Environment, Nuclear Safety and Civil Protection, Belgium | 1998 | ARLIS | "POLSCALE" A Guide, Reference System and Scale for Quantifying and Assessing Coastal Pollution and Clean-up Operations in Oil-polluted Coastal Zones | Standardization of shoreline oiling severity is proposed for global use after the Amoco Cadiz incident. Dovetails with Shoreline Cleanup Assessment Technique (SCAT) development. | Standard units for estimating amount/volume of oil not addressed in sufficient detail for ROSI metric addition. |
| 7/27/23 | Kenneth Finkelstein & Erich R. Gundlach | 1981 | ARLIS - Environmental Science & Technology (American Chemical Society) | Method for estimating spilled oil quantity on the shoreline | A new, accurate method is used to calculate an oil budget for the volume of oil which came ashore during the Amoco Cadiz oil spill. | Oil per km (e.g., oil tonnage per kilometer (34.6 for heavy coverage and 4.1/km for light coverage) was determined (page 547). Table 3 uses metric tons/km. Spill volume of 233,000 metric tons for the Amoco Cadiz. Not particularly useful for ROSI metric units. |
| 8/14/23 | D.M. Masterson | 2009 | DOI Library acquisition | State of the art of ice bearing capacity and ice construction | Ice is an effective and economical means of supporting loads for construction and resource extraction. The main requirement is to have continuous ice of sufficient thickness to support the intended loadings. Ice has been used to support heavy loads, both mobile and stationary and long-term loads such as oil and gas drilling rigs. It has been used to support the installation of offshore pipelines and related facilities. The paper describes the various uses of ice as a load-bearing medium and presents methods for determining required thicknesses.<br>The bending of floating ice under applied load causes flexural stress to be imposed on the ice cross section. Because ice is weak in tension, the critical stress is the maximum tensile stress at the bottom of the ice directly under the load. The paper presents standard methods of calculating the maximum, extreme fibre stress for different types of loads and presents an allowable stress for safe use of the ice as a load-bearing medium. This allowable stress is also instrumental in ensuring that long term, creep deformation does not result in submergence of the ice surface. The paper presents a method of estimating long-term deflection and also presents a method of assessing the effects of dynamic or moving loads.<br>Grounded ice roads require sufficient thickness to spread applied wheel loads and avoid overstressing of the tundra or seabed. A method of assessing the support provided by widely differing subgrade conditions is<br>presented. Construction methods and techniques for ice roads and structures, including the best types of equipment to use, are presented, with photographs. Issues such as snow removal vs. flooding of thick snow are discussed. Durability of the road surface and surface repairs is outlined.<br>During the construction phase of ice structures, the quality control (QC) tasks verify material quantity and material quality as required by the design. An outline of considerations for this task is presented. Failures and<br>anecdotal information related to the design, construction and use of ice roads and structures are presented, with illustrative photographs. | This paper, it's citations, and other research could be considered for future proofing/research to steer ROSI towards a more operational aspect of planning to account for speed limits and engineering requirements of floating vs. grounded ice roads that may be built to as cited in the operational considerations mentioned in the tactics used in the development of ROSI. However, since ROSI is a PLANNING tool, and since a considerable amount of information would be needed from the field during an actual spill response (e.g., water depth, ice thickness, distances to shorefast ice zones, weight of vehicles), creation of a program to take all of the engineering factors into account to construct an ice road is outside the planning scope of this project, represents potential liabilities, and, since ice roads are constructed annually by various engineering firms for various reasons, this type of program may already exist. |
| 8/23/23 | E.H. Owens; E. Taylor; K. O'Connell; C. Smith | 2009 | https://www.osti.gov/etdeweb/biblio/21212551 | Waste management guidelines for remote (Arctic) regions (AMOP 2009) (Environment Canada, Arctic Council EPPR Working Group, Government of Norway, Government of the United States are listed as sponsoring organizations) | Abstract<br>Oil spill response operations in Arctic regions involve well planned logistics support due to the remoteness and lack of infrastructure in most locations. The waste material generated by oil spill response field activities must be managed, recycled or disposed. In remote areas, in-situ shoreline treatment options are preferred since they require minimal manpower and generate very little waste. The Emergency Prevention, Preparation and Response Working Group of the Arctic Council has developed guidelines and strategies for oil spill waste management in Arctic regions. In addition, a waste management calculator software program was developed to provide a planning framework to illustrate the potential consequences of different options for different shore types and oil types. Potential shoreline treatment waste generation volumes and waste types can then be identified. The planning tool identifies the preferred shoreline treatment options, estimates the amount of waste that would be generated and identifies the amount and per cent of the types of waste that are associated with each treatment option. A review of 11 case studies has shown that there is no correlation between the volumes of waste generated by shoreline treatment response activities and the original volume of spilled oil. Rather, the volume of waste generated during a response operation is a function of the nature of the spill, location, and length of oiled shoreline, combined with decisions made by the spill management team and the selected treatment methods. 10 refs., 4 tabs., 4 figs. | 11 case studies cited: Reviewed in detail for metric units and applicability - m3 used to measure waste per m2. While "Arctic" is included in the title, and "a spill on solid ice in which a response is required or appropriate, the key strategy decision in terms of waste generation is whether to (i) mechanically contain and recover the oil or (ii) burn the oil." is mentioned as a consideration for the spill management team, no case studies of spills on solid ice are provided. The cases studied (all tanker (10) or motor vessels (1) were: Amoco Cadiz (1976), Haven (1991), Braer (1993), Sea Empress (1996), Katina-P (1992), Prestige (2002), Metula (1974), Exxon Valdez (1989), Erika (1999), Aragon (1989), and Seledang Ayu (2004/5) with the amount of waste generated vs. the amount spilled are spills compared (note: most waste was oiled sediments and/or personal protective equipment and/or sorbents).<br><br>The creation and introduction of "The Waste Management Calculator" for estimating the amount of material (fairly accurately based on the numbers compared) is presented. A search on the EPPR website and elsewhere via: Duck Duck Go, the ADEC Contingency Plan Tools website (https://dec.alaska.gov/spar/ppr/contingency-plans/response-plans/tools/) , a Google Scholar search, a search of the EPPR website, and a Google search was not able to find the calculator – it is last mentioned in a 2011 report to the Arctic Council. EPPR was contacted via email using the addresses on their "Contact" page and we await their response. Even though this calculator would not be interchangeable with the ROSI calculator, a comparison should be made to be thorough in the research. |

| Date | Source | Date2 | Website/Source | Document | Summary | Purpose/Use |
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| 8/28/23 | Plaris Applied Sciences Inc and The Oil Spill Training Company Ltd | 2008 | Archived acquisition from EPPR (Arctic Council) Also see line, above, regarding Waste Management Guidlenies for remote (Arctic) regions. Owens, Talor, O'Connell, Smith. 2009. | Waste Management Calculator and User's Guide | Introduction: The Waste Management Calculator is an interactive, graphic-oriented computer tool for use by non-technical (or technical) managers, decision makers, and planners. This tool can be used to evaluate response options with regards to the types and approximate volumes of wastes that potentially would be generated by different response techniques and different treatment endpoint standards. The tool was developed jointly by Polaris Applied Sciences, Inc. and The Oil Spill Training Company Ltd, for the Emergency Prevention, Preparedness and Response (EPPR) Working Group of the Arctic Council under the direction of the Joint Secretariat (Inuvialuit Settlement Region), with support from the Governments of Canada, Norway and the United States. | This guide and calculator were last mentioned in 2011 report to the Arctic Council and had to be retrieved by special request from the archives. It was 'lost' when they changed to another web system/host (Ole. Kristian Bjerkemo, EPPR Chair, email, 2023-08-25). The guide and calculator address primarily beach characterization (Substrate) using SCAT techniques to estimate the amount of material that should be planned for removing material from shorelines. Other limitations include an assumed 1m depth of removal for oiled snow shorelines (no basis given in the User's Guide) and a presumption of width (e.g., 0.5m-3m for Medium) oiled shorelines, among other limitations that are less customizable than ROSI to meet the purpose of the BSEE Request for Proposals. The platform also only works in Windows (Windows 10 for the version tested) via an .exe file installation so is not web based/less versatile. Volumes given in m3 verifies ROSI bulk volume metric volume choice. Oil distribution given in percent and thickness in cm. Examined late in the project for completeness. |

| Search Engine Used | Source and Terms Used | Notes/Comments |
|---|---|---|
| Duck Duck Go | | |
| | https://www.uscg.mil/Resources/Library/ › National Marine Biological Library catalog | https://nmbl.org/ |
| | Catalogue - Canada.ca | |
| | Heavy equipment | |
| | Heavy equipment rating | |
| | oil spill ice | |
| | oil spill snow ice | |
| | oil spill recovery snow ice | |
| | oil spill recovery ice snow | |
| | International Oil Spill Conference Proceedings | |
| | standard documentation units for spill response in snow and ice | |
| | metric documentation units for spill response in snow and ice | |
| | ice road pressure wave speed limit | |
| | oily waste calculator | |
| Alaska Resoursce Library and Information Services (ARLIS) Catalog | https://jlc-web.uaa.alaska.edu/client/en_US/arlis/search/ | |
| | capacity snow oil | |
| | sorptive capacity snow | (note: No results found) |
| | oil spill ice | |
| | oil spill ice snow | |
| | Task Force on Oil Spill Preparedness technical report | |
| Heavy Equipment Forums | https://www.heavyequipmentforums.com/ | |
| International Oil Spill Conference (IOSC) Proceedings | https://meridian.allenpress.com/iosc | |
| | oil on snow | |
| Google Scholar | european oil spill cleanup case studies in snow | |
| | european land-based oil spill cleanup case studies in snow | |
| National Academy of Science | https://www.nationalacademies.org/home | |
| | oil spill in snow | (note: Few relevant publications found; those reviewed are cited) |
| | oil spill tactics in snow | |
| | oil spill response in snow | |
| | oil spill tactics snow | |

| Search Engine Used | Source and Terms Used | Notes/Comments |
| --- | --- | --- |
| ARLIS | https://www.arlis.org/<br>oil spill ice<br>oil spill ice snow<br>sorptive capacity snow<br>Task Force on Oil Spill Preparedness Technical Report<br>Capacity snow oil | |
| TRB Publications Index | https://pubsindex.trb.org/<br>Snow removal<br>oiled snow removal | |

# Appendix C:  Interview Questions and Summaries

Note for interviewees: The following questions will cover some considerably basic operational items. This is intended to capture any information that may be desirable for providing a solid low-level foundation for anyone not already familiar with the use of yellow iron within 3 tactics from the Alaska Clean Seas Tactics Manual:  R-1 Mechanical Recovery of Lightly Oiled Snow, R-3 Recovery of Oil-Saturated Snow, R-5 Recovery of Embedded Oil (ice only), and R-29 Ice Mining. Our focus is on the use of yellow iron equipment as depicted in these tactics; the interview questions will reflect this focus. For this purpose, yellow iron equipment includes front-end loaders, dump trucks, bobcats, ice miners, and roto trimmers.

## C.1 SUMMARY OF TACTICS (SELECTED INFORMATION FROM THE TACTICS AS PRESENTED IN THE ACS TACTICS MANUAL)

### C.1.1 Common Planning Considerations for R-1, R-3, R-5, and R-29

- A front-end loader with an 8-cubic-yd snow bucket can move 500 cubic yd of snow in an hour and fill a dump truck in 10 minutes.
- Because the front-end loaders fill dump trucks as fast as they pull into position, dump trucks are the bottleneck.
- Dump Truck Recovery Rate = Tc / (Lt + Tt + Ut)
  - Where:
    - Tc = Truck Capacity
    - Lt = Load Time (10 min or 0.17 hr)
    - Ut = Unload Time (5 min or 0.08 hr)
    - Tt = Travel Time ((miles to disposal * 2)/ 35 mph)
  - The ratio of dump trucks to loaders to fill trucks without delay = 1 / (0.17 hr + 0.114 hr + 0.08 hr) = 1 / (0.364) = 2.7 trucks per loader.
- This tactic is limited to oiled snow with no free liquids.

### C.1.2 R-1 Mechanical Recovery of Lightly Oiled Snow

- **Description**:  A wide-track dozer and front-end loader pile the snow, and then a loader loads it into dump trucks on nearby gravel pads, roads, or ice roads. After a loader has filled a truck, the truck hauls the oiled snow off for disposal. A Bobcat would replace the front-end loader in hard-to-reach or tight quarters.
- **Capacities for Planning**:
  - One cubic yard of lightly oiled snow contains 0.3 bbl of oil.
- **Deployment Considerations and Limitations:**
  - Collect the top six inches of snow into piles for recovery. If snow cover is light or the snow will be used for blending, collect all the snow.

### C.1.3 R-3 Recovery of Oil-Saturated Snow

- **Description**: Access the oiled snow with dozers and loaders, pile the snow with the dozers, and then load it into dump trucks located on nearby gravel pads, roads, or ice roads. After a front-end loader has filled a truck, the truck hauls the oiled snow off for disposal.
- **Capacities for Planning**:
  - One cubic yard of oil-saturated snow contains up to 2.4 bbl of oil.

### C.1.4 R-5 (Ice Only)

- **Note:** This tactic is only being considered for its use on ice for this project; the references to frozen or oiled gravel are being ignored at this time.
- **Description**: A trimmer is used to recover oil embedded in the surface of a frozen pad or ice. A trimmer uses a rotary blade system to chop and collect the surface material at varying depths. The worked-over material is collected with a front-end loader and transferred to a dump truck.

### C.1.5 R-29 Ice Mining

- **Description:** During the winter, ice rubble piles can form at shorelines and manmade structures in the Beaufort Sea. Oil entrained in these piles can be accessed by removing the oiled ice with an ice-miner that grinds up the ice and deposits it in a pile that can be picked up with a front-end loader and hauled away by dump truck.
- **Capacities for Planning**:
  - Capacity of ice miner: 1,400 cubic yd per hour for sea ice, 1,420 cubic yd per hour for freshwater ice.

## C.2 QUESTIONS

### C.2.1 Equipment

- What specific yellow iron equipment is used for Tactics R-1, -3, -29 and R-5 (Ice Only), as in makes and models?
  - The tactics generally list front-end loaders, dump trucks (various capacities of 10, 20 and 25 cubic yard capacities), bobcats, ice miners, roto trimmers.
    - Is there alternative equipment that may be brought in and used to accomplish the same tasks?
- What entities provide the equipment? (Who owns it?)
  - Are there alternate entities that could be asked to provide additional equipment?

### C.2.2 Capacities

- What are the actual capacities of the equipment – advertised versus as used?
  - How does actual usable capacity change based on snow conditions or the content of oil in the snow?

### C.2.3 Operational Speed

- What is the speed of operation – how long does it take to complete each portion of the tactics R-1, -3, -29?
    - What factors might affect the speed of a given task?
    - The tactics state that a dump truck can be filled by a front-end loader in 10 minutes. What factors apply to this statement?
        - What capacity dump truck is considered (there are references to dump truck with capacities of 10, 20, and 25 cubic yards)?
        - What capacity front-end loader bucket is considered?
        - What effect does the oil content of the snow have on timing?
    - Does the unloading time of a dump truck vary significantly depending on the volume of the truck? The oil content of the load?
    - Are the buckets of front-end loaders a standard size?
        - If not, what is the typical range?
        - What's the typical bucket fill percentage used for differences in oil content of the snow?
        - Does the bucket size make a significant difference in the time required to load a truck?
            - If so, is this incorporated into the loading calculations (e.g., as an average time)?

### C.2.4 Training

- Does the experience of an operator significantly affect the loading time?
    - What kind of training do operators usually receive?
    - Is any of the training specific to the movement of oil-soaked snow?
            - If so, how does that ultimately affect recovery calculations? (i.e., are specially trained operators significantly faster?)

### C.2.5 Tactic Review Process

- How are the tactics R-1, -3, -5, -29 reviewed and updated in the Tactics Manual?
    - Is there a standard process for reviewing and updating these tactics?
        - What is that process?
            - Who is involved?
    - Have the formulas for those tactics been updated or changed since the original development?
    - Have the formulas been compared to the actual use of the equipment, whether through field testing or actual response work?
    - How do differences in snow texture/dryness/wetness/etc. affect actual performance compared to the formulas? Has this been quantified and tested?
    - How do differences in the oil content in the snow affect actual performance compared to the formulas?
    - Have technological advances in the loading equipment made any significant difference in the time calculations?

  - Are there any recent spills that this equipment has been used on that helps verify the formulas in the tactics?
- Tactic R-1 states "One cubic yard of lightly oiled snow contains 0.3 bbl of oil." Tactic R-3 states "One cubic yard of oil-saturated snow contains up to 2.4 bbl of oil." How was this determined?
  - What factors can affect this volume?
  - Do various types of snow (fresh/old/dry/wet/wind compacted/machine compacted (e.g., snow roads), etc.) hold significantly different volumes of oil?
  - Does mixing heavily oiled snow with lightly oiled snow significantly change the volume of oil in the snow?
  - What is the difference between lightly and heavily oiled snow? Who makes that determination?

### C.2.6 Miscellaneous

- Does ACS review scenarios in oil spill response plans to confirm the tactics are used appropriately? Do plan writers request a review of the scenarios prior to public review?
- Do you think these formulas have held up against time/are they still valid?
- Are there any publications or studies that we should look at or people that we should talk to?
- Are there any other questions that you think I should be asking?
- Is there any additional information that would be helpful for this project?

## C.3 INTRODUCTION AND PURPOSE OF INTERVIEWS

Step 1:  CALL recipients and let them know the email will follow so they don't think it's spam.

Step 2:  Introductory email with attached questions.

Dear [NAME]:

You have been selected for an interview as part of the development of the Bureau of Safety and Environmental Enforcement's (BSEE) Oil Spills in Snow and Ice Calculator Tool (calculator) based on your expertise and prior involvement in developing the tactics in the Alaska Clean Seas (ACS) Technical Manual (TM).

The calculator is envisioned to be a planning tool to help plan holders assess their ""yellow ironiron" equipment needs and response capabilities for recovering oil in snow and on solid ice. The tool will focus specifically on tactics that involve the use of yellow iron, i.e., ACS tactics R-1, R-3, R-5 (ice only), and R-29, and will use the formulas listed in the ACS TM. This tool will be made available on the BSEE website for use by the public.

As part of our research, we would like to understand better how the formulas in the ACS TM were developed, whether any additional research has been done that you may be aware of to verify or update the formulas, and to determine if there may be additional research that should be conducted to reassess and potentially update the formulas. Any recommendations that develop through these interviews and a literature review will be included in a final project report submitted to the BSEE OSPD Response Research Branch. Any future research would be conducted under a separate effort.

Your voluntary participation in the interview process would be greatly appreciated. You will be acknowledged for your support and contribution to the project in project presentations and the final report unless you wish to remain anonymous. Your preference will be respected.

We have attached a copy of the questions we will be asking you during the interview. We anticipate the interview will take no more than one hour of your time. Any additional information relevant to this project that you might want to add would, of course, be greatly appreciated.

Please let us know if you are familiar with the tactics and can provide information to support our research, and the time(s) that would be best to contact you via telephone, Microsoft Teams, Zoom, or, in person. We would like to interview you prior to April 30, 2022, if possible.

If you have suggestions of other experts who we should interview, please let us know. Contact information if available would also be helpful.

# C.4 INTERVIEW HIGHLIGHTS

## C.4.1 Alaska Clean Seas, Written Responses, June 14, 2022

### C.4.1.1 Equipment

- What specific 'yellow iron' equipment is used for Tactics R-1, -3, -29 and R-5 (Ice Only), as in makes and models?
  *There are no specific makes and models associated with the tactics. The equipment comprises primarily heavy construction equipment pieces which all function basically the same. They are more often categorized by size or capacity rather than make and model.*
    - The tactics generally list front-end loaders, dump trucks (various capacities of 10, 20 and 25 cubic yard capacities), bobcats, ice miners, roto trimmers.
        - Is there alternative equipment that may be brought in and used to accomplish the same tasks?
          *Possibly, however alternative equipment items would most likely be size or capacity varieties of the same basic type of equipment. An example of this would be a low-profile mining loader may be able to pass underneath pipelines to access an area that a standard loader could not fit. This would remove the need to consider moving a loader over live pipelines with a crane. In that case the capacity of the loader may be the same (or similar) but the capability would be uniquely suited to that situation.*
- What entities provide the equipment? (Who owns it?)
  *The equipment is owned by a variety of companies on the North Slope: ACS, the Member Companies, contract construction and oil field support companies in Deadhorse, and some companies outside of the local area are included in the Technical Manual. Tactic L-6 Table 10 lists equipment inventory by contractor.*
    - Are there alternate entities that could be asked to provide additional equipment?
      *Possibly yes, however the Member Companies often have long-standing contracts with local oilfield support companies and a more streamlined ordering process. It is also possible that an existing equipment contracting company may subcontract additional equipment from another vendor rather than turn down a request for an item it did not have. The Member Company requestor may not actually know or be able to specify which subcontractor supplies the equipment.*

### C.4.1.2 Capacities

- What are the actual capacities of the equipment – advertised versus as used?
  *While there may be variability based on unique conditions, the "advertised" and "actual" capacities should be viewed as the same. A three-yard bucket will hold three yards. The exact volume in each load may depend on many things, including the material's type, composition, grain size and weight, degree of oiling, liquid content, the terrain and surface conditions over which the loader must travel, the presence of any obstacles, flow lines, structures, sensitive areas, the operator's experience and comfort with the equipment, the weather, daylight and time of day.*

- How does actual usable capacity change based on snow conditions or the content of oil in the snow?
  *The snow conditions may affect how much sticks in the bucket when it is dumped into the dump truck or dump box. The operator may tilt the bucket rapidly or against its stops in an effort to knock loose any snow stuck in the bucket. If that doesn't work, a person can shovel the bucket clear of the stuck snow. Similarly, having more oil content in the snow does not change the bucket's capacity; three yards is still three yards. It would likely result in a greater amount of oil recovered per bucket, and may also result in snow sticking in the bucket until the operator knocked it loose. It could also end up recovering more snow, as the snow may be heaping and stick beyond the edges of the bucket.*

### C.4.1.3 Operational Speed

- What is the speed of operation – how long does it take to complete each portion of the tactics R-1, -3, -29?
  *This depends on many variables. The figures presented in these tactics are provided as reasonable planning standards. Conditions such as the size and location of the spilled oil, presence of obstacles, structures, flow lines, wildlife and sensitive areas, depth and amount of snow, snow topography, weather conditions, and proximity of simultaneous operations would all affect the speed of accomplishing the tactics.*
  - What factors might affect the speed of a given task?
    *As stated above, conditions such as the size and location of the spilled oil, presence of obstacles, structures, flow lines, wildlife and sensitive areas, depth and amount of snow, temperature and weather conditions, and proximity of simultaneous operations would all affect the speed of accomplishing the tactics. Any of these variable conditions (or many at once) may occur during a cleanup. Qualified operators would focus on safety and effectiveness rather than speed.*
  - The tactics state that a dump truck can be filled by a front-end loader in 10 minutes. What factors apply to this statement?
    - What capacity dump truck is considered (there are references to dump truck with capacities of 10, 20, and 25 cubic yards)?
      *The example in Technical Manual Tactic R-1 (page 2 of 2) is a 20-yard dump truck. The majority of dump trucks listed in the current L-6 Table 10A have a 25 yard capacity. 20 yards was used as a reasonable estimate (differing by less than one bucket).*
    - What capacity front-end loader bucket is considered?
      *The tactic states that an 8-yard snow bucket is used in the example.*
    - What effect does the oil content of the snow have on timing?
      *Oil content and the depth of penetration may affect timing if the operator is unable to load the bucket as fully with each pass. For example, a lightly oiled area of snow with low penetration and*

*absorption may result in smaller amounts of recovered snow per bucket.*

- Does the unloading time of a dump truck vary significantly depending on the volume of the truck? The oil content of the load?

  *The unloading time of the dump truck does not vary significantly with these variables. However, snow that sticks in the bottom of the dump bed may take slightly more time to remove if the operator must shake it loose or get it shoveled out. Unload time may also be a factor of access to the disposal site and the size and style of dump truck.*

- Are the buckets of front-end loaders a standard size?

  *Multiple standard sizes.*

  - If not, what is the typical range?

    *Buckets ranging from 3, 4, 4.5, 5, 6, 7, and 8 yard capacity are available for wheeled loaders; 7 and 8 yard buckets are most common snow buckets. Skidsteer/Bobcat-style snow and light material buckets are 1.5 to 2.0 cubic yard capacity.*

  - What's the typical bucket fill percentage used for differences in oil content of the snow?

    *The operator will attempt to fill each bucket load. The oil content does not determine fill percentage.*

  - Does the bucket size make a significant difference in the time required to load a truck?

    *A larger bucket will fill the truck faster than a smaller one. Each situation is different, however, and the operator may encounter more or less oiled snow to recover in different areas of the spill. They may also need to switch to smaller buckets or skid steer loaders in more confined areas.*

    - If so, is this incorporated into the loading calculations (e.g., as an average time)?

      *No, the loading examples are based on an 8-yard bucket and 20-yard dump truck.*

### C.4.1.4 Training

- Does the experience of an operator significantly affect the loading time?

  *With any piece of equipment, the experience of the operator with both the equipment and the assignment may affect the results. All operators will be qualified by their respective company before operating the equipment.*

  - What kind of training do operators usually receive?

    *Contract companies will have unique training and qualification programs to qualify their operators. At ACS, we have three levels of training, organized into three separate Proficiency Checks (PCs), which are our standard method of instruction on equipment and procedures. Loader PCs* *must be completed on each make and model prior to a person operating the specific equipment:*

- *Level 1 Awareness Level PC – This course includes an overview of the equipment, performing the safety assessment prior to its operation; performing the pre start-up inspection and procedures, start-up procedures; performance of basic vehicle operations; the removal/attachment of forks and/or bucket; and performing the shutdown procedures.*
- *Level 2 Operator Level PC – This course is used to approve personnel for the operation of the specific loader without supervision. The PC includes successfully completing an ACS-accepted classroom and practical training course. Upon completion, a qualifier approves the individual to operate the identified equipment without supervision.*
- *Level 3 Instructor/Qualifier Level PC – This course is used to develop personnel capable of instructing the operation of the specific loader. Prerequisites include completion of the Level 1 and Level 2 PCs on the specific model of loader and maintained annual qualification as a competent operator. Additionally, they must have successfully instructed a minimum of one class with another qualifier. Finally, the Level 3 applicant must be approved by manager/supervisor to instruct courses unsupervised.*

- Is any of the training specific to the movement of oil-soaked snow?

  *No.*

  - If so, how does that ultimately affect recovery calculations? (i.e., are specially trained operators significantly faster?)

    *Not applicable.*

#### C.4.1.5 Tactic Review Process

- How are the tactics R-1, -3, -5, -29 reviewed and updated in the Tactics Manual?
  - Is there a standard process for reviewing and updating these tactics?
    - What is that process?
      - *The Technical Manual is reviewed annually, and updates made as needed. The Planning & Development Managers keep a running record of corrections, changes, suggestions for improvements throughout the year and make updates including adding new tactics. These are typically processed by the fourth quarter and printed and distributed by the end of the year.*
      - *When assessing the need for updates and additions, every effort is made to keep the tactics detailed enough to be relevant and*

*meaningful without over-characterizing subtly different tactics with too many specific variants.*

- *Following a spill or exercise, any new information, techniques, equipment, and tactics are assessed for inclusion or update in the manual.*
- *During North Slope Spill Response Team (NSSRT) weekly training, large-scale joint training exercises, annual Mutual Aid Drills (MAD), and Government-Initiated Unannounced Exercises (GIUEs), the Planning and Operations Departments review lessons learned and develop changes in tactics and procedures if warranted.*
- *Every Operations Lead and Support Technician, Warehouse, Maintenance, Communications and the Training Specialists are required to complete at least one NPREP (National Preparedness for Response Exercise Program) report annually. These reports are conducted on any type of equipment deployment exercise or an actual spill response event. We allow more latitude beyond the guidelines of NPREP, as that program does not address many of the critical factors and important lessons that promote a safe and effective response. This interview is an excellent example of the latitude we accept, as NPREP does not address using snow for recovery, cutting slots in ice, delineation of oil on and under ice, setting up for Arctic safety and safely, efficiently managing a spill response in difficult austere, Arctic environments. The goal of this program is to develop lessons-learned and areas for improvement in the tactics, procedures and equipment. These lessons are often best identified by the personnel tasked with performing the tactics.*
- Who is involved?
  *Updating and coordination for the Technical Manual is done by the Planning Managers. They maintain the distribution lists and ensure that plan holders receive their copies.*
  *Nearly all ACS personnel have a role in the continual improvement of our company, policies, procedures, and tactics. As described above, Operations and Planning Department personnel are required to report lessons and improvements through the NPREPs and other findings as they conduct their weekly training. Operations Supervisors, the Operations Managers, and the Planning Managers review and provide feedback on the NPREPs.*

- Have the formulas for those tactics been updated or changed since the original development?
  *The formulas in the referenced tactics have not been updated. The calculations and models were developed and published in the Arctic and Marine Oil Spill*

*Program (AMOP) Technical Seminars sponsored by Environment and Climate Change Canada.*

- Have the formulas been compared to the actual use of the equipment, whether through field testing or actual response work?
  *Formal, specific field testing and validation has not been carried out, however periodically a spill response will present an opportunity to check these and other tactics' recovery numbers against actual numbers by melting and separating oiled snow.*
- How do differences in snow texture/dryness/wetness/etc. affect actual performance compared to the formulas? Has this been quantified and tested?
  *The original modeling and research often identified variables in the models that would require further review, as well as those which did not have a significant impact. These specific parameters have not been retested since their development.*
- How do differences in the oil content in the snow affect actual performance compared to the formulas?
  *It does not affect the performance of the tactic, only the amount of oil in a given load.*
- Have technological advances in the loading equipment made any significant difference in the time calculations?
  *No, loaders are still loaders. Technological improvements have mostly related to fuel efficiency, operator comfort and convenience, and the style of controls.*
- Are there any recent spills that this equipment has been used on that helps verify the formulas in the tactics?
  *Not specifically. The loaders, skid steers and walk-behinds are used on most winter spill responses. Their continued use attests to the validity and applicability of these tactics rather than the recovery formulas.*

- Tactic R-1 states "One cubic yard of lightly oiled snow contains 0.3 bbl of oil." Tactic R-3 states "One cubic yard of oil-saturated snow contains up to 2.4 bbl of oil." How was this determined?
  *Actual test spills were used in the late 1970s1970s and early 1980s1980s to develop many of these tactics and models. Other field-testing experiments were conducted to develop these equations.*
  - What factors can affect this volume?
    *Amount of oil, temperature of the oil, weather are some of the variables. There are not specific or exact numerical ranges assigned to these terms.*
  - Do various types of snow (fresh/old/dry/wet/wind compacted/machine compacted (e.g., snow roads), etc.) hold significantly different volumes of oil?
    *Anecdotally yes, but we do not gather data on this. The temperature of the oil can have an effect also, since it will cause some melting of the snow and thus creation of water in the mixture before (possibly) refreezing.*
  - Does mixing heavily oiled snow with lightly oiled snow significantly change the volume of oil in the snow?

*Unsure what this refers to. The volume of oil per unit volume of snow will change based on the concentrations of the two snow volumes that are mixed. How significant depends on how much the constituent volumes are.*

- What is the difference between lightly and heavily oiled snow? Who makes that determination?
  *This is a part of the spill volume estimation. Different companies perform this differently, but it would be included in the volume estimation and cleanup plan at a spill.*

### C.4.1.6 Miscellaneous

- Does ACS review scenarios in oil spill response plans to confirm the tactics are used appropriately? Do plan writers request a review of the scenarios prior to public review?
  *ACS Operations and Planning Managers review ODPCPs for all of our Member Companies. We review the scenarios, response strategies, equipment and tactics selected, and conduct a general overall review of the plans. This is done at the request of the plan holders. We make suggestions, corrections and recommendations as needed.*
- Do you think these formulas have held up against time/are they still valid?
  *Yes, we do. The equipment in question represents a broad range of construction equipment designed for heavy earth-moving work. The basic assumptions in the Technical Manual allow for a range of oil content, snow conditions, operator experience levels, and environmental conditions. The equipment does not lend itself to precision work; rather it is excellent at removing large areas of contaminated material quickly and safely.*
- Are there any publications or studies that we should look at or people that we should talk to?
  *Many of the AMOP Proceedings included publication of the models and reports from deliberate and accidental spills that were used to develop these formulas. A literature review beginning with the AMOP and IOSC (International Oil Spill Conference) Proceedings would be a good place to start. Additionally, reaching out to some of the authors of these studies may yield more of the background and development of the formulas.*
- Are there any other questions that you think I should be asking?
  *None specifically.*
- Is there any additional information that would be helpful for this project?

## C.5 ALASKA CLEAN SEAS (ACS) INTERVIEW FOLLOW UP, JULY 8, 2022

**Attendees:**

BSEE
Kristi McKinney

ACS
Fred McAdams
Royce O'Brien
John Pulis

ARCTOS Alaska, a Division of ***NORTECH***
Kirsten Ballard
Greg LeBeau

**Topics**

- ACS participants on the call were Fred McAdams, John Pulis, Royce O'Brien
    - This call was a follow-up to the written response by ACS and was used to clarify a few points from that reply.
- The times listed in the tactics provide for some variabilities that can't otherwise be accounted for
    - Example:  When dumping a load of snow, the driver may be required to get out of the cab and shovel snow out of the dump – sometimes snow will stick to the dump.
- John suggested that it would be best for the calculator to use default values of 8-yards for a loader bucket and 20-yards for dump truck capacity. In case other equipment might be used, it would be good to have the ability to change those default values in the calculator.
    - The tactics, and therefore the spill response plans, are based on using 8-yard loaders and 20-yard dump trucks.
- ACS suggested leaving the default values of oil in snow at 0.3 cu yd for R-1 and 2.4 cu yd for R-3. Mixing of oiled snow doesn't change these values enough to create a middle value for planning purposes.
- John volunteered ACS to assist testing the calculator. It's in ACS' best interest to support such a project.
    - Additionally, ACS would be happy to assist with any future real-world testing of tactics or research.
- We discussed that the intent of the tactics in the ACS Tactical Manual are intended to be solely **planning standards**; they should not be expected to serve as performance standards due to the large number of variables that can affect an operation.

# C.6 METRIC ADDITION

Introductory language and a series of questions were drafted and approved by the project team to send to the Arctic oil spill response experts. Of the four that were asked to participate, two provided responses to the questions posed, along with a former member of the project team. They also participated in the testing of ROSI. The electronic mail (email) sent regarding the metric units follows. Their replies are in the electronic files for the project.

## C.6.1 Electronic Mail Questions for Experts

Dear <Expert>-

We have developed the **Recovery of Oil on Snow and Ice (ROSI)** calculator to facilitate development and assessment of an operator's oil spill response plan for a well blowout, tank failure, pipeline leak, or other oil spill that occurs during winter months and results in recovery operations on snow and solid ice using yellow iron equipment as described in the Alaska Clean Seas (ACS) Technical Manual (TM). This project is for the U.S. Bureau of Safety and Environmental Enforcement (BSEE).

The initial version of the calculator was created using U.S. Customary Units (USCU), and we are now looking to expand its functionality by including metric units. You can find the current version of the USCU ROSI and User’s Manual here: https://devapiconnection.com/. We are concerned about making ROSI as globally useful as possible and are looking into how to best express the recovered oil-snow ratio using the metric system.

We would like to ask you about how we should express this ratio, and, invite you to test the metric version once it’s ready for testing.

If you could please review the following and provide answers to the questions posed, we would be grateful and will be sure to mention you in the acknowledgements and in the other parts of the Final (revised) report regarding the development of ROSI. If you would prefer *not* to be mentioned, please let us know along with your answers.

1. In USCU, we have used barrels of oil per cubic yard of snow (bbl/cy)
    a. We want to use a universally accepted metric unit expression for this ratio for the metric version of ROSI
    b. What would be your suggestion as to how to express this ratio?
        i. Barrels of oil per cubic meter of snow (bbl/c m)
        ii. Liters of oil per cubic meter of snow (l/c m)
        iii. Cubic meters of oil per cubic meters of snow (c m/c m)
        iv. Different units?
2. What is the basis for your units suggestion, e.g., commonly used terminology in the European spill cleanup theater? A scientific paper? A regulatory requirement?

3. Is there anyone whom you think might be interested in joining the testing of Metric ROSI, or whom we should consult about the ratio expression? If so, please send us their contact information.
4. Would you like to participate in the testing of the metric version?
5. Can we express our gratitude by mentioning you in the Acknowledgements section of our revised Final Report? If so, please provide your preferred name, title and affiliation as you would like to see it in the report.
6. We are requesting a reply to these questions as soon as is convenient for you, preferably no later than June 9, 2023.

Attached is a copy of our final report on the development of the USCU version of ROSI if you would like more detailed information on ROSI and our findings – we will be revising it to include the metric version before the end of the project period of August 31, 2023.

### C.6.2 Electronic Mail Responses to Metric Unit Questions

Are included in the electronic records for the project.

## C.7 INTERVIEWS SUMMARY

The interviews followed the same pattern as the research conducted for this project and yielded comparable results:  there is an incredible amount of knowledge on responding to oil spills in the arctic, but the emphasis tends towards ignition to reduce the overall impacts and on-water (in broken ice) physical recovery. In general, the use of yellow iron to recover oil on ice is acknowledged as a viable option but no real attention to the details of such recovery is provided beyond vague comments to the effect of ‘work with the local responders for best results.’

Choices for interview candidates were made based on those known to be experts in various aspects of spill response. There were two tiers of interview candidates; the first tier was considered the most likely to provide applicable information for this project and to be most accessible for interviewing, and the second tier was made up of alternates with similar qualifications.

Due to this project’s very narrow focus on the use of yellow iron to recover oil on ice, we have not included names of interviewees who did not provide specific knowledge of the development of the ACS tactics examined.

The Planning and Operations Managers of ACS engaged their entire supervisory staff to ensure a comprehensive and supportive written response to our initial inquiry. We followed that response with an interview over MS Teams. The entire ACS management team deserves credit for their participation, input and expertise for the development of ROSI. Most of the references to yellow iron response tactics referred to ACS. ACS’ information provided significant guidance in some of the choices made in developing the calculator to provide the most effective support to a plan reviewer or a plan writer. Examples of this include the reliance on the default values provided in the tactics for equipment capacities, percentage of oil in snow, and loading/offloading times. ACS provided a clear understanding of the broad list of variables that could potentially affect any given response, and how that affected the choice of default values for the tactics. They additionally stressed that the tactics in the TM are for planning purposes only; actual times for any given tactical activity can be expected to vary from the written tactic based upon the specific circumstances of each response.

The metric addition provided an exercise in research and application where standardized terminology for the recovery of oiled snow was found to be lacking. The opportunity to propose standard terminology to further refine the spill response compendium was established.

In summary, despite the incredible amount of knowledge that exists around oil spill response in the arctic, it is clear that the best source of information regarding the yellow iron tactics that this project is focused on is the people who use them regularly. As far as the tactics themselves, it must be understood by anyone looking at them that they are for planning purposes only and may not accurately reflect the actual performance during a response due the long list of variables that are specific to any given response. Standard terms for metric and USCU for the recovery of oiled snow/ice as used in ROSI should be proposed to the ISO and other governing entities for standard terminology.

# Appendix D: ACS Tactics Cited

# Appendix D – ACS Tactics Cited

## TACTIC R-1 Mechanical Recovery of Lightly Oiled Snow (Page 1 of 2)


Snow provides a good sorbent material for oil and forms a mulch-like mixture that is easily removed with heavy equipment such as front-end loaders and dump trucks.

A wide-track dozer and front-end loader pile the snow, and then a loader loads it into dump trucks on nearby gravel pads, roads, or ice roads. After a loader has filled a truck, the truck hauls the oiled snow off for disposal. A Bobcat would replace the front-end loader in hard-to-reach or tight quarters.

If nearby heavily oiled snow needs blending to ease recovery, then loaders and dozers may be used to push the lightly oiled snow into the heavily oiled snow area. Mixing the lightly oiled snow with the heavily oiled snow would generate less waste.

### EQUIPMENT AND PERSONNEL

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Wide-Track Dozer | All | Piling oiled snow | 1 | 1 | 1 hr | 0.5 hr |
| Front-End Loader | All | Transfer oiled snow into dump trucks | 1 | 1 | 1 hr | 0.5 hr |
| Dump Truck | GPB, KRU, Peak, CH2M Hill, Alpine | Transfer oiled snow to disposal site | ≥2* | ≥2 | 1 hr | 0.5 hr |

*Number of dump trucks depends on distance to disposal area.

**TOTAL STAFF** **≥5 (includes 1 spotter that works with equipment to protect tundra)**

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*



*NOTE: All values given on these pages are for planning purposes only.*

## Mechanical Recovery of Lightly Oiled Snow (Page 2 of 2) TACTIC R-1

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Semi and Trailer | GPB, KRU, Alpine | Transport wide-track dozer | 1 | 1 driver | 1 hr | 0 |
| Heater | All | Heat | ≥1 | 1 initial setup | 1 hr | 0.5 hr |
| Fuel Truck | All | Fuel heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Mechanic Support | All | Support heavy equipment | 1 | 1 | 1 hr | 0.5 hr |
| Lube Truck | All except Badami | Provide fluids to heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Light Plant | All | Illumination | ≥1 | 2 for initial setup, and 1 to check and fuel occasionally. | 1 hr | 0.5 hr |

### CAPACITIES FOR PLANNING

- One cubic yard of lightly oiled snow contains 0.3 bbl of oil. Snowmelters can typically handle 30 cubic yd of lightly oiled snow per hour.
- A wide-track dozer can build an initial snow berm around the largest tank spill on the Slope within an hour.
- A front-end loader with an 8-cubic-yd snow bucket can move 500 cubic yd of snow in an hour and fill a dump truck in 10 minutes. See Tactic L-6, Table 9A, for capacities of dump trucks available on the North Slope.
- Following is an example of recovery of lightly oiled snow for one 20-cubic-yd dump truck, with 2 miles between load and unload points:

$$\text{Dump Truck Recovery Rate} = \frac{T_c}{L_t + T_t + U_t} = \frac{20 \text{ cubic yd}}{0.17 \text{ hr} + \left(\frac{2 \text{ mi} * 2}{35 \text{ mph}}\right) + 0.08 \text{ hr}} = 55 \text{ cubic yd/hr (or 16.5 bbl/hr)}$$

*Where:*

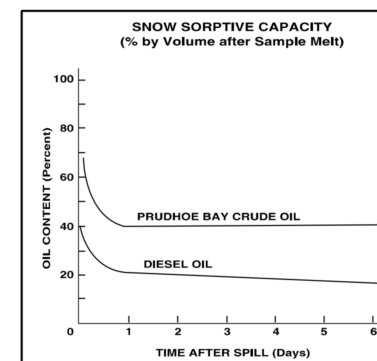
$T_c$ = *Truck Capacity*

$L_t$ = *Load Time (10 min or 0.17 hr)*

$U_t$ = *Unload Time (5 min or 0.08 hr)*

$T_t$ = *Travel Time* $\left(\frac{\text{miles to disposal} * 2}{35 \text{ mph}}\right)$

The ratio of dump trucks to loaders to fill trucks without delay = 1 / (0.17 hr + 0.114 hr + 0.08 hr) = 1 / (0.364) = 2.7 trucks per loader.

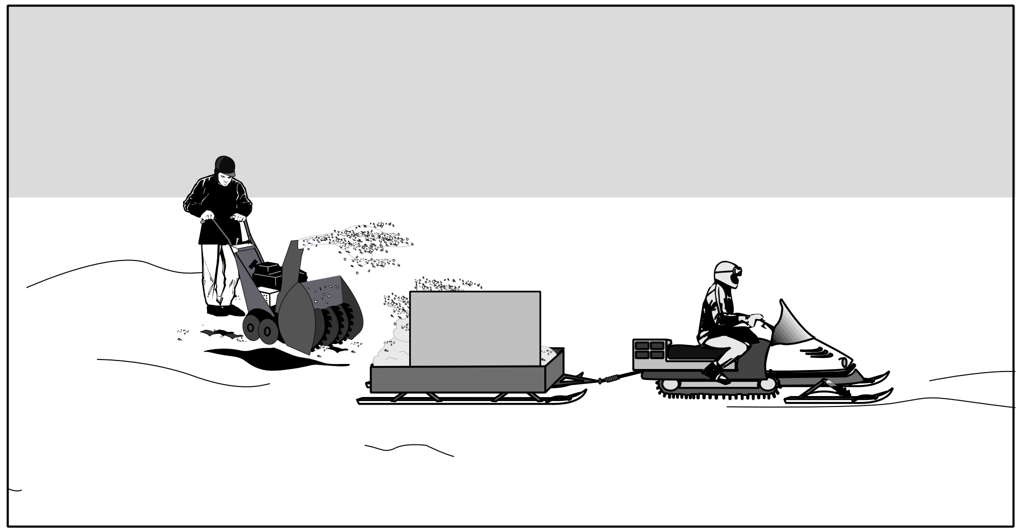



### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic is limited to oiled snow with no free liquids. Collect the top 6 inches of snow into piles for recovery. If snow cover is light or the snow will be used for blending, collect all of the snow.
- When working with equipment around or near flowlines, add a spotter to each front-end loader or wide-track dozer.
- An ice road allows dump trucks into recovery sites on tundra.

*NOTE: All values given on these pages are for planning purposes only.*

## TACTIC R-1A Use of Snow Blower to Remove Lightly Misted Snow (Page 1 of 2)



Lightly misted snow can be cleaned up using a snow blower and snow machine with trailer. The snow can be cleaned up either directly off of the ground or by using brooms to sweep oiled snow into windrows for more effective recovery. Once the trailer is full, it is transferred by snow machine to a front-end loader on the gravel pad or road. The loader then transfers the snow into dump trucks on the pad or road.

### EQUIPMENT AND PERSONNEL

- Crew size consists of two sweepers, a snow blower operator, and a snow machine operator. The number of crews will not exceed the number of snow blowers available.

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Shovel and Broom | All | Recovery | Variable | — | 0.5 hr | 0.5 hr |
| Snow Machine with Trailer | All | Transfer | 3 | 3 | 1 hr | |
| Snow Blower | ACS, Badami, Northstar, Alpine | Recovery | 1 | 1 | 1 hr | |
| Front-End Loader (8-cubic-yd) | All | Transfer | 1 | 1 | 1 hr | |
| Dump Truck | GPB, KRU, CH2M Hill, Peak, AIC, Alpine | Transfer | ≥2 | ≥2 | 1 hr | |

**TOTAL STAFF ≥7**

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*



## Use of Snow Blower to Remove Lightly Misted Snow (Page 2 of 2) TACTIC R-1A

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Light Plant | All | Illumination | ≥1 | 2 for initial setup, and 1 to check and fuel occasionally | 1 hr | 0.5 hr |
| Heater | All | Heat | 1 | 1 for initial setup | 1 hr | |
| Fuel Trailer | All | Fuel | 1 | 1 for initial setup | 1 hr | |

### CAPACITIES FOR PLANNING

- Snow machine trailers have a 1/2 cubic yd capacity.
- Snowmelters typically handle 30 cubic yd of lightly oiled now per hour, providing 30 bbl/hr of water, plus the oil.

### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic is limited to oiled snow with no free liquids.
- The number of crews on the spill depends on the size of the spill.
- Lightly oiled snow may be blended with heavily oiled snow in the area to enhance recovery.
- Warm-up areas are needed for responders.

## TACTIC R-2 Manual Recovery of Lightly Oiled Snow (Page 1 of 2)

Broom and shovel the oiled snow into piles. The piles are then transferred with shovels to garbage cans, totes, or similar containers. Once a container is full, it is transferred with a snow machine or Argo to a front-end loader near the gravel pad or road. The loader then transfers the snow into dump trucks on the pad or road.

### EQUIPMENT AND PERSONNEL

- Crew size consists of six shovelers, and the number of crews varies with the size of the spill.

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Shovel and Broom | All | Recovery | 6 | 6 | 0.5 hr | 0.5 hr |
| Snow Machine or ATV | All | Transfer | 3 | 3 | 1 hr | |
| Front-End Loader | All | Transfer | 1 | 1 | 1 hr | |
| Dump Truck | GPB, KRU, Peak, AIC, CH2M Hill, Alpine | Transfer | 1 | 1 | 1 hr | |
| | | | TOTAL STAFF | 11 (10 if dump-truck operator loads truck) | | |

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

 *NOTE: All values given on these pages are for planning purposes only.*

## Manual Recovery of Lightly Oiled Snow (Page 2 of 2) TACTIC R-2

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Light Plant | All | Illumination | $\geq$1 | 2 for initial setup, and 1 to check and fuel occasionally. | 1 hr | 0.5 hr |
| Heater | All | Heat | 1 | 1 initial | 1 hr | 0.5 hr |
| Fuel Truck | All | Fuel heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |

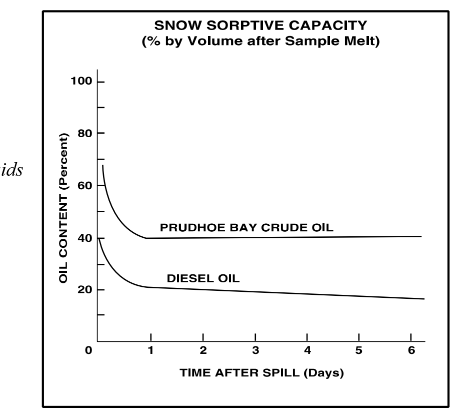
### CAPACITIES FOR PLANNING

- With 6 workers, this technique can recover 30 cubic yd of snow in 10 hours (10 hours worked in a 12-hour shift), depending on weather and terrain. In cold weather a typical 12-hr work shift provides 8 labor hours from a shoveler. Because lightly oiled snow contains 0.3 bbl of oil per cubic yd of snow, one crew of 6 can recover 9 bbl of oil in 10 hours, or 0.9 bbl/hr oil.

$$\text{30 cubic yd snow} \times \frac{\text{1 cubic yd water}}{\text{10 cubic yards snow}} = \text{3 cubic yd liquids}$$

$$\text{3 cubic yd liquids} \times \frac{\text{27 cubic ft}}{\text{1 cubic yd}} \times \frac{\text{1 bbl}}{\text{5.6 cubic ft}} = \text{14.5 bbl liquids}$$

$$\frac{\text{30 cubic yd snow}}{\text{14.5 bbl liquids}} \quad \text{2 cubic yd snow per bbl of liquids}$$

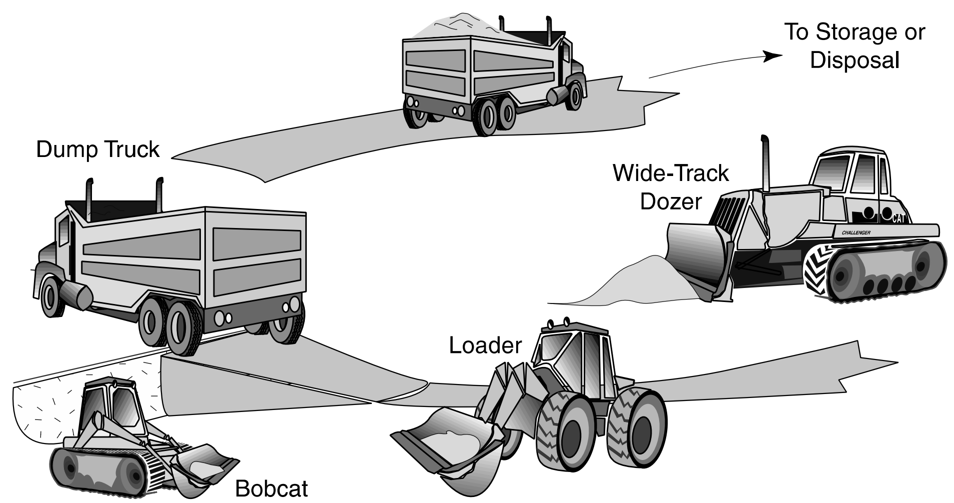



### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic is limited to oiled snow with no free liquids.
- When working with equipment around or near flowlines, add a spotter to each front-end loader.
- Manual recovery is the preferred technique when working in tight areas, when the ground is too rough for equipment, or there is insufficient snow cover for equipment.
- The number of crews on the spill depends on the size of the spill.
- The lightly oiled snow may be blended with heavily oiled snow in the area.
- Snowmelters typically handle 30 cubic yd of lightly oiled snow per hour, providing 14.5 bbl/hr of water, plus the oil.
- Warm-up areas are needed for responders.

*NOTE: All values given on these pages are for planning purposes only.* 

## TACTIC R-3 Recovery of Oil-Saturated Snow (Page 1 of 2)




Snow provides a good sorbent material for oil and forms a mulch-like mixture that is easily removed with heavy equipment such as front-end loaders and dump trucks. A Bobcat replaces the front-end loader in hard-to-reach or tight quarters.

Access the oiled snow with dozers and loaders, pile the snow with the dozers, and then load it into dump trucks located on nearby gravel pads, roads, or ice roads. After a front-end loader has filled a truck, the truck hauls the oiled snow off for disposal, typically to snowmelters in lined pits. If heavily oiled snow needs blending to ease recovery, loaders and dozers push nearby lightly oiled snow into the heavily oiled snow area for recovery. Clean snow can also be used for blending.

Oil in areas inaccessible by vacuum trucks or heavy equipment is recovered with sorbents and manual labor. The sorbents are collected in totes, garbage cans, or bags and transferred with snow machine, ATVs, or pickup truck to a front-end loader, which transfer the waste into a dump truck for removal and disposal. Sorbents must be placed in oily waste bags and then put in an oily waste dumpster.

### EQUIPMENT AND PERSONNEL

- A dump truck requires one operator. Personnel numbers deploying and collecting sorbents vary with the size and configuration of the spill. Personnel typically work in pairs for sorbent deployment and recovery.

| | EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|---|
| | Wide-Track Dozer | All | Piling oiled snow | 1 | 1 | 1 hr | |
| | Front-End Loader | All | Transfer oiled snow into dump trucks | 1 | 1 | 1 hr | |
| or | Bobcat | ACS, PBE, KRU, Alpine | Transfer oiled snow to loaders | 1 | 1 | 1 hr | 0.5 hr |
| | Dump Truck | GPB, KRU, Peak, AIC, Alpine | Transfer oiled snow to disposal site | 2 | 2 | 1 hr | |
| | Snowmelter | Deadhorse, Alpine | Melt snow | 2 | 8 | 2 hr | |
| | Sorbent | All | Recovery | Variable | Variable | 0.5 hr | |

**TOTAL STAFF** **11 (includes 1 spotter that works with equipment to protect tundra)**

 *NOTE: All values given on these pages are for planning purposes only.*

## Recovery of Oil-Saturated Snow (Page 2 of 2) TACTIC R-3

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Semi and Trailer | GPB, KRU, Alpine | Transport wide-track dozer | 1 | 1 driver | 1 hr | 0 |
| Heater | All | Support heavy equipment | ≥1 | 1 initial setup | 1 hr | 0.5 hr |
| Fuel Truck | All | Fuel heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Mechanic Support | All | Support equipment | 1 | 1 | 1 hr | 0.5 hr |
| Lube Truck | All except Badami | Provide fluids to heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Light Plant | All | Illumination | Variable | 2 for initial setup, and 1 to check and fuel occasionally. | 1 hr | 0.5 hr |

### CAPACITIES FOR PLANNING

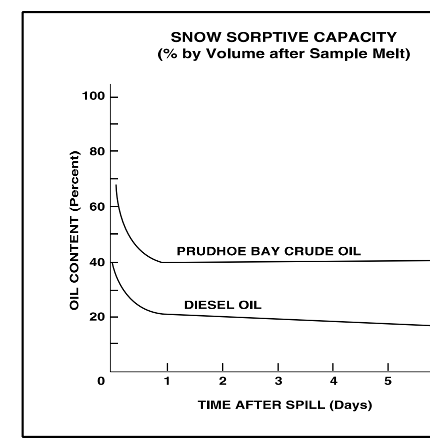
- A front-end loader with an 8-cubic-yd snow bucket can fill a dump truck in 10 minutes and move 500 cubic yd of snow per hour. The dump trucks available on the Slope typically have 10-, 20-, or 25-cubic-yd capacity. Because the front-end loaders fill dump trucks as fast as they pull into position, dump trucks are the bottleneck.
- A snow melter can process 30 yd / hour of heavily oiled snow resulting in 70 bbls/hour of recovered oil.
- One cubic yard of oil-saturated snow contains up to 2.4 bbl of oil.
- Following is an example of recovery of oiled snow for one 20-cubic-yd dump unit:

$$\text{Dump Truck Recovery} = \frac{T_c}{L_t + T_t + U_t} = \frac{20 \text{ cubic yd}}{0.17 \text{ hr} + \left(\frac{2 \text{ mi} * 2}{35 \text{ mph}}\right) + 0.08 \text{ hr}} = 55 \text{ cubic yd/hr}$$

*Example:* $T_c$ = Truck Capacity
$L_t$ = Load Time (10 min or 0.17 hr)
$U_t$ = Unload Time (5 min or 0.08 hr)
$T_t$ = Travel Time $\left(\frac{\text{miles to disposal} * 2}{35 \text{ mph}}\right)$

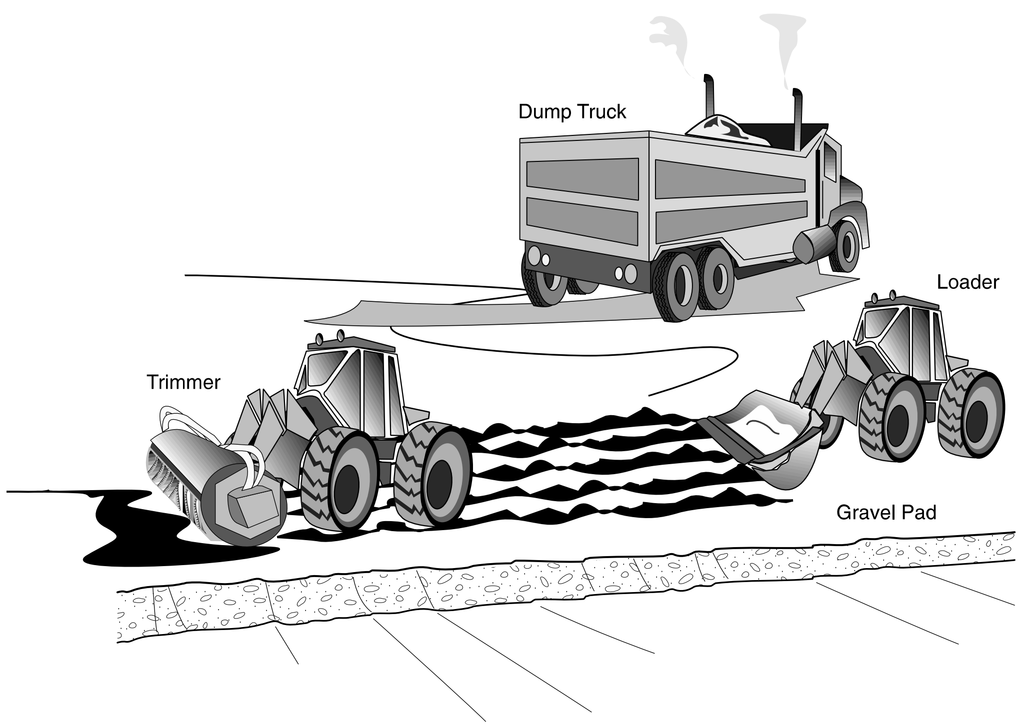
### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic is limited to oiled snow with no free liquids. Otherwise, lined or leak-proof dump trucks may be used.
- If the oiled snow is too saturated for handling, blend lightly oiled snow or clean snow with it, or use Tactic R-6.
- If delivery of snow exceeds snowmelter capacity, the snow can be contained in lined pits until it is processed. Existing lined pits, upright tanks, or dry ponds can be used, when available, to store snow; otherwise temporary lined pits can be constructed as necessary.
- If the dump trucks cannot access the oiled area, build an ice road to keep the loaders from traveling too far.
- After removal of free oil, oiled snow, and after flushing, contain and monitor the area until breakup. Insulate ice roads or ice berms to provide containment during breakup, when the oil can be removed with direct suction, portable skimmers, or burning.




*NOTE: All values given on these pages are for planning purposes only.* 

## TACTIC R-5 Recovery of Embedded Oil (Page 1 of 2)




A trimmer is used to recover oil embedded in the surface of a frozen pad or ice. A trimmer uses a rotary blade system to chop and collect the surface material at varying depths. The worked-over material is collected with a front-end loader and transferred to a dump truck.

A scratcher is used to break up frozen gravel or ice in areas where a trimmer cannot reach. A scratcher is a fork attachment for a front-end loader which can reach areas in tight quarters. A Super Sucker may also be used to remove a thin top layer.

Where the embedded oil is not recovered, the area is stabilized and the perimeter bermed and sealed, and monitored until breakup. Breakup is accelerated in the contained area by placing a layer of black Visqueen over it. The Visqueen is lifted as necessary, and the pools of oil removed with direct suction, portable skimmers, or burning.

 *NOTE: All values given on these pages are for planning purposes only.*

## Recovery of Embedded Oil (Page 2 of 2) TACTIC R-5

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### EQUIPMENT AND PERSONNEL

| | EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|---|
| | Trimmer (Loader-mounted, 10-ft wide) | Peak | Recovery of frozen surface material | 1 | 1 | 2 hr | 0.5 hr |
| or | Trimmer (Bobcat-mounted, 2-ft wide) | ACS, KRU, Alpine | Recovery of frozen surface material | 1 | 1 | 1 hr | 0.5 hr |
| or | Front-End Loader w/ Scratcher and Bucket | All | Transfer oiled snow into dump trucks | 1 | 1 | 1 hr | 0.5 hr |
| or | Backhoe | GPB, KRU, Peak, AIC, Alpine | Recovery of frozen surface material | 1 | 1 | 2 hr | 0.5 hr |
| or | Super Sucker | Peak, CH2M Hill, Alpine | Recovery of frozen surface material | 1 | 2 | 1 hr | 0.5 hr |
| | Dump Truck | GPB, KRU, Peak, AIC, Alpine | Transfer oiled snow to disposal site | ≥2 | ≥2 | 1 hr | 0.5 hr |
| | | | TOTAL STAFF | | ≥4 | | |

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Semi and Trailer | GPB, KRU, Alpine | Transport heavy equipment | 1 | 1 driver | 1 hr | 0 |
| Heater | All | Support heavy equipment | ≥1 | 1 initial setup | 1 hr | 0.5 hr |
| Fuel Truck | All | Fuel heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Mechanic Support | All | Support equipment | 1 | 1 | 1 hr | 0.5 hr |
| Lube Truck | All except Badami | Provide fluids to heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Light Plant | All | Illumination | ≥1 | 2 for initial setup, and 1 to check and fuel occasionally. | 1 hr | 0.5 hr |

### CAPACITIES FOR PLANNING

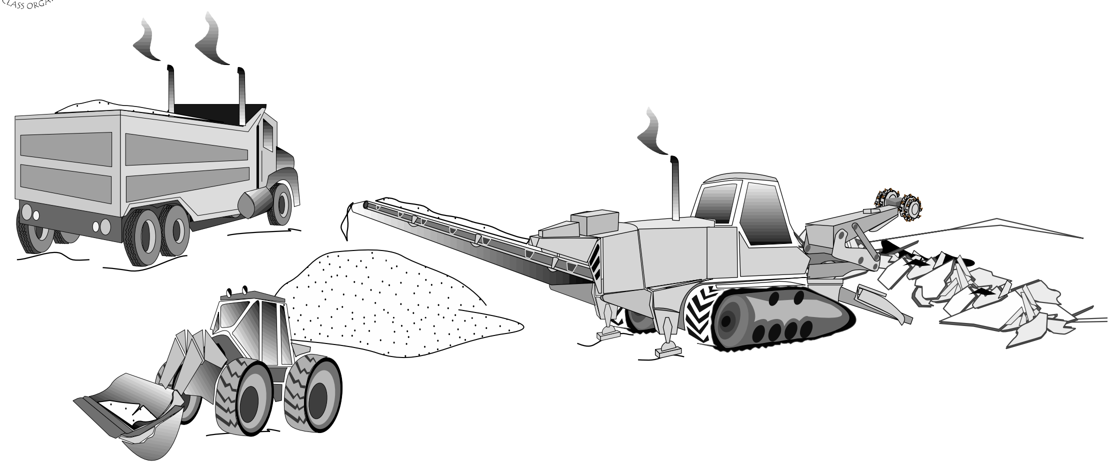
- A front-end loader can fill a dump truck in 30 minutes. The average dump truck available on the Slope has a 20-cubic-yd capacity.
- One cubic yard of oiled gravel contains 0.125 bbl of oil.
- A Super Sucker uses an 8-inch hose and can recover 14 cubic yd of gravel in one hour. The storage capacity of a Super Sucker is 65 bbl or 14 cubic yd. A Super Sucker can also be reduced to 6-inch, 4-inch, or 2-inch hose, and "Ys" allow the use of more than one hose.
- The speed of a trimmer operation depends on many variables, including depth of contamination, hardness of surface, and size of trimmer.

### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- A trimmer is preferred over a backhoe to remove frozen gravel. When gravel is loose enough, a backhoe or front-end loader may be used.
- Removal of oil embedded in tundra can be achieved by removing the tundra or burning it out with weed burners. Alternatively, the tundra can be contained and monitored until breakup when oil melts out, allowing recovery with direct suction, portable skimmers, or burning.
- A civil work permit from the operator is required for work on a pad.

*NOTE: All values given on these pages are for planning purposes only.* 

## TACTIC R-29 Ice Mining (Page 1 of 2)




During the winter, ice rubble piles can form at shorelines and manmade structures in the Beaufort Sea. Oil entrained in these piles can be accessed by removing the oiled ice with an ice-miner that grinds up the ice and deposits it in a pile that can be picked up with a front end loader and hauled away by dump truck.

This tactic can be used in winter and into breakup as long as the ice is thick enough to support the weight of vehicles and heavy equipment.

### EQUIPMENT AND PERSONNEL

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Ice Miner | GPB, KRU | Grinding oiled ice rubble | 1 (3 are available on the Slope) | 1 | 1 hr | 0.5 hr |
| Roto Trimmer | KRU, GPB | Grinding oiled ice rubble | 1 (3 are available on the Slope) | 1 | 1 hr | 0.5 hr |
| Front-End Loader | All | Transfer oiled snow into dump trucks | 1 | 1 | 1 hr | 0.5 hr |
| Dump Truck | GPB, KRU, Peak, AIC, Alpine | Transfer oiled snow to disposal site | ≥2 | ≥2 | 1 hr | 0.5 hr |

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

 *NOTE: All values given on these pages are for planning purposes only.*

## Ice Mining (Page 2 of 2) TACTIC R-29

**NOTE:** *"Base Location" is storage location (may change seasonally); "Mobe Time" is time to get it out of storage, prepare it for operation, and make it ready to travel (concurrent for all equipment); "Deploy Time" is time to make it operational for its intended use at the spill site. These times do not include travel time from base to spill site, which may have multiple components (see Tactic L-3).*

### SUPPORT

| EQUIPMENT | BASE LOCATION | FUNCTION | PIECES | # STAFF PER SHIFT | MOBE TIME | DEPLOY TIME |
|---|---|---|---|---|---|---|
| Semi and Trailer | GPB, KRU, Alpine | Transport ice miner | 1 | 1 driver | 1 hr | 0 |
| Heater | All | Heat | ≥1 | 1 initial setup | 1 hr | 0.5 hr |
| Fuel Truck | All | Fuel heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Mechanic Support | All | Support heavy equipment | 1 | 1 | 1 hr | 0.5 hr |
| Lube Truck | All except Badami | Provide fluids to heavy equipment | 1 | Once per shift | 1 hr | 0.5 hr |
| Light Plant | All | Illumination | ≥1 | 2 for initial setup, and 1 to check and fuel occasionally. | 1 hr | 0.5 hr |

### CAPACITIES FOR PLANNING

- Capacity of ice miner: 1,400 cubic yd per hour for sea ice, 1,420 cubic yd per hour for freshwater ice.
- A front-end loader with an 8-cubic-yd snow bucket can fill a dump truck in 10 minutes and move 500 cubic yd per hour. The dump trucks available on the Slope typically have 10-, 20-, or 25-cubic-yd capacity. To keep pace with the ice miner, it may be necessary to load more than one truck at a time.
- Following is an example of recovery of oiled ice for one 20-cubic-yd dump unit:

$$\text{Dump Truck Recovery} = \frac{T_c}{L_t + T_t + U_t} = \frac{20 \text{ cubic yd}}{0.17 \text{ hr} + \left(\frac{2 \text{ mi} * 2}{35 \text{ mph}}\right) + 0.08 \text{ hr}} = 55 \text{ cubic yd/hr}$$

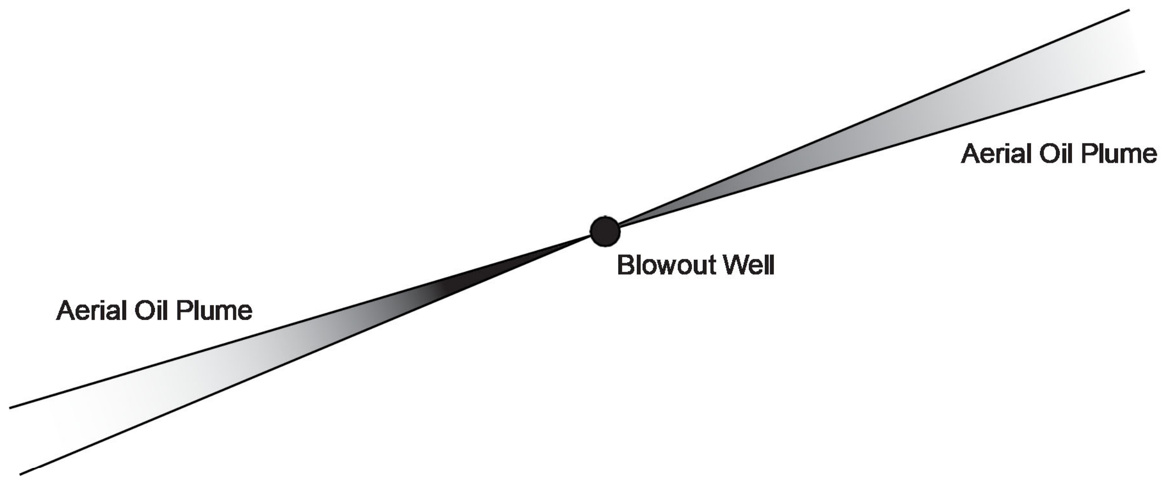
Example: $T_c$ = Truck Capacity
$L_t$ = Load Time (10 min or 0.17 hr) $\quad T_t$ = Travel Time $\left(\frac{\text{miles to disposal} * 2}{35 \text{ mph}}\right)$
$U_t$ = Unload Time (5 min or 0.08 hr)

### DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic is limited to oiled ice with no free liquids.
- If the dump trucks cannot access the oiled area, build an ice road to keep the loaders from traveling too far.
- After removal of free oil, oiled snow, and after flushing, contain and monitor the area until breakup. Insulate ice roads or ice berms to provide containment during breakup, when the oil can be removed with direct suction, portable skimmers, or burning.

*NOTE: All values given on these pages are for planning purposes only.* 

## TACTIC T-6 Blowout Modeling (Page 1 of 8)




The purpose of this tactic is to provide contingency planners with a method for determining how oil will be deposited from a surface well blowout, for use in developing response scenarios in facility-specific contingency plans.

An unobstructed surface well blowout can send a plume of oil into the atmosphere. The distribution of oil falling from the aerial plume depends upon the height that the oil is propelled and the size of the oil droplets. The gas flow rate controls the plume height and subsequent fallout distribution.

Downwind oil distributions predictions are modeled for the following conditions:

- Alaska North Slope crude oil
- Atmospheric Stability Class D
- Median oil drop diameter of 750 μm
- Release height (feet above ground surface) of 0

The methods used to complete the modeling are described in *Oil Deposition Modeling for Surface Oil Well Blowouts* (Belore, McHale & Chapple, 1998 Arctic and Marine Oilspill Technical Program, Environment Canada).

Wind speed has no net effect on the deposition pattern. A high wind reduces the plume rise height by bending the plume but it also carries the oil downwind faster. Drops fall to the ground sooner but travel just as far from the source.

 *NOTE: All values given on these pages are for planning purposes only.*

## Blowout Modeling (Page 2 of 8) TACTIC T-6

Figures 1A and 1B associate typical gas flow rates with oil flow rates and gas-to-oil ratios. A gas flow rate found in Figures 1A or 1B is used to select curves in Figures 2 to 11. Figures 2 to 11 have been developed using an oil drop size distribution with a 750 μm volume median diameter. This drop size distribution was derived from an annular, two-phase flow situation. The shaded area in Figure 1B identifies flows outside of the annular flow conditions for which this drop size distribution was derived. The oil drops formed under these "low-flow" conditions are likely to be larger than those used to develop Figures 2 to 11. Therefore, Figures 2 to 11 are not valid for the flow conditions that fall in the shaded areas below the "limit lines" plotted for each of the pipe diameters in Figure 1B.

Figures 2 to 11 show the downwind length and width of the aerial plume where a percentage of the total oil flow has fallen to the surface for different outlet pipe diameters. The highest gas flow curve shown in each of these figures represents the flow rate where sonic velocity is achieved (the maximum possible exit velocity). Use the largest gas flow curve in the figure if higher gas flow rates are predicted for releases from pipes of these diameters. Higher flow rates (at STP) than those shown in the figures are possible due to pressure/density factors at the pipe exit.

Ten percent of the oil is assumed to be in the form of drops so small (50 m or less) that they do not fall to the ground but are held aloft by atmospheric turbulence.

The following example illustrates how to use Figures 1 through 11:

A well is assumed to be discharging oil and gas at a rate of 12,000 bopd with a gas-to-oil ratio (GOR) of 750 scf/bbl through a 6.184 inch inner diameter pipe. To determine the amount of oil that falls within 200 meters from the source, complete the following steps:

From Figure 1b, determine the gas flow to be about 8.5 mmscf/d.

On Figure 4, interpolate between the 5 and 10 mmscf/d curves to approximate the 8.75 curve. From this interpolated curve, get the percent of oil falling within 200 meters of the source (about 72%). The total volume of oil falling within 200 meters of the source is the total oil flow of 12,000 bopd times 0.72 times the duration of the blowout period.

To determine the width of the fallout at 200 meters, use Figure 5 and determine the fallout width at 72% of oil on "ground" (about 40 meters) for 8.75 mmscf/d. This is the width that would be oiled if the wind came from the same direction during the entire release. If the wind is shifting, the plume will deposit oil over a much wider area. If the wind's directional persistence throughout the release period is known, these values can be applied to determine the percentage of oil falling and the resulting oil thickness in the various sectors around the spill source.

*NOTE: All values given on these pages are for planning purposes only.* 

**TACTIC T-6** **Blowout Modeling (Page 3 of 8)**

FIGURE 1A. GAS FLOW - OIL FLOW - GOR

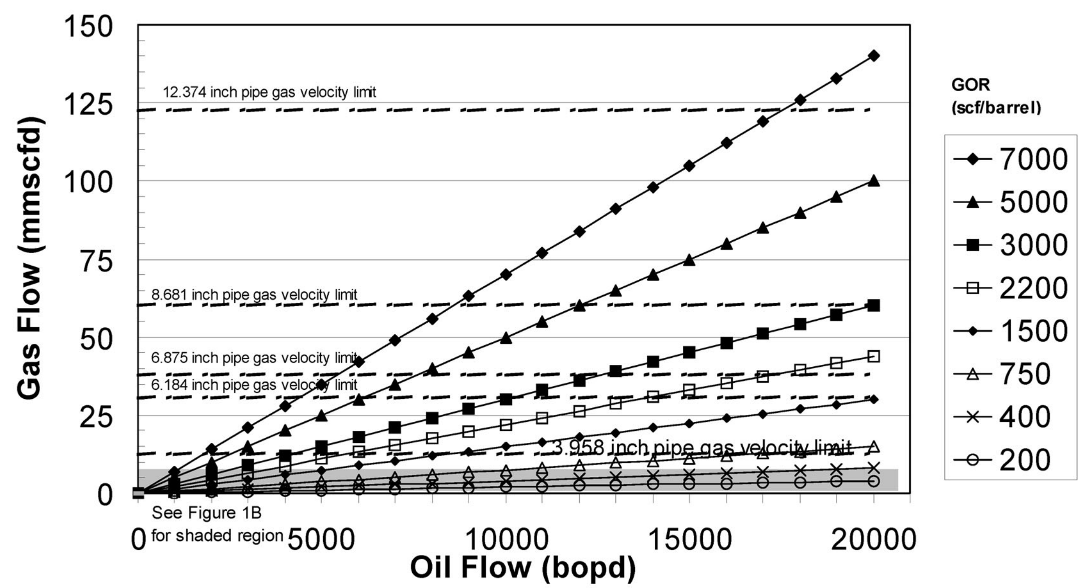
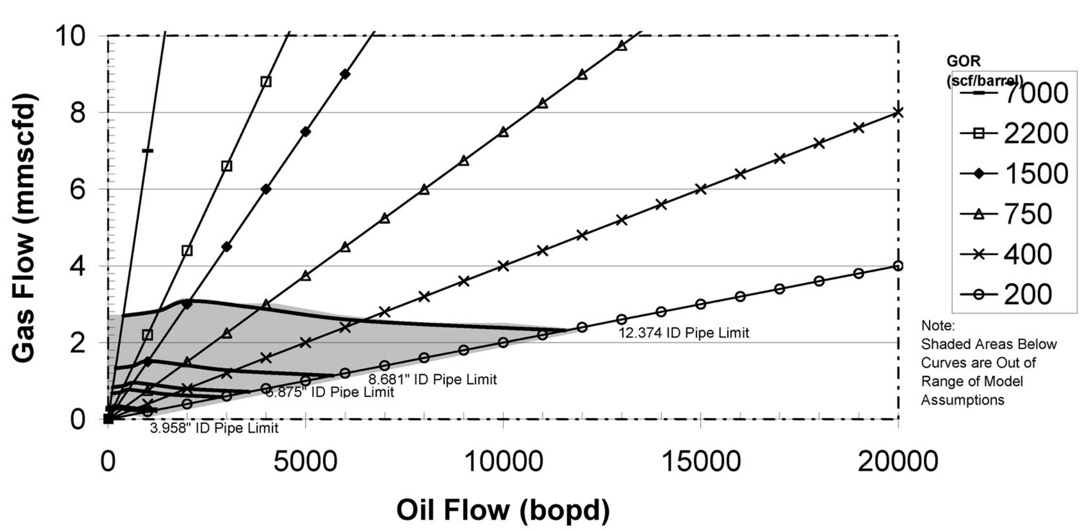



FIGURE 1B
GAS FLOW - OIL FLOW - GOR (low flows)






*NOTE: All values given on these pages are for planning purposes only.*

**Blowout Modeling (Page 4 of 8)** **TACTIC T-6**

FIGURE 2
OIL FALLOUT PERCENT VS. DISTANCE FROM SOURCE (3.958-INCH ID PIPE)

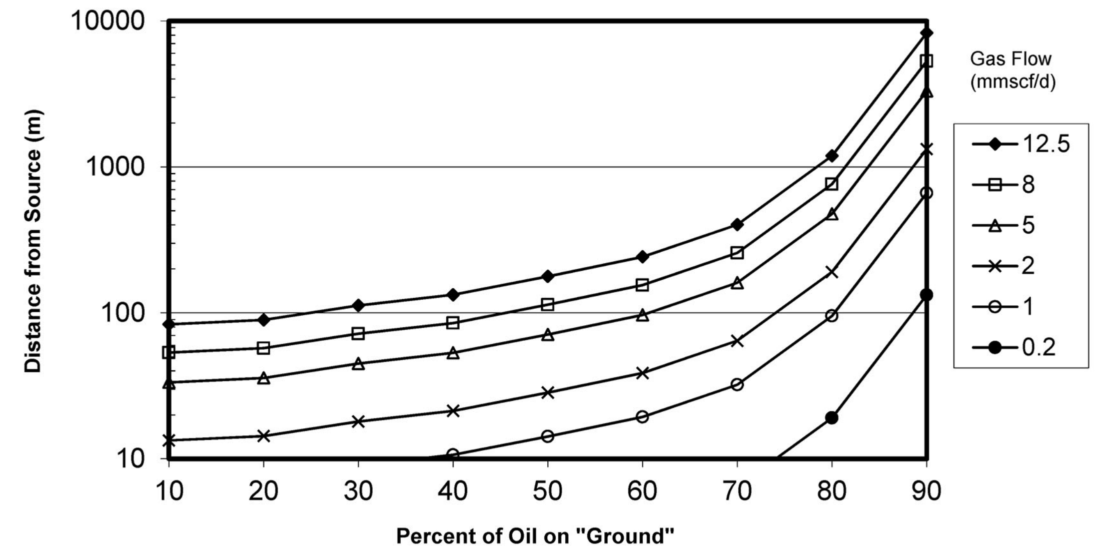
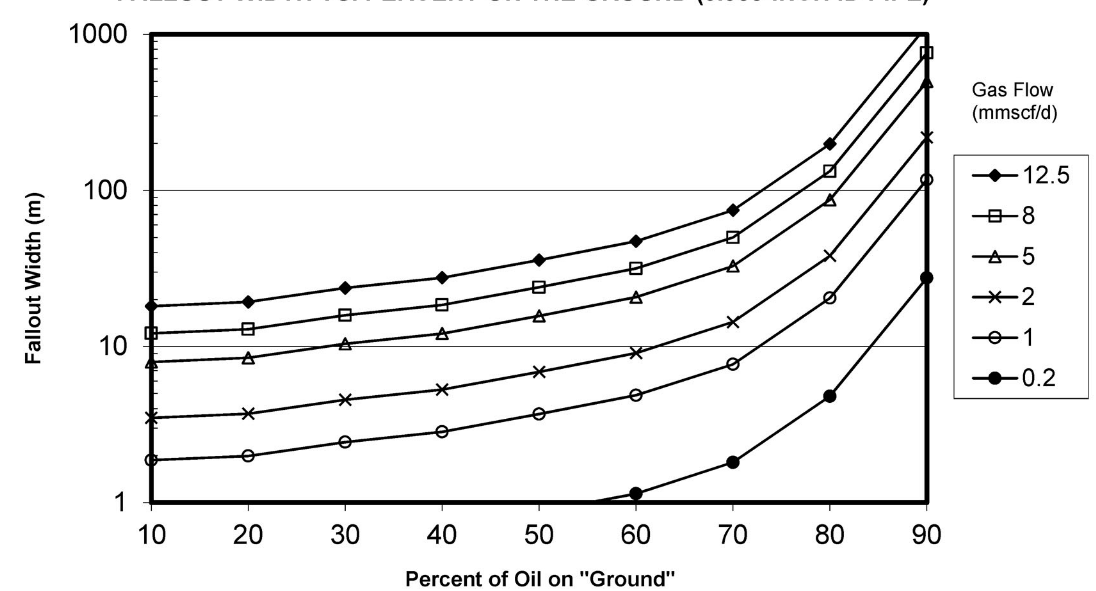



FIGURE 3
FALLOUT WIDTH VS. PERCENT ON THE GROUND (3.958-INCH ID PIPE)




*NOTE: All values given on these pages are for planning purposes only.*

## TACTIC T-6 Blowout Modeling (Page 5 of 8)

FIGURE 4
OIL FALLOUT PERCENT VS DISTANCE FROM SOURCE (6.184-INCH ID PIPE)

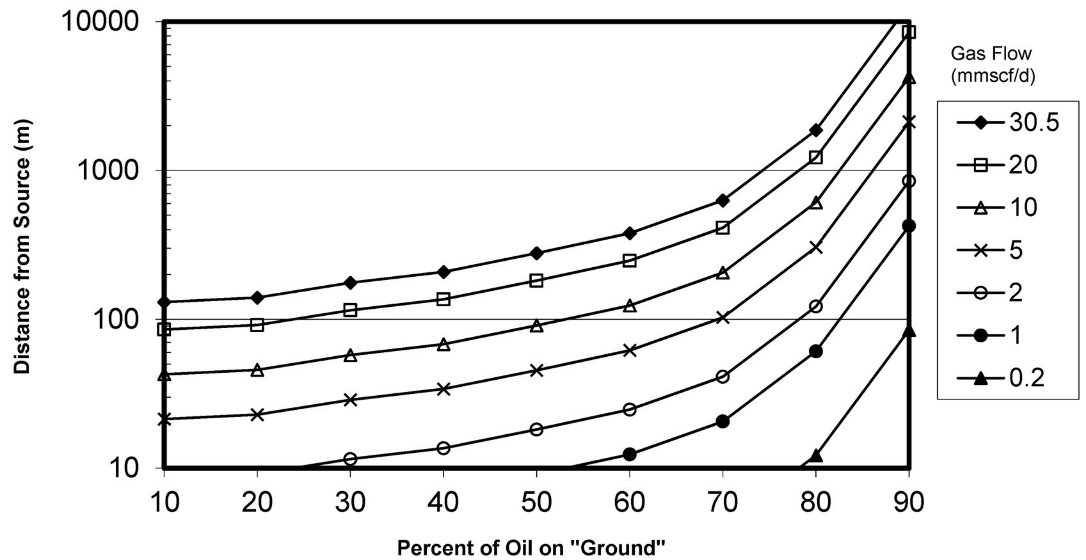
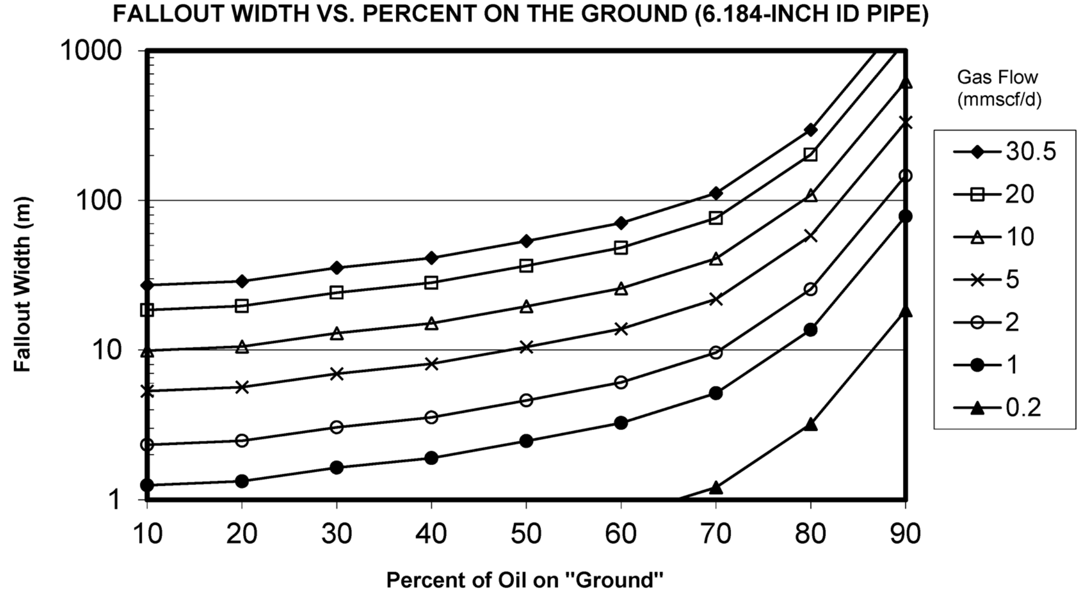



FIGURE 5
FALLOUT WIDTH VS. PERCENT ON THE GROUND (6.184-INCH ID PIPE)

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## Blowout Modeling (Page 6 of 8) TACTIC T-6

FIGURE 6
OIL FALLOUT PERCENT VS DISTANCE FROM SOURCE (6.875-IN ID PIPE)

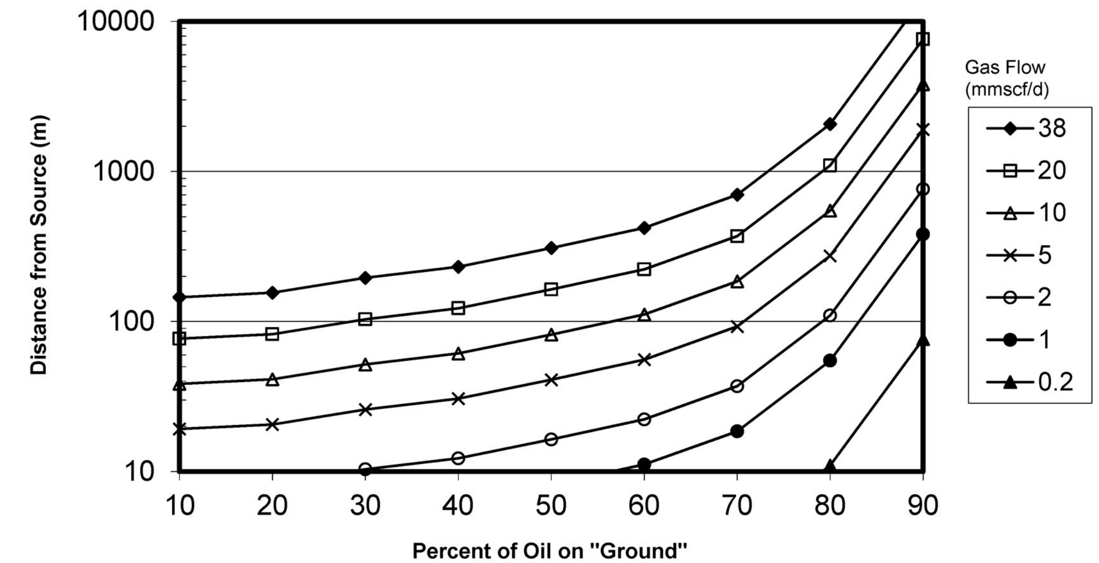
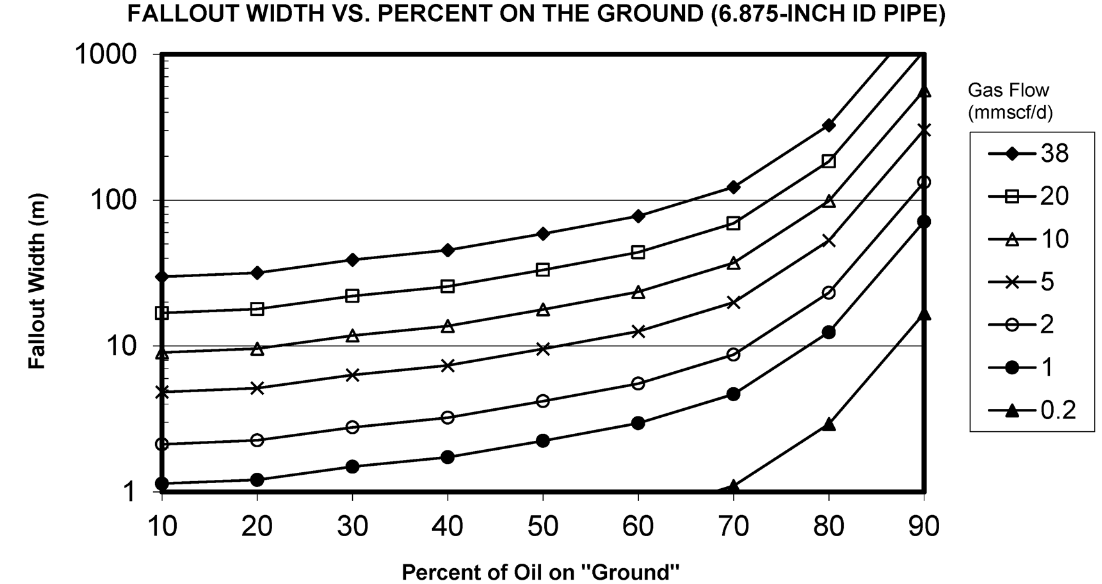



FIGURE 7
FALLOUT WIDTH VS. PERCENT ON THE GROUND (6.875-INCH ID PIPE)

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**TACTIC T-6 Blowout Modeling (Page 7 of 8)**

FIGURE 8
OIL FALLOUT PERCENT VS DISTANCE FROM SOURCE (8.681-IN ID PIPE)

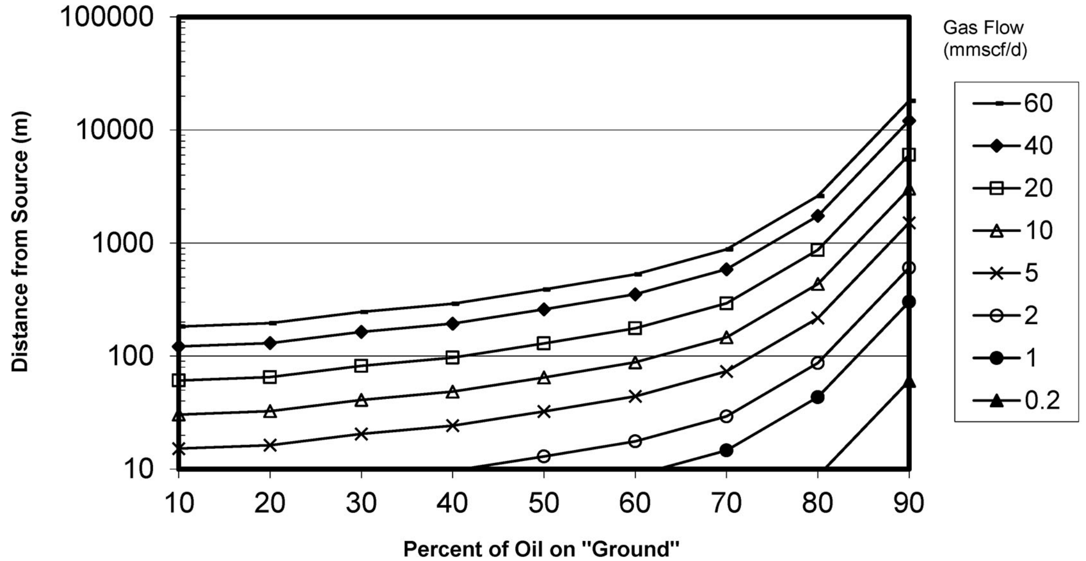
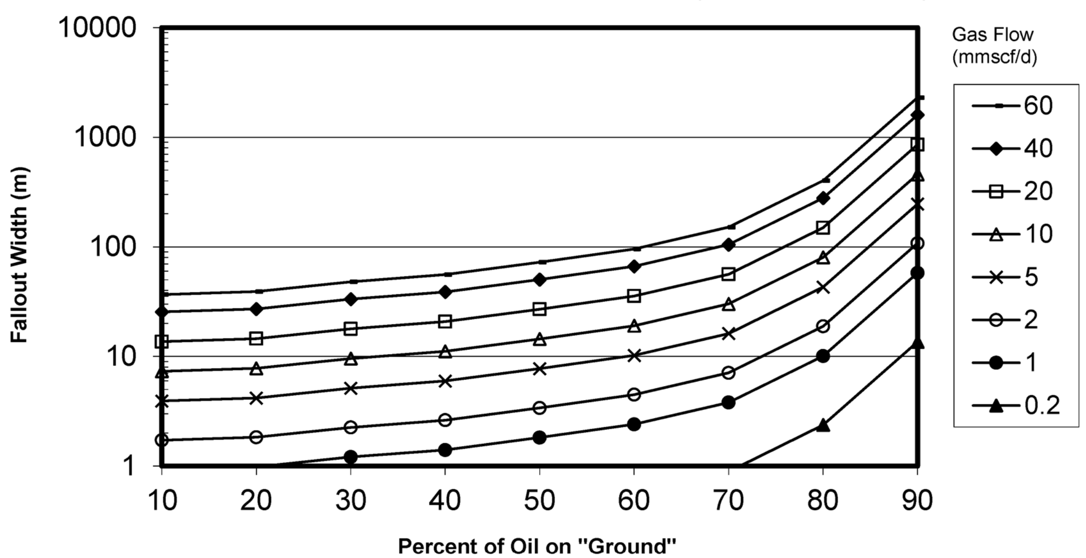



FIGURE 9
FALLOUT WIDTH VS. PERCENT ON THE GROUND (8.681-INCH ID PIPE)






*NOTE: All values given on these pages are for planning purposes only.*

**Blowout Modeling (Page 8 of 8) TACTIC T-6**

FIGURE 10
OIL FALLOUT PERCENT VS DISTANCE FROM SOURCE (12.374-IN ID PIPE)

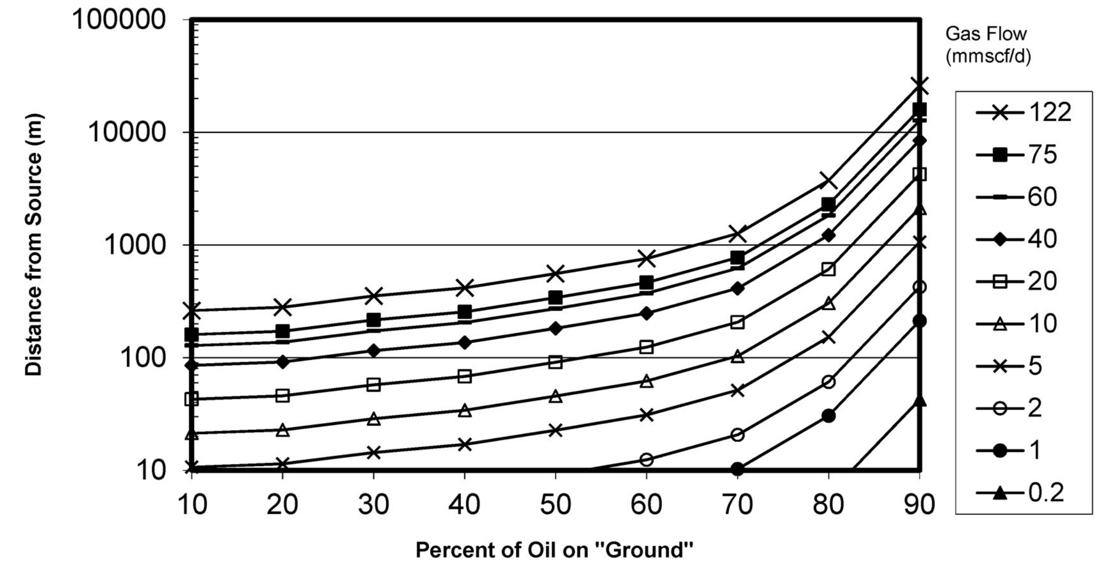
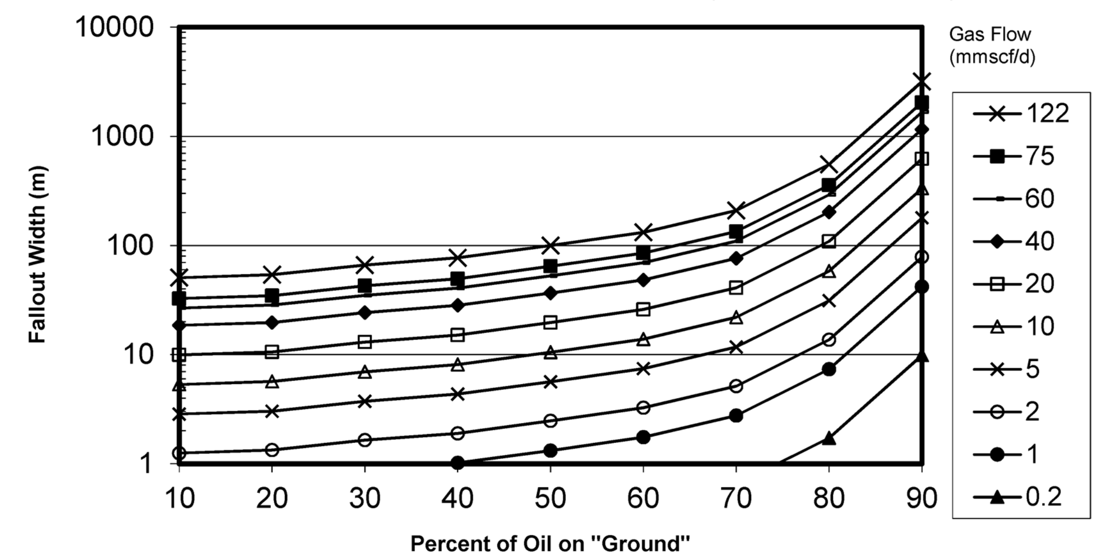



FIGURE 11
FALLOUT WIDTH VS. PERCENT ON THE GROUND (12.374-INCH ID PIPE)




*NOTE: All values given on these pages are for planning purposes only.*

## TACTIC T-7 Spill Volume Estimation (Page 1 of 2)

### SPILL VOLUME ESTIMATION

**OIL IN OR ON SOILS**

- It is difficult to estimate the amount and extent of subsurface pollution from hydrocarbons spilled and trapped in soil.
- Hydrocarbons in soil may exist in three phases:
  – As vapors within the pore spaces
  – As residual liquid attached to or trapped between soil particles
  – As dissolved components of oil in moisture surrounding soil particles
- Generally, oil retention increases with decreasing grain size, poorer sorting of soils, and increasing oil viscosity.
- Oil retention of initially water-saturated soils is generally lower than for initially dry soils.
- The "retention capacity" factor for different types of soils provides an estimate of volume of liquid retained per unit pore volume. Following are rules of thumb for retention capacity of soil types:

| | Silt | Sand | Gravel |
|---|---|---|---|
| **Crude Oil** | 12% - 20% | 4% - 13% | 0% - 5% |
| **Diesel** | 7% - 12% | 2% - 8% | 0%- 2% |
| **Gasoline** | 3% - 7% | 1% - 5% | 0% - 1% |

**OIL ON ICE AND SNOW**

- Field experience and data from actual spills indicate that oil-holding capacities of ice and snow range as high as 1,600 barrels per acre.
- Equations for estimates:
  $V (bbl) = (4.14 \times 10^5) \times A (mi^2) \times t (in.)$
  $V (bbl) = 647 \times A (acres) \times t (in)$
  $V (bbl) = (1.48 \times 10^{-2}) \times A (ft^2) \times t (in.)$
  $V (gal) = 42 \times V (bbl)$
  V = Volume of oil spill
  A = Area of oil slick or contaminated zone
  t = Thickness of oil slick or contaminated zone (with snow, t = equivalent oil thickness)

**OIL ON WATER**

- Oil Color
  – Sheen (silver-gray): Use $10^{-6}$ inch as average thickness
  – Iridescent (blue green): Use $10^{-4}$ to $10^{-5}$ inch as average thickness
  – Blue-black (aged, wind-blown): Use $10^{-2}$ to $10^{-3}$ as average thickness
  – Blue-black (fresh/equilibrium conditions): Use $10^{-1}$ inch as average thickness
  – Emulsion (brown/ "chocolate mousse"): Use $10^{-1}$ inch as average "oil" thickness (actually 2 to $3 \times 10^{-1}$ inch with 50% to 70% water).

- Equations for estimates:
  $V (bbl) = 4.14 \times 10^5 A (mi^2) \times t (inches)$
  $V (bbl) = 647 A (acres) \times t (inches)$
  $V (bbl) = 1.48 \times 10^{-2} A (ft^2) \times t (inches)$
  $V (gal) = 0.624 A (ft^2) \times t (inches)$
  V = Volume of oil spill
  A = Area of slick at thickness t
  t = Thickness of oil slick

 *NOTE: All values given on these pages are for planning purposes only.*

## Spill Volume Estimation (Page 2 of 2) TACTIC T-7

**ENCOUNTER RATE CALCULATIONS**

- Calculations used to estimate the amount of oil moving past in a stream, entering a collection boom, or in a windrow/patch of oil.

  $EnR (gpm) = 37 \times W (ft) \times V (ft/sec) \times t (in)$
  $EnR (bbl/hr) = 53.33 \times W (ft) \times V (ft/sec) \times t (in)$
  $EnR (bbl/day) = (1.28 \times 10^3) \times W (ft) \times V (ft/sec) \times t (in)$
  W = Width of oil swath
  V = Velocity in feet per second (1 knot = 1.68 ft/sec)
  t = Thickness of oil slick

### ESTIMATING SPILL SOURCE VOLUMES AND FLOW RATES

**LEAK RATE CALCULATIONS**

| | | |
|---|---|---|
| One drop/second | = | 1 gallon per day |
| Thin stream breaking to drops | = | 24 gallons per day |
| Small stream (about 1/8 inch) | = | 84 gallons per day |
| Large stream (about 1/4 inch) | = | 936 gallons per day |

*A simple rule of thumb is to divide 10,000 by the number of seconds it takes to fill a five-gallon pail.*

**ESTIMATES FOR CAPACITY**

- Pipeline per linear foot
  – For volume in gallons per foot: square the inside diameter (in inches) and multiply by 4 percent (0.04)
  – For volume in barrels per foot: square the inside diameter (in inches) and divide by 1,000
  – To find the volume of a pipeline in barrels per mile: square the inside diameter (in inches) and multiply by 5.13

- For vertical cylindrical tanks:

  $V (gal) = 0.0034\, d (in.) \times d (in.) \times h (in.)$
  $V (gal) = 5.88\, D (ft) \times D (ft) \times H (ft)$
  d = diameter in inches
  D = diameter in feet
  h = height of liquid in inches
  H = height of liquid in feet

**NOTE:**

The National Oceanic and Atmospheric Administration publishes an observer's guide that contains more information on estimating oil spill volumes.

*NOTE: All values given on these pages are for planning purposes only.* 

# 5 Abbreviations and Acronyms

LIST OF ACRONYMS

| | |
|---|---|
| AK | Alaska |
| AAC | Alaska Administrative Code |
| ACS | Alaska Clean Seas |
| ACP | Area Contingency Plan |
| ARP | Alaska Regional Plan |
| ADEC | Alaska Department of Environmental Conservation |
| AMOP | Arctic Marine Oil Spill Program |
| ARRT | Alaska Regional Response Team |
| ARLIS | Alaska Resource Library and Information Services |
| A & WAACP | Arctic & Western Alaska Area Contingency Plan |
| bbl | barrels |
| bopd | barrels of oil per day |
| BMC | Blowout Model Calculator |
| BIPM | Bureau International de Poids et Mesures |
| BSEE | Bureau of Safety and Environmental Enforcement |
| CFR | Code of Federal Regulations |
| DOI | Department of Interior |
| EPA | Environmental Protection Agency |
| ESRP | Estimated Recovery System Potential (calculator) |
| FAA | Federal Aviation Administration |
| FOSC | Federal On Scene Coordinator |
| GC | Gathering Center |
| GOR | Gas to Oil Ratio |
| GUI | Graphical User Interface |
| hr | hour |
| ISB | In-situ burning |
| IOSC | International Oil Spill Conference |
| ISO | International Standards Organization |
| MS Teams | Microsoft Teams |
| MMS | Minerals Management Service |
| NCP | National Contingency Plan |
| NIST | National Institute of Standards and Technology |
| NPREP | National Preparedness for Response Exercise Program |
| NEC/AAAE | Northeast Chapter of the American Association of Airport Executives |
| OSPD | Oil Spill Preparedness Division |
| OSRP | Oil Spill Response Plan |
| ODPCP | Oil Discharge Prevention and Contingency Plan |
| PC | Proficiency Checks |
| PPRP | Prevention Preparedness and Response Program |
| RC | Revised Calculator (ROSI) |
| RT | Revised Tool |
| RCP | Regional Contingency Plan (Alaska) |
| RPS | Response Planning Standard |

| | |
|---|---|
| RFAI | Request for Additional Information |
| RFQ | Request for Quote |
| ROSI | Recovery of Oil on Snow and Ice Calculator |
| SI | International System of Units |
| SPAR | Spill Prevention and Response |
| TM | Tactics Manual (Alaska Clean Seas) |
| UM | User’s Manual (Recovery of Oil on Snow and Ice Calculator) |
| US | United States |
| USCG | United States Coast Guard |
| USCU | United States Customary Units |
| WCD | Worst Case Discharge |

**Department of the Interior (DOI)**
The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

**Bureau of Safety and Environmental Enforcement (BSEE)**
The mission of the Bureau of Safety and Environmental Enforcement works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.

**BSEE Oil Spill Preparedness Program**
BSEE administers a robust Oil Spill Preparedness Program through its Oil Spill Preparedness Division (OSPD) to ensure owners and operators of offshore facilities are ready to mitigate and respond to substantial threats of actual oil spills that may result from their activities. The Program draws its mandate and purpose from the Federal Water Pollution Control Act of October 18, 1972, as amended, and the Oil Pollution Act of 1990 (October 18, 1991). It is framed by the regulations in 30 CFR Part 254 – *Oil Spill Response Requirements for Facilities Located Seaward of the Coastline*, and 40 CFR Part 300 – *National Oil and Hazardous Substances Pollution Contingency Plan*. Acknowledging these authorities and their associated responsibilities, BSEE established the program with three primary and interdependent roles:

- Preparedness Verification,
- Oil Spill Response Research, and
- Management of Ohmsett - the National Oil Spill Response Research and Renewable Energy Test Facility.

The research conducted for this Program aims to improve oil spill response and preparedness by advancing the state of the science and the technologies needed for these emergencies. The research supports the Bureau's needs while ensuring the highest level of scientific integrity by adhering to BSEE's peer review protocols. The proposal, selection, research, review, collaboration, production, and dissemination of OSPD's technical reports and studies follows the appropriate requirements and guidance such as the Federal Acquisition Regulation and the Department of Interior's policies on scientific and scholarly conduct.