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Inland Estimated Recovery System Potential Preliminary Factors, Requirements and Conceptual Model

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Inland ERSP Preliminary Factors, Requirements and Conceptual Model

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EXECUTIVE SUMMARY

The study objective was to develop a set of algorithms and a model architecture that may be used to create an ERSP calculator applicable for the unique features and operational challenges of mechanical oil spill response operations in inland environments. This document provides the framework for developing the conceptual model for the Inland Estimated Recovery System Potential (ERSP) Calculator centered on the premise that the calculator is primarily a planning tool for oil spill response. The intended use of the calculator is to estimate the potential mechanical oil recovery capability of a skimming system based on its encounter rate, configuration, swath width, pumping rate, operating time, and storage capacity under generally favorable environmental conditions. **Note: As a planning tool, the Inland ERSP Calculator is specifically not designed for application as a measure or predictor of actual oil spill recovery performance in the field.**

In addition to outlining the conceptual model framework for the Inland ERSP Calculator, this document also provides the initial requirements for the calculator. This includes the functional, user, system and data requirements for the development of the actual response planning tool.

To prepare for mechanical recovery operations in a vast spectrum of oil spill scenarios, response officials and planners must be able to objectively and relatively simply quantify the potential capabilities of a wide variety of different types of equipment. The use of a “response calculator” or “response planning tool” facilitates more accurate planning for equipment caches, resource management, oil spill response plans, and Oil Spill Removal Organization (OSRO) classifications. To this end, several organizations developed response calculators over the years including the ERSP Offshore calculator that the Bureau of Safety and Environmental Enforcement (BSEE) created in collaboration with the USCG. The Offshore ERSP calculator is based on oil encounter rate and evaluates mechanical recovery equipment as a complete “system,” as opposed to focusing on an individual component, such as the skimmer capacity or an intake pump. While the Offshore ERSP calculator appears to improve mechanical recovery planning for offshore skimming operations, the USCG recognized that it may not be applicable for inland operating environments. In more confined, shallow areas with restrictions on maneuverability and variable surface water width, the offshore skimming systems with large swath width and large onboard or tethered storage solutions are less likely to be effective. To mitigate these shortcomings and support the ERSP calculator’s possible adaptation by the USCG and/or inclusion into regulations, the United States Coast Guard (USCG) Office of Marine Environmental Response Policy (CG-MER) desires to incorporate the inland and nearshore operating environments into a new ERSP calculator.

The Inland ERSP Calculator incorporates significant portions of the existing Offshore ERSP Calculator with respect to the approach of calculating oil recovery based on the amount of recoverable oil, swath width, throughput efficiency, and recovery efficiency for open-water areas. The Inland ERSP Calculator also adapts the approach of the Offshore ERSP Calculator to shoreside conditions by considering the current flow that moves oil towards the skimmers in shoreside collection points rather than the speed of the advancing skimmer. However, there are some significant departures from the Offshore ERSP Calculator in that the Inland ERSP Calculator takes into account oil behavior by oil group to better quantify the amount of recoverable oil.



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LIST OF ACRONYMS AND ABBREVIATIONS

ADIOS	Automated Data Inquiry for Oil Spills
AMPD	Average Most-Probable Discharge
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
bbl	barrels
BSEE	Bureau of Safety and Environmental Enforcement
CAPS	capability limits
CFR	Code of Federal Regulations
CG-REG	Coast Guard Office of Standards, Evaluation, and Development
CG-MER	Coast Guard Office of Marine Environmental Response Policy
EDRC	Effective Daily Recovery Capacity
EPA	Environmental Protection Agency
ERSP	Estimated Recovery System Potential
FRP	Facility Response Plan
kts	knots
MMPD	Maximum Most-Probable Discharge
NOAA	National Oceanic and Atmospheric Administration
NSFCC	National Strike Force Coordination Center
NRT	National Response Team
OSRO	Oil Spill Removal Organization
OSRP	Oil Spill Response Plans
RDC	United States Coast Guard Research and Development Center
ReSET	Recovery System Evaluation Tool
ROC	Response Options Calculator
RRT	Regional Response Team
SIMAP	Spill Impact Model Application Package
SME	Subject Matter Expert
VRP	Vessel Response Plan
USCG	United States Coast Guard
WCD	Worst-Case Discharge



1 INTRODUCTION AND OBJECTIVES

The study objective for this project was to develop a set of algorithms and a model architecture that may be used to create an Estimated Recovery System Potential (ERSP) calculator applicable for the unique features and operational challenges of mechanical response operations in inland environments. In this report, the “project team” or “team” refers to the Contractor team and the USCG Research and Development Center (RDC) as the Project Manager for this study. This inclusive team worked together to accomplish the objectives of this project.

1.1 Background

To prepare for mechanical recovery operations to be employed in a vast spectrum of oil spill scenarios, response officials and planners must be able to objectively and relatively simply quantify the potential capabilities of a wide variety of different types of equipment. The use of a “response calculator” or “response planning tool” facilitates more accurate planning for equipment caches, resource management, oil spill response plans, and Oil Spill Removal Organization (OSRO) classifications. Appendix A provides background on the historical need for response calculators and an overview of existing calculators used as response planning tools.

Mechanical oil spill recovery planning currently depends on an equation contained in the Oil Pollution Act of 1990 and Executive Order 12777. This equation assigns an oil removal capability value to an individual oil skimmer. The Effective Daily Recovery Capacity (EDRC) calculator, which is the current standard oil spill recovery planning calculation method, depends only on the skimmer’s nameplate capacity.¹ Specifically, EDRC is calculated by taking 20 percent of the manufacturer’s rated throughput capacity over a 24-hour period. This 20 percent efficiency factor takes into account the limitations of the recovery operations due to available daylight, sea state, temperature, viscosity, and emulsification of the oil being recovered. The EDRC calculator came under heavy scrutiny as an inadequate means for vessel and facility plan holders to calculate their oil spill equipment needs in the wake of the 2010 Deepwater Horizon incident. The EDRC calculation omitted factors such as the encounter rate and onboard storage of skimmers. These limitations led the Bureau of Safety and Environmental Enforcement (BSEE) to develop a new calculator called the Estimated Recovery System Potential (ERSP)² in collaboration with the USCG.³

The Offshore ERSP calculator is based on oil encounter rate and evaluates mechanical recovery equipment as a complete “system,” as opposed to focusing on an individual component, such as the skimmer capacity or an intake pump. The Offshore ERSP calculator incorporated previously neglected factors such as decreasing oil thickness over time, swath width of skimmers, speed of the skimmers relative to the oil spill, oil/water separability, pump rate, onboard fluid storage, and one-way transit time to offload. Despite the more comprehensive system approach of the Offshore ERSP calculator, the simpler EDRC calculator remains the only oil spill response planning standard in the Code of Federal Regulations.

¹ The primary EDRC regulation is located in 33 CFR (Code of Federal Regulations) 154, Appendix C and CFR 155, Appendix B; and 30 CFR 254.44, which are administered by the USCG and BSEE, respectively. EDRC is also included by reference in 40 CFR 112 of the Environmental Protection Agency (EPA).

² <https://www.bsee.gov/sites/bsee.gov/files/mechrecovery-cal.html>

³ 79 *Federal Register* 45832. 6 August 2014.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Under many circumstances, the Offshore ERSP Calculator will “over-estimate” the amount of oil that would be recovered in a specific situation. A contractor demonstrated this phenomenon in a study conducted for BSEE for response capability planning for offshore blowouts (Figure 1).⁴

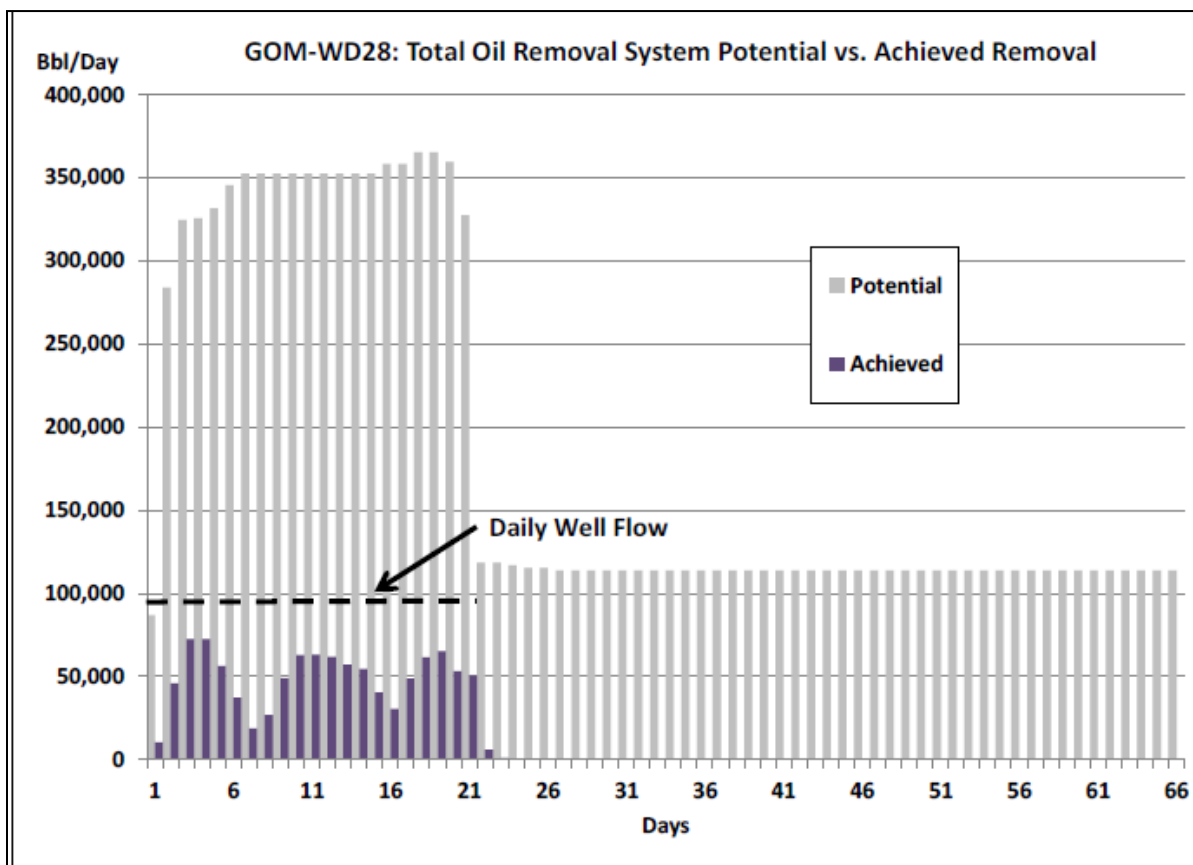


Figure 1. Example of potential (ERSP) removal capability and achieved removal for hypothetical blowout.⁴

In that study, the contractor compared the estimated removal capability, as estimated by the application of the Offshore ERSP Calculator,⁵ to the achieved removal based on a simulation of the blowout scenario. The effects of environmental conditions (e.g., currents, wave height, darkness), as well as the behavior of the oil in the environment (i.e., weathering and spreading on the water surface), limited the amount of oil recovered. Figure 2 shows a comparison between the different recovery estimates. A spill model (i.e., an oil spill trajectory and fate model, such as SIMAP) simulates the oil behavior and the degree to which the oil may be removed with mechanical recovery operations taking into account the limitations of recoverable oil (i.e., spreading, thickness on water surface, and patchiness) and environmental conditions that may hamper recovery, such as wave height, currents, and darkness. This approach more accurately reflects recovery in an actual spill situation. The EDRC and ERSP approaches do not address these types of limitations and would therefore generally over-estimate the recovery that would likely be realized under actual spill conditions.

⁴ Buchholz et al. 2016. After day 22, there is no oil removal because the oil is too thin on the water surface to allow for any recovery. The ERSP calculator indicates a “potential” recovery because it is not taking into account the fact that there is no longer any recoverable oil.

⁵ The ERSP Calculator, as presented in BSEE and Genwest Systems (2015), is referred to in this document as the “Offshore ERSP Calculator” to distinguish it from the Inland ERSP Calculator for which the project team developed the conceptual model described.



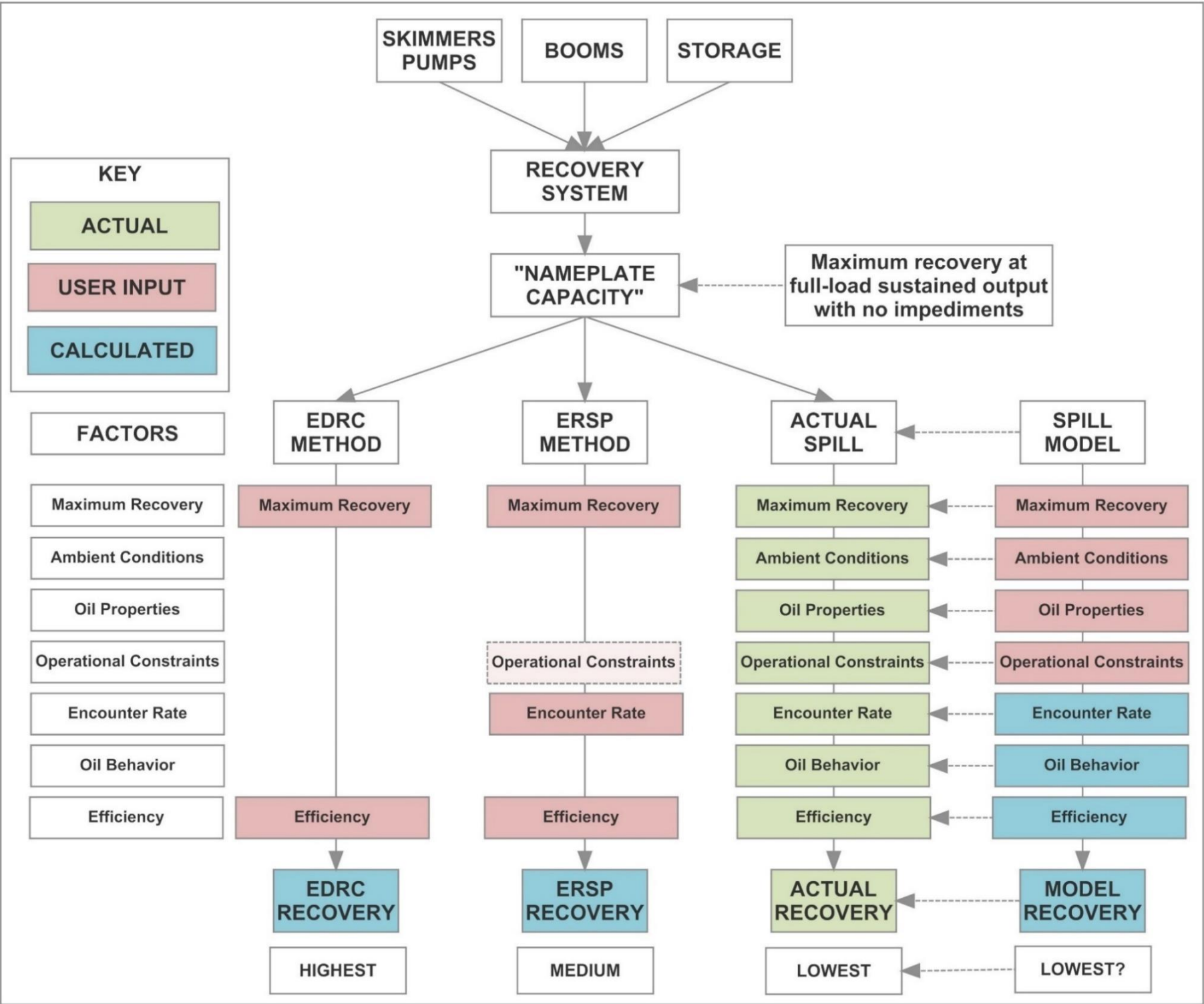


Figure 2. Comparison of recovery estimates by approach.



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While the Offshore ERSP calculator appears to improve mechanical recovery planning for offshore skimming operations, USCG recognized that it may not be applicable for inland operating environments. In more confined, shallow areas with restrictions on maneuverability and variable surface water width, the offshore skimming systems with large swath width and large onboard or tethered storage solutions are less likely to be effective. To mitigate these shortcomings and support the ERSP calculator's possible adaptation by USCG and/or inclusion into regulations, the Coast Guard Office of Marine Environmental Response Policy (CG-MER) desires to incorporate the inland and nearshore operating environments into a new ERSP calculator.

1.2 Purpose of the Inland ERSP Calculator as a Response Planning Tool

The framework for developing the conceptual model for the Inland ERSP Calculator is centered on the premise that the calculator is primarily a response planning tool for oil spills. The intended use of the calculator is to estimate the potential mechanical oil recovery capability of a skimming system based on its encounter rate, configuration, swath width, pumping rate, operating time, and storage capacity under generally favorable environmental conditions. The calculator does not take into account such environmental factors as debris, ice, sediment, extreme weather conditions, site accessibility issues, or any extenuating circumstances that may significantly reduce the effectiveness of mechanical recovery operations under geo-specific field or actual operating conditions.

Neither the Inland ERSP Calculator under development nor the existing Offshore ERSP Calculator take into account uncontrollable environmental conditions that may affect recovery system effectiveness in response operations. However, the incorporation of system and operations features in both of the calculators allows users to use them to estimate the potential for increasing recovery. For example, the calculators might be used to quantify the effect of increasing pumping rates by technical modifications or by including nighttime operations into the operational plan to significantly increase recovery rates.

Note: As a response planning tool, the Inland ERSP Calculator is specifically **not** designed for application as a measure or predictor of actual oil spill recovery performance in the field. While the use of the Inland ERSP Calculator in conjunction with other adjunct tools may provide better estimates of performance based on geo-specific field conditions or on certain mitigating circumstances, this is outside of the intended purpose of the tool.

An example of the way in which a response planning tool such as the Inland ERSP Calculator should be applied is for estimating the amount of recovery capability (skimming systems) that would be needed to meet the requirements for a Maximum Most Probable Discharge (MMPD) for facilities in generically-defined inland environments. Examples of additional applications for the response planning tool include: calculating the estimated recovery in a specific oil spill scenario (such as for an Oil Spill Response Plan for an inland facility or vessel); calculating the estimated recovery based on specific mobilization and transit times to a specific site; or customizing the characteristics of an inland waterway with the estimated amount of resource requirements for open-water and shoreside recovery operations.



2 POTENTIAL INLAND ERSP CALCULATOR

2.1 White Paper

In the first phase of this project, the team conducted interviews with government and industry subject matter experts (SMEs) to address the following tasks:

- Demonstrate the challenges and potential limitations of application of mechanical oil containment and recovery under various conditions (e.g., higher-velocity currents, shallower water, etc.), given field experience from case studies.
- Identify the factors, parameters, or variables (collectively called “factors”) that apply to planning for mechanical oil spill response in the inland environment (i.e., inland rivers, canals, lakes, and other waterways).
- Identify any assumptions, or limitations of each factor and its applicability to the problem.
- Identify the technical importance of each factor by gauging its sensitivity and impact on model validity and accuracy. Provide the sensitivity analyses (e.g., inputs for current velocity, oil surface thickness, oil spreading, viscosity, presence of ice or debris, ambient environmental factors) to provide more realistic estimates of capability under the more challenging inland response conditions.
- Determine the complexity of each factor in terms of research required, user workload (time and knowledge/experience required of user to input best value), usability, error-potential, data-availability (e.g., past actual operations, electronic charts, equipment capabilities reports, weather databases, simulations, etc.), potential for assigning a default value, potential for providing selection guidance to users, required update frequency for this application, and development level of effort.
- Incorporate possible highly-targeted test-tank or field (spill of opportunity) trials of equipment under specific conditions to establish realistic parameters and inputs for important variables in the ERSP model.
- Determine whether the factors are already included in the current Offshore ERSP calculator or fit the general model of the current Offshore ERSP calculator by classifying them as “encounter”, “recovery”, “storage”, or “offloading” factors.
- Identify the extent of the applicability of these factors across the variety of inland environments (e.g., lake vs. river location, weather, scenario, etc.).

The team selected interviewees to represent a broad spectrum of expertise and interests related to oil spill response operations. They included representatives from the following USCG offices: CG-MER, the Office of Standards, Evaluation, and Development (CG-REG), RDC, the National Strike Force Coordination Center (NSFCC), and several District offices. Other government agencies interviewed included the U.S. Environmental Protection Agency (EPA), BSEE, and the National Oceanic and Atmospheric Administration (NOAA). From industry, the team interviewed representatives from OSROs, oil companies, and other oil spill response experts. The team incorporated the outcomes of the interviews and the synthesis of the results in *Preliminary Analysis of Mechanical Oil Spill Response Planning Modeling Factors: White Paper* prepared for this analysis.⁶

⁶ Rowe et al. 2019.



2.2 General Issue of Purpose of Potential Inland ERSP Calculator

The interviewees generally expressed two different viewpoints about the purpose of the Inland ERSP Calculator and its implications. One viewpoint was that the use of the Inland ERSP Calculator as a *tactical response tool* during an incident required accounting for multiple geographic and environmental conditions (e.g., corralling of oil within containment boom with thicker oil for skimming operations, size of containment area, ice conditions, debris conditions, geography of the river, and shoreline cleanup). The second was that the use of the Inland ERSP Calculator should be used as a *response planning tool* to verify regulatory compliance of the Facility Response Plan (FRP) or Vessel Response Plan (VRP). Plan holders must ensure they are contracted with OSROs for sufficient response capability in the event of an incident. OSROs must verify their equipment capabilities with the USCG NSFCC.

As discussed previously, the purpose of the Inland ERSP Calculator is strictly as a *response planning tool*. Because there are different understandings of the purpose of the tool within the regulatory, industry, and response communities, the implementation of the Inland ERSP Calculator will require education about its purpose and appropriate application.

2.3 Recovery Factors for Potential Inclusion in Inland ERSP Calculator

The team asked White Paper interviewees to identify factors that would affect inland recovery for possible inclusion in the Inland ERSP Calculator. Table 1 summarizes interview results.

Table 1. White paper interview responses of major potential ERSP factors.⁷

Factor	Significance in Determining Recovery in Inland Environment	Challenges or Concerns for Inclusion in Inland ERSP Calculator	Importance for Inclusion in Inland ERSP Calculator
Sea State	Only spills in the Great Lakes and other large bodies of water in the inland environment will be impacted by winds and sea state. ⁸	Sea state is more relevant to an Offshore ERSP Calculator, but this input is not included in that calculation. Therefore, it is less relevant to include for the Inland ERSP Calculator.	This factor is much less important inland because inland responses do not deal with wave height limitations as with open water boom, skimming systems, and vessels.
Water Depth	Many areas are shallow, restricting types of skimmers and boats. Shallow water depth will limit the use of support vessels that would be constrained due to their draft.	Inclusion of this factor will depend on the scenario.	Different size boom, skimmers, and storage devices will be required for each scenario.
Oil Collection Points	One of the most important factors in inland responses in rivers is being able to divert the oil towards the shoreline for removal, much more so than removal by skimmers in the water.	Booming techniques will be a combination of deflection and collection in fast-moving waters as opposed to containment and collection in open water. Any input in a calculator for this variable will make a significant impact on other parts of the system.	For “constrained river” areas of response, it is important for all naturally-occurring collection points to be pre-loaded into the calculator.

⁷ Adapted from: Rowe et al. (2019). These statements reflect the viewpoints of the interviewees and are not necessarily the views of the project team.

⁸ Schulze 1998.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Table 1. White paper interview responses of major potential ERSP factors (Cont'd).

Factor	Significance in Determining Recovery in Inland Environment	Challenges or Concerns for Inclusion in Inland ERSP Calculator	Importance for Inclusion in Inland ERSP Calculator
Temporary Storage	While inland storage capacities are much smaller, they are often not integral to the skimming system. It is easier to find portable temporary storage to allow for either continuous recovery efforts or minor delays when offloading. The inland area is very limited by the size of the vessels. In the inland area, more barges and bladders would be used. Storage may actually be easier Inland than in the Offshore due to the ability to use vacuum trucks.	Two inputs for temporary storage are possible: One that calculates like the Offshore ERSP, and one that can calculate if the storage is not integral to what the storage need would be based on hours of operation, pump capacity, etc.	Temporary storage should be considered in the Inland ERSP calculator.
Decanting	Decanting regulations will vary by jurisdiction. ⁹	Ability to decant is a measurable factor that could be incorporated into the calculator. However, being able to release the treated water during a spill event may not be allowed without special permissions from the Regional Response Team (RRT) or the National Response Team (NRT).	Decanting is probably a variable that is not relevant to inland spills given the volumes are likely much lower as compared to offshore spills. Large storage tanks would not be used in these scenarios. Regulations are also more stringent for decanting in inland waterways.
Skimmer Class and Type	The types of skimmers used make a significant difference in a response. A weir skimmer would collect a greater percentage of water than an oleophilic skimmer, but these two skimmers would have the same rating. This difference is captured in the ERSP, but not the EDRC. Recovery efficiency is important. The type of skimmer is much more important an input than viscosity and emulsion values are. Oil collection can be maximized by the type of skimmer used. The type of skimmer head becomes very important (brush vs weir). This is true for both offshore and inland responses.	It is important for the ERSP Calculator to include inputs for "Types" of skimmers (e.g., manufacturer types) versus "Classes" of skimmers (e.g., weir, brush, drum)	Skimmer class is important in determining response efficiency, but it is not currently being applied in the Offshore ERSP Calculator and should not necessarily be included in the Inland ERSP Calculator.

⁹ See National Contingency Plan Revisions, 59 F.R. 47401, Sept. 15, 1994; SL Ross Environmental Research Ltd. 2005.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Table 1. White paper interview responses of major potential ERSP factors (Cont'd).

Factor	Significance in Determining Recovery in Inland Environment	Challenges or Concerns for Inclusion in Inland ERSP Calculator	Importance for Inclusion in Inland ERSP Calculator
Ice	Ice coverage would be important in selecting the right kind of mechanical assets to fit the recovery strategy.	The techniques used to recover oil in ice conditions are significantly different than in other environments. ¹⁰ There is no way to put any standards for an ice response as the size of the spill, thickness, and coverage of the ice, and the underlying currents will determine the best recovery method.	Difficult to incorporate into the Inland ERSP Calculator.
Debris	Debris is a problem in all environments, but would be greater perhaps in inland spill events. Skimmers cannot work once debris is caught up in the system.	Debris will significantly impact the type of booming and recovery methods in the inland environment. The size and type of debris will dictate what type of booming and skimming methods will be the most effective. No single input could capture this variable in a meaningful way.	Difficult to incorporate into the Inland ERSP Calculator
Sediment Load	Sediment impacts recovery, throughput, and decanting among other variables. However, it is better left for response planners to adapt to their specific sediment load situations in their local Area Contingency Plan.	For sediment load, there are too many variables to consider (density, quantity) when trying to identify a single input value for a calculator.	Difficult to incorporate into the Inland ERSP Calculator
Mobilization and Transit Time	Mobilization times are important aspects of response in inland environments. The geography and access are much more complicated inland which may result in longer transit times in some cases. Overall, inland response operations tend to have quicker mobilization times than for spills far offshore because there are shorter distances involved. The OSRO Guidelines / Current Regulations are a great starting point for mobilization times and on scene times.	ERSP is about skimming capability. It should not consider mobilization time. Response plans should cover this element of the response. The calculator should consider that the 24-hour clock starts when the skimmer turns on.	General consensus is that mobilization should not be part of any ERSP Calculator (Inland or Offshore), but rather it should be considered in the oil spill response plans.
Current Velocity	Fast water will be an issue in some inland environments. In a river, the current is important. However, boom can be set bank to bank and collection points can be established for skimmer deployments. In a lake, the equipment set-up would be more difficult.	Currents in rivers and streams can be more variable and significant than those in the offshore environment. A single input variable for a calculator severely limits the wide range of possibilities.	Current velocity would be the primary measurable factor that could and should be incorporated into the Inland ERSP Calculator because there is a greater potential for higher currents than what is experienced offshore.

¹⁰ Hansen 2014; Telford and Quam 1979.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Table 1. White paper interview responses of major potential ERSP factors (Cont'd).

Factor	Significance in Determining Recovery in Inland Environment	Challenges or Concerns for Inclusion in Inland ERSP Calculator	Importance for Inclusion in Inland ERSP Calculator
Swath Width	Swath width is typically smaller inland. For the encounter rate inland, if the right booming configuration is used, encounter rate can be maximized.	A single input would not be practical as each response scenario will require different recovery techniques. Attempting to identify the recovery potential for each scenario would be a tremendous undertaking.	It may not be feasible to include swath width.
Oil Type	In offshore, most products are more persistent. Inland, the range of products is very broad.	Different equipment is needed to pump high and low viscosity oils. Positive displacement pumps work much more effectively for low temperature, high viscosity products while centrifugal pumps can move high temperature, low viscosity oils	Very important consideration, persistent oils remain in the environment longer. Non-persistent oils are not recoverable for the most part. This factor is an important consideration since it dictates skimmer type.
Product Fate	There is a lot more dispersion inland because of the current. Light oils may not be recoverable.	Product fate is a very important consideration.	Unclear how to incorporate this into the Inland ERSP Calculator.
Inland Feasibility of Advancing Skimmer Systems	For advancing skimmer systems, there would be differences in the formulas due to the encounter rate and many different assumptions when compared to the Offshore ERSP.	It would be easier to develop two ERSP calculators, one for stationary systems and one for advancing systems.	Important to incorporate encounter rate into the Inland ERSP Calculator. It may need to be done separately for advancing and non-advancing skimming systems.
Inland Feasibility of Non-Advancing Skimmer Systems	Due to the inland environmental conditions, the primary type of skimming system is stationary. Generally, the oil is contained within a boomed area. In an offshore situation, the responders are chasing oil (wind rows) to get ahead of it. In inland areas, the oil is coming towards the skimmers.	It is feasible to develop an ERSP for stationary systems. Use current data instead of skimmer speed, collection boom length, distance from shore, and reach into water body.	ERSP can be incorporated for stationary systems in moderate current environments in inland rivers, creeks, and tributaries.
Great Lakes/Open Waters Issues	In situations where the “inland” waterway is comprised of open water, the same assets necessary for mechanical oil recovery would apply to both “open ocean” or “inland” environments. The systems brought on to mitigate the spill would essentially be the same.	The size of the water body is not a critical factor. It is important to establish how the water within that “body” is acting.	The Great Lakes and other open waters are more like offshore environments with some exceptions.



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Table 1. White paper interview responses of major potential ERSP factors (Cont'd).

Factor	Significance in Determining Recovery in Inland Environment	Challenges or Concerns for Inclusion in Inland ERSP Calculator	Importance for Inclusion in Inland ERSP Calculator
River/Restricted Water Issues	In constrained waters, the system would be dependent on corralling the spilled oil to a collection point onshore. For example, a boom-vane sub-system would be needed to deploy chevron booming which would drive the fast-moving oil to shore for collection and removal.	In fast-water booming situations, at a minimum, the calculator should notate the presence of the boom-vane sub-system, in good working order, as well as the time it takes for trained responders to arrive for deployment operations.	Restricted waters may be an important factor for fast-water booming situations.
Accessibility to Spill Site	The accessibility of the spill site is most important for “constrained river” environments in remote areas where roads leading to the site are difficult to transverse, especially for large vehicles carrying equipment or vacuum trucks.	There is some complexity to this variable, especially when considering pipeline right of ways that may not be on mapped roads. It is not possible to accurately predict the transit time.	Accessibility is a major issue for many inland responses. It would be an important factor to include, but difficult to quantify this input due to the variability in sites.
Aerial Surveillance	Aerial surveillance would be important in Great Lakes scenarios. Otherwise, aerial direction would be somewhat useless for directing the skimmers. Aerial surveillance is best used in the inland regions for determining where the oil’s leading edge is and for advising responders where they should be staging equipment to get ahead of the spill. ¹¹	Aerial observation (but not remote sensing) is part of the capability limits (CAPS) rule and should be updated if there is an update to equipment CAPS. Trained visual observation is clearly no longer the state of the art for oil detection. Accurate oil detection is so critical for both accurate targeting and period of operation extension that this portion of the regulatory requirement should not simply be lumped with the calculus that provides the required amount of removal hardware.	Perhaps important for Great Lakes scenarios, but not important for other inland scenarios.

2.4 Technical Challenges for Development of Inland ERSP Calculator

The recovery factors considered in Table 1 and the overall outcome of the White Paper¹² illuminate the major technical challenges for the Inland ERSP Calculator, namely:

- Incorporating those factors that would reasonably be considered to be essential to the purpose of the calculator as a response planning tool rather than a performance tool;
- Steering away from incorporating those factors that are too highly specific to particular spill scenarios; and
- Eliminating those factors that are environmental conditions that would affect recovery performance in the field rather than affect system potential.

¹¹ CEDRE 2015.

¹² Based on Rowe et al. 2019.



2.5 Factors Selected for Inclusion in Inland ERSP Calculator

The team considered the criteria of the response planning tool's purpose, non-scenario specificity, and system potential rather than environmental conditions in selecting the factors for potential inclusion in the calculator. In addition, the team needed to consider the practicality of incorporation of factors with respect to the need to categorize environments in a generic fashion, as well as for overall user-friendliness in its ultimate application.

In the White Paper¹³, the project team converted interviewee responses on the various factors (in Table 1), into scores and ranking based on the ranking criteria shown in Table 2.

Table 2. Ranking categories for factors.¹⁴

Issue Scoring-Ranking	Ranking Description
1	Low Priority: Not to be Considered for Further Evaluation/Research
2	
3	Moderate Priority: Has Positives & Negatives: Consider for Further Evaluation/Research
4	
5	High Priority: Consider for Further Evaluation/Research

¹³ Rowe et al. 2019.

¹⁴ Rowe et al. 2019.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

The outcomes of the factor rankings are shown in Table 3.

Table 3. Ranking of Inland ERSP Factors by interview respondents and team.¹⁵

Factor	Interview Respondents	Team	Team Comments
Current Velocity	5	5	Variable velocities, ebb & flood, waterbody specific, incentives for fast water resources
Oil Collection Points	5	3	Oil Collection points are unknown, planning calculator cannot forecast location/size/volume
Accessibility to Spill Site	5	2	Difficult to include this input in calculator
Skimmer Class/Type	4	5	Skimmer class/type important to determine effectiveness on various products & sea state
Temporary Storage	4	4	Inland temporary storage constraints differ from offshore
Product Fate	4	4	Persistent vs non-persistent oils differ
Inland Feasibility of Advancing Skimmer Systems	4	4	Need two separate calculators, one for advancing and one for stationary
Inland Feasibility of Non-Advancing Skimmer Systems	4	4	Need two separate calculators, one for advancing and one for stationary
Great Lakes/Open Waters Issues	4	4	Offshore ERSP could be applicable to Great Lakes ¹⁶
River/Restricted Water Issues	4	4	Boom configuration & current are important especially for stationary systems
Ice/Debris/Sediment	4	3	Difficult to include meaningful ice/debris/sediment impact in a response planning tool. These values would differ based on many factors, including location, season, etc.
Sea State	3	4	Sea State affects skimmer system recovery effectiveness, but this factor is much more important offshore ¹⁷
Swath Width	3	4	Important for both advancing and stationary systems ¹⁸
Water Depth	3	3	Water Depth influences draft & size of advancing skimmers, may not impact stationary systems: % of shallow water capability in planning standard
Mobilization and Transit	3	3	OSRO Classification addresses mobilization, planning standard already includes transit time
Oil Type	3	3	Skimming time on water versus on shoreline; match skimmer class/type to product
Aerial Surveillance	3	2	Not as important inland as offshore
Decanting	2	3	Lakes vs Rivers differ, shoreside decanting vs on water
Transfer-Offloading Pumps	2	2	Pump type and pumping rate would be important for persistent oils, less so for non-persistent
Salinity-Freshwater	1	1	ERSP calculates for floating product

¹⁵ Adapted from: Rowe et al. 2019. Only factors that would affect recovery were considered. Opinions on the use of the tool, etc., were excluded.

¹⁶ Inland ERSP Calculator does not include the Great Lakes.

¹⁷ ITOPF 2012.

¹⁸ ASTM F1780-18; ITOPF 2012.



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The team ultimately included the following factors (in no particular order of importance) in the conceptual model for the Inland ERSP Calculator:

- 1) Current velocity.
- 2) Oil collection points.
- 3) Accessibility to spill site.
- 4) Skimmer class/type.
- 5) Temporary storage.
- 6) Product fate.
- 7) Inland feasibility of advancing skimmer systems.
- 8) Inland feasibility of non-advancing skimmer systems.
- 9) Open water issues.
- 10) River/restricted water issues.
- 11) Sea state.
- 12) Swath width.
- 13) Water depth.
- 14) Mobilization and transit time.
- 15) Oil type.
- 16) Decanting.
- 17) Transfer-offloading pumps.

Section 3 contains a detailed description of the conceptual model of the Inland ERSP Calculator and the mode of incorporation for each factor.

The factors that the team specifically excluded in the conceptual model for the Inland ERSP Calculator were ice, debris, and sediment. The team concluded that, while these factors could affect recovery rates and feasibility, they are too scenario-specific to be incorporated into the response planning tool. The team determined responders would need to consider the way in which specific types of equipment might operate in ice, debris, and sediment conditions as part of the development of specific Oil Spill Response Plans. The team also decided that the Great Lakes could be adequately addressed with the regular application of the existing Offshore ERSP Calculator.

The team relegated mobilization, transit time, and site accessibility to inclusion only in a module outside the main Inland ERSP calculator, referred to as the Customization Module. These factors would clearly affect recovery performance in actual spill scenarios. However, the OSRO Classification already addresses mobilization as part of its planning standard. The calculated recovery rates from the Inland ERSP Calculator are based on the assumption that the site is accessed and the response equipment is deployed as per the standard time factors. Within the Inland ERSP Calculator website, the user will have the option to apply features within the Customization Module, to be discussed in further detail in Section 3, to estimate differences in outcome based on varying mobilization and transit times, as well as accessibility.

3 CONCEPTUAL MODEL OF INLAND ERSP CALCULATOR

3.1 Basic Terminology in Inland ERSP Calculator Conceptual Model

The following terms and acronyms are applied in the Inland ERSP Calculator conceptual model. Some of the terminology is specific to the model.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

- **Accessibility of site:** The degree to which a spill site can be reached and approached in order to allow responders to bring in work crews and equipment for mechanical recovery operations.
- **Advancing skimmer system:** An oil recovery system designed to sweep out the spill area of oil; a skimmer that operates when the system is moving (see Figure 3).¹⁹
- **Automated Data Inquiry for Oil Spills (ADIOS):** An initial oil spill response tool developed by the NOAA Office of Response and Restoration Emergency Response Division used to quickly access information about the properties and weathering of crude oils and refined products when spilled into water.
- **Average Most-Probable Discharge (AMPD):** For both vessels and facilities, the lesser of 50 barrels (bbl) or 1 percent of the Worst-Case Discharge (WCD);²⁰ for the Inland ERSP Calculator, a volume of up to 50 bbl.
- **Barrel (bbl):** 42 gallons of oil.
- **Batch spill:** A spill, discharge, or release of oil that occurs nearly instantaneously or over a relatively short period of time (minutes to hours and typically within 24 hours).
- **Confined-Flow (C-F):** A waterway without open-water areas but with at least some degree of flow or current, e.g., a creek.
- **Confined-Stagnant (C-S):** A waterway without open-water areas and also with no detectable flow or current, e.g., a pond.
- **Continuous spill:** A spill, discharge, or release of oil that occurs at a steady rate over a longer period of time (days, weeks, or months, and typically in periods after the first 24 hours).
- **Current:** The movement of water related to tides or gravitational forces that make it flow downhill.
- **Custom swath:** Swath for additional recovery or collection (active or passive) on water in shallower locations where the waterway configuration is relatively confined but does include some open areas that are too shallow for boats and advancing skimming systems.
- **Decanting:** The processing of collecting oil-water mixtures and returning the separated water back to the waterway to allow for efficient storage of collected oil (see Figure 3).
- **Discharge:** A release or spill of oil.
- **Discharge-specific factors:** The volume of the spill, discharge, or release, in addition to its duration.
- **Dissolution:** Dissolving or dispersion of soluble components of the spilled oil into the water.
- **Emulsification:** The mixing of oil and water into a phase in which oil droplets are suspended in water.
- **Encounter rate:** The amount and speed at which the skimmer comes in contact with the spilled oil.
- **ERSP:** Estimated Recovery System Potential.
- **Evaporation:** The vaporization of the lighter, more volatile components of the spilled oil.
- **Flow waterway:** A waterway with a detectable current, independent of the waterway dimension.
- **Inland ERSP Calculator:** The tool to be used to estimate the Estimated Recovery System Potential (ERSP) for inland environments, incorporating the Open-Water Recovery Calculator Module and the Shoreside Recovery Estimation Tool (see Figure 5).

¹⁹ ASTM 2018.

²⁰ 40 CFR§ 300.5.



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- **Customization Module:** An additional module outside of the main Inland ERSP Calculator, but included as a feature within the website, that the user has the option to use in order to calculate estimated recovery for specific spill scenarios based on geo-specific conditions and other factors, such as mobilization, transit time, accessibility, and/or relative percentage of open-water (see Figure 5).
- **Maximum Most-Probable Discharge (MMPD):** For facility spills, the lesser of 1,200 bbl or 10 percent of the Worst-Case Discharge (WCD), and for a vessel spills, the lesser of 2,500 bbl if oil capacity is less than 25,000 bbl, and 20 percent of oil capacity if the capacity is greater than 25,000 bbl²¹ for the Inland ERSP Calculator, a spill in the thousands of bbl.
- **Maximum total fluid recovery rate:** The maximum rate at which fluids (oil, water-in-oil emulsion, and free water) can be processed by the skimming component of the system.
- **Mobilization:** The time it takes to prepare equipment for deployment, load equipment, and assemble crews prior to departing from a home base or an equipment site.
- **Navigable waterways:** Internal waters of the United States that are subject to tidal influence, and internal waters that are not subject to tidal influence that: (1) are or have been used, or are susceptible for use, by themselves or in connection with other waters, as highways for substantial interstate or foreign commerce, notwithstanding natural or man-made obstructions that require portage; or (2) a governmental or non-governmental body, having expertise in waterway improvement, determines to be capable of improvement at a reasonable cost (a favorable balance between cost and need) to provide, by themselves or in connection with other waters, as highways for substantial interstate or foreign commerce (based on 33 CFR § 2.36).²²
- **Night/darkness restriction:** The cessation or reduction of recovery operations during hours of darkness due to visibility constraints.
- **Offshore ERSP Calculator:** The name applied, within the context of this report and the Inland ERSP Calculator conceptual model, to the ERSP Calculator previously developed for use in offshore waters by the Bureau of Safety and Environmental Enforcement.²³
- **Oil Behavior Module:** A component of the Inland ERSP Calculator that calculates the weathering and emulsification of spilled oil by Oil Group to determine the amount of recoverable oil.
- **Oil behavior-specific factors:** The factors that affect the way in which spilled oil behaves and determines the condition and fate of the oil, as well as the availability of recoverable oil.
- **Oil fate:** The chemical and physical processes that oil goes through after a spill, including the movement of the oil.
- **Oil Group I:** Non-persistent oil, such as jet fuel and gasoline [(at least 50 percent of which, by volume, distill at a temperature of 340°C (645°F); and at least 95 percent of which, by volume, distill at a temperature of 370°C (700°F)].
- **Oil Group II:** Light oil, such as diesel, No. 2 fuel oil, light crude (specific gravity <0.85 or °API >35.0).
- **Oil Group III:** Medium oil, including most crudes (specific gravity 0.85 to <0.95 or °API ≤35.0 and >17.5).

²¹ 40 CFR§ 300.5.

²² Navigable waterway definition relates only to “internal waters”

²³ BSEE and Genwest Systems 2015.



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- **Oil Group IV:** Heavy oil, such as heavy crude and bunker fuel (specific gravity 0.95 to 1.0 or °API ≤ 17.5 and > 10.0).
- **Open water:** An inland (or internal) waterway with enough expanse and depth to accommodate boats and mechanical recovery equipment that would generally be operated as advancing skimming systems.²⁴
- **Open-Flow (O-F):** A waterway with open-water areas and at least some degree of flow or current, e.g., a river.
- **Open-Stagnant (O-S):** A waterway with open-water areas but generally without any detectable flow or current, e.g., a closed lake.
- **Open-Water Recovery Calculator Module:** The portion of the Inland ERSP Calculator that is used to estimate recovery potential on open-water areas. The Open-Water Recovery Calculator Module is a modification of the Offshore ERSP Calculator and is distinct from the latter (see Figure 5).
- **Open-water recovery:** On-water recovery operations that generally include the use of advancing skimming systems, as would be done in an offshore setting.
- **Patchiness:** The degree of continuity or discontinuity of an oil slick on the water surface.
- **Recovery efficiency:** A measure of the amount of oil/emulsion recovered compared to the total fluids recovered.
- **Recovery period:** The daily hours that oil recovery equipment operates.
- **Recovery system-specific factors:** The characteristics and capacities of the skimming system or equipment that affect the degree of recovery, including those related to skimming (maximum total fluid recovery rate, throughput efficiency, and recovery efficiency), and storage (available storage, percent decant, and decant pump rate).
- **Release duration:** The time period over which a continuous release occurs, e.g., a pipeline release that occurs at a rate of 10 barrels (bbl) per hour for three days, or an oil well that releases at a certain rate over several days or longer.
- **Release magnitude:** A specified input into the Inland ERSP Calculator that relates to the volume of spillage, whether that is a specified amount or a more generic AMPD, MMPD, or WCD volume.
- **Response Options Calculator (ROC):** A publicly-available oil spill planning and response model tool developed by Genwest Systems, Inc., to simulate oil weathering, spreading, and recovery by advancing skimming systems, dispersant application, and in-situ burning. ROC combined and updated NOAA's ADIOS and Spill Tools Programs and included new algorithms for oil slick spreading.
- **Sea state:** The degree of turbulence and waves on an open body of water, generally the ocean, but potentially also for a large lake or wide river with sufficient wind fetch to allow for the generation of waves.
- **Shoreside active collection:** Shoreside recovery operations in waterways with sufficient current to allow for the oil to be directed toward a stationary skimming system, acting as the speed would in an advancing skimmer system.
- **Shoreside Active Collection Calculator:** The portion of the Shoreside Collection Calculator used to estimate shoreside active collection (for locations with current) (see Figure 5).

²⁴ Presence of open-water areas in an inland water does not preclude the need for shoreside collection. These areas are considered separately.



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- **Shoreside collection:** Recovery operations conducted directly adjacent to the shore of the waterway with collection points created by booms and recovery achieved by stationary skimming systems; the oil is essentially brought to the skimmers by the current.
- **Shoreside passive collection:** Recovery operations conducted directly adjacent to the shore of the waterway with collection points created by booms and recovery achieved by pumping without the benefit of the oil being brought to the skimmers due to a lack of current.
- **Shoreside Passive Collection Calculator:** The portion of the Shoreside Collection Calculator used to estimate shoreside passive collection (for locations with no current) (see Figure 5).
- **Shoreside Recovery Estimation Tool:** The portion of the Inland ERSP Calculator used to estimate recovery in shoreside areas where stationary skimmers would be used in collection points adjacent to the shore (see Figure 5).
- **Site-specific factors:** The factors at a spill site that would affect operational issues, including current and workable swath, as well as situational constraints, such as mobilization time, accessibility, and high wind-sea state issues.
- **Situational constraint:** The factors that affect the degree of oil recovery in a specific spill scenario, such as mobilization, transit time, accessibility, and high wind-sea state issues.
- **Stagnant waterway:** A waterway generally without a detectable current, independent of the waterway dimension.
- **Stationary skimmer system:** A skimming system designed to operate in a fixed shoreside position rather than being towed or otherwise advanced through the water.
- **Swath:** The width over which the skimming system encounters an oil slick (see Figure 3).
- **Throughput efficiency:** The percentage of oil/emulsion taken on board the skimming system that ends up in the storage tank, out of the total volume of oil/emulsion encountered.
- **Transit Time to site:** The time that it takes to transit to the spill site and begin recovery operations.
- **Waterway characteristics:** The main factors that are used to describe or classify an inland waterway for the Inland ERSP Calculator, i.e., dimension and flow.
- **Waterway classifications:** The generic classifications of inland waterways for the Inland ERSP Calculator, including Confined-Flow (C-F), Confined-Stagnant (C-S), Open-Flow (O-F), and Open-Stagnant (O-S).
- **Waterway dimension:** The general width or expanse of the waterway so as to distinguish a waterway with “open-water” areas or being “confined” with no “open-water” areas.
- **Waterway flow:** The presence (or absence) of a detectable current at most times. Waterways are classified as being either “flow” or “stagnant,” independent of their waterway dimension classification. If there generally is sufficient wind fetch to allow oil to be blown across the water surface, this might also be considered part of “flow.”
- **Weathering:** The chemical and physical processes that oil undergoes after spilling, primarily evaporation and emulsification, which change the consistency and characteristics of the remaining oil, as well as the volume of recoverable oil.
- **White Paper:** The report, *Preliminary Analysis of Mechanical Oil Spill Response Planning Modeling Factors: White Paper* (Rowe et al. 2019) prepared for this project.
- **Wind fetch:** The distance that wind can travel over open water or land (adjacent to the waterway) to create waves and affect sea state.



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- **Workable swath:** The swath width that can practically be achieved in shoreside collection based on the equipment and site constraints.
- **Worst-Case Discharge (WCD):** For facilities, the largest foreseeable discharge in adverse weather conditions; for vessels, the discharge of the vessel's entire fuel or cargo oil, whichever is greater.²⁵ For the Inland ERSP Calculator, the WCD is a spill of tens of thousands to hundreds of thousands of bbl of oil or more.

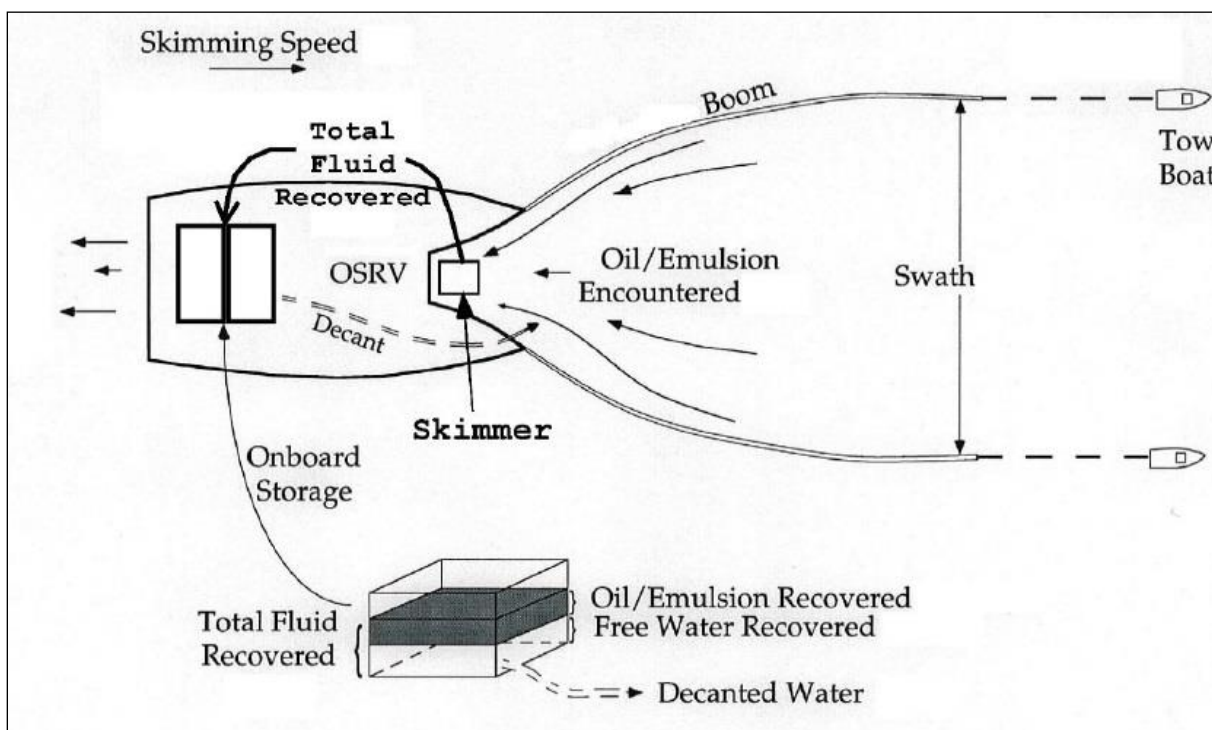


Figure 3. Advancing skimming recovery system components.²⁶

3.2 Overall Architecture of Inland ERSP Calculator

For the description of the conceptual model of the Inland ERSP Calculator, the team developed figures that are color-coded to allow the reader to connect the various figures visually. The color scheme is shown in Figure 4.

²⁵ 40 CFR§ 300.5. For facilities: (1) Where applicable, the loss of the entire capacity of all in-line and break out tank(s) needed for the continuous operation of the pipelines used for the purposes of handling or transporting oil, in bulk, to or from a vessel regardless of the presence of secondary containment; plus (2) The discharge from all piping carrying oil between the marine transfer manifold and the non-transportation-related portion of the facility. The discharge from each pipe is calculated as follows: The maximum time to discover the release from the pipe in hours, plus the maximum time to shut down flow from the pipe in hours (based on historic discharge data or the best estimate in the absence of historic discharge data for the facility) multiplied by the maximum flow rate expressed in barrels per hour (based on the maximum relief valve setting or maximum system pressure when relief valves are not provided) plus the total line drainage volume expressed in barrels for the pipe between the marine transfer manifold and the non-transportation-related portion of the facility; and for a mobile facility it means the loss of the entire contents of the container in which the oil is stored or transported.

²⁶ Source: BSEE and Genwest Systems 2015.

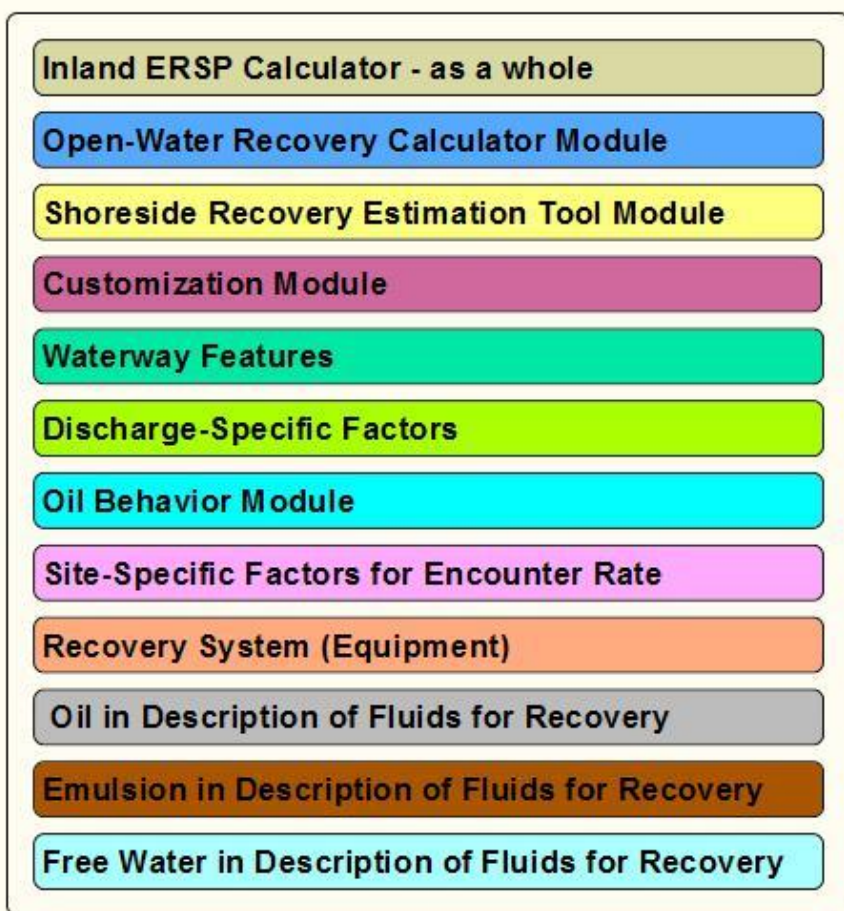


Figure 4. Color scheme for conceptual model diagrams and flowcharts.²⁷

The Inland ERSP Calculator is composed of two basic parts: the Open-Water Recovery Calculator Module, which is applied to estimate mechanical recovery in the open-water portions of an inland waterway, and the Shoreside Recovery Estimation Tool Module, which is applied to estimate recovery in shoreside collection areas where advancing skimmers cannot operate. The Shoreside Recovery Estimation Tool Module includes two subcomponents: the Shoreside Active Collection Calculator and the Shoreside Passive Collection Calculator, which are applied to estimate recovery in shoreside areas with and without currents, respectively. The purpose of this tool is to ***estimate recovery potential in a more general manner for generic inland waterway types for response planning***. The relationship between the various component modules of the Inland ERSP Calculator is shown in Figure 5.

²⁷ Color coding within this and the following figures is for convenience, but not necessary for the interpretation of the figures.

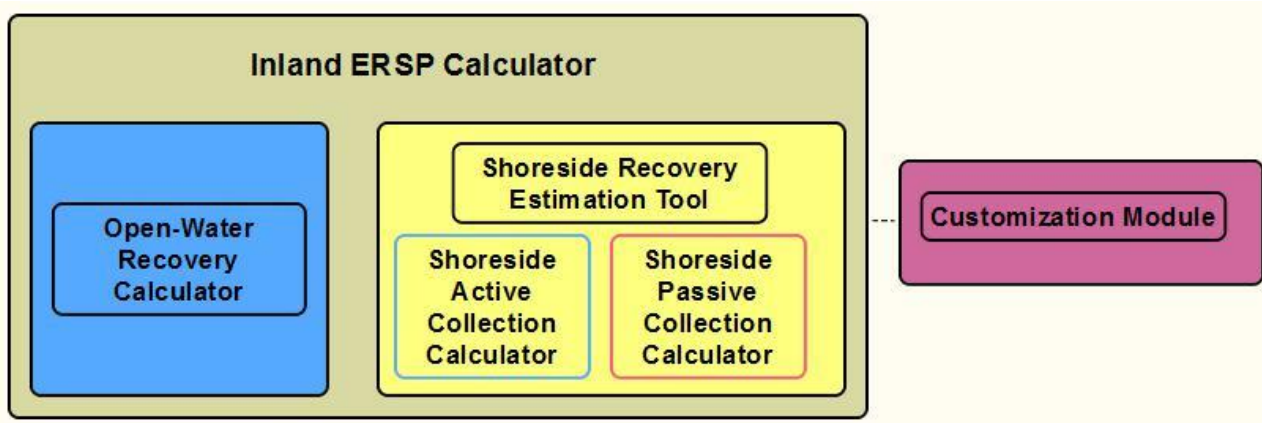


Figure 5. Main component modules of inland ERSP calculator.

Developers will largely base the Open-Water Recovery Calculator on the existing Offshore ERSP Calculator and will not fully re-create it for the Inland ERSP Calculator. The user will have the option to enter non-default input values in the Customization Module within the website, but outside of the main Inland ERSP Calculator (Open-Water Recovery Calculator and Shoreside Recovery Estimation Tool). The Customization Module will modify the results of the Inland ERSP Calculator based on geo-specific site characteristics inputs, including mobilization and transit time to the site, provided by the user. The purpose of this module is to provide a means to estimate recovery potential for specific Oil Spill Response Plans (OSRPs).

Figure 6 provides an overview of the scenario inputs, recovery factors and tool relationships within the Inland ERSP Calculator to be discussed in more detail throughout the remainder of Section 3. A simplified description of this overview is as follows:

- The user selects the essential inputs as part of the identification of the scenario, and these set up what is occurring with the spilled oil in its environment.
- Next, there are various factors (i.e., recovery factors from the scenario) from the user inputs that will affect the degree to which oil can potentially be recovered.
- The user then adds the recovery system, which will be removing a portion of the spilled oil. There are various factors that are defined by the engineering of the skimming system. These are the recovery factors from the equipment, which then, along with the scenario factors, are fed into the Inland ERSP Calculator to determine the recovery that can potentially occur.

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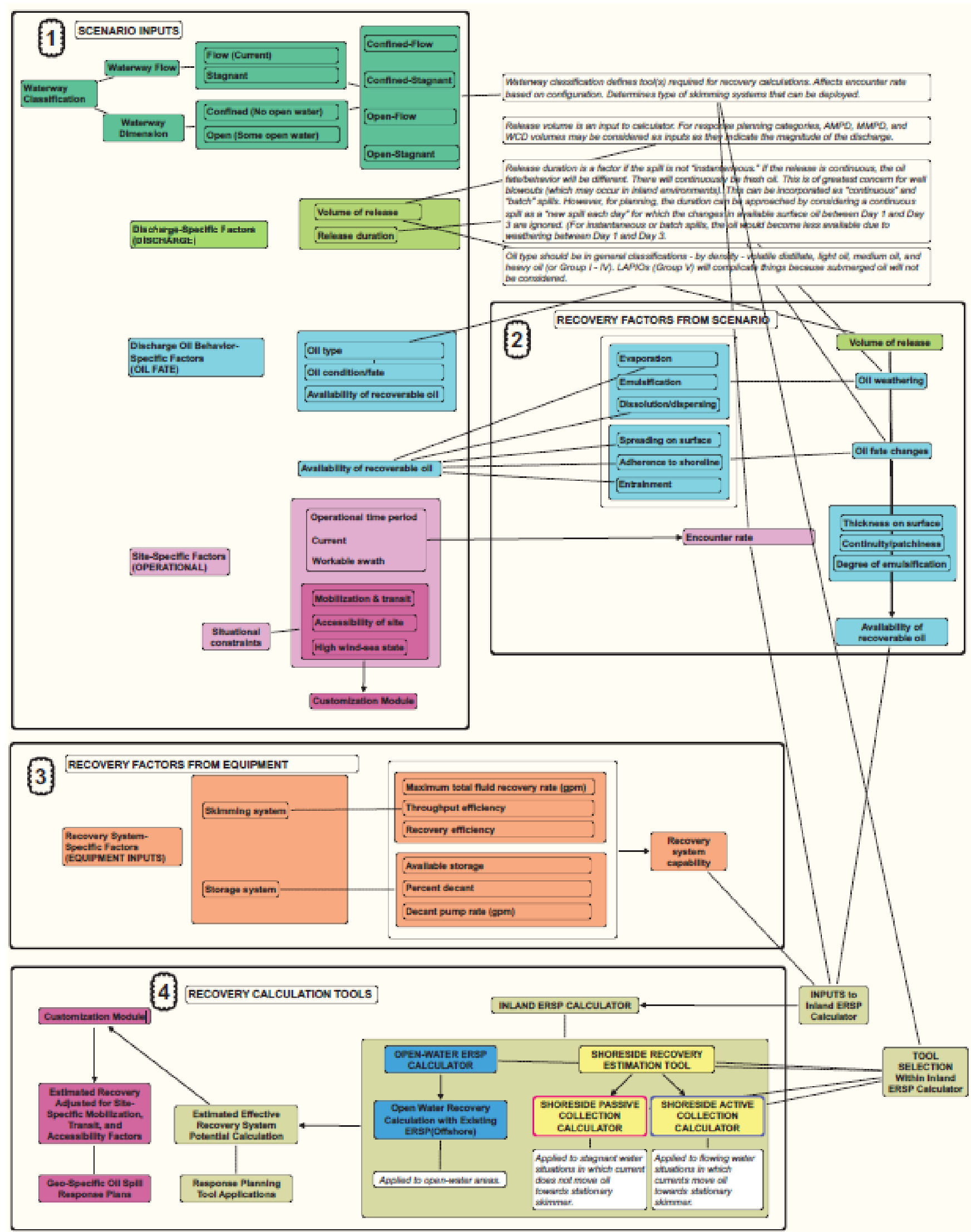


Figure 6. Scenario input, recovery factor, and tool relationships in inland ERSF calculator.



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3.3 Definition of Generic Waterways

The term “inland waterways” encompasses a broad spectrum of different types of waterways within the United States. In the context of the Inland ERSP Calculator, “navigable” and “non-navigable” waterways are included if a skimming system (advancing and/or stationary) might potentially be employed to conduct mechanical recovery operations in the event of an oil spill.

Since the Inland ERSP Calculator itself is not intended to be a geo-specific or spill scenario-specific recovery estimation tool, the team elected to develop a more generic classification approach for inland waterways. The classification captures the most important features of waterways with respect to mechanical recovery operations in oil spills. The Great Lakes were specifically excluded from the classification as per the results of the White Paper.²⁸ However, the Great Lakes connecting channels (e.g. St. Clair River, St. Marys River, Detroit River, etc.) would be acceptable as waterways for the Inland ERSP calculator.

The variety of potential inland oil spill scenarios include, but are not limited to, oil releases from: a submerged pipeline crossing a waterway, an above-ground pipeline crossing a waterway, a shoreside pipeline, a shoreside facility with storage tanks, a shoreside loading dock with a pipeline, a tank or non-tank vessel in transit, a tank or non-tank vessel at a loading or fueling dock, a small vessel in transit, a small vessel at a fueling dock, a railroad crossing a waterway, a shoreside railroad, a shoreside tanker truck, or a shoreside inland production well. The term “shoreside” is used here loosely, meaning any on-land spill source in which the spill might reach a waterway. After considering the variety of spill scenarios and receiving environments, the team identified three major characteristics of waterways to include in the calculator:

- 1) Dimension (wide vs. more confined configuration);
- 2) Flow (presence or absence of current or flow); and
- 3) Wind fetch (presence or absence of open areas with sufficient fetch to allow winds to create waves high enough to impede mechanical recovery).

Waterway dimension was divided into two main types:

- 1) “Confined,” in which the configuration and depth of the waterway could not reasonably accommodate open-water recovery operations (e.g., a small creek or stream, or a small pond); and
- 2) “Open-water,” in which there is sufficient space and depth to accommodate open-water recovery operations with boats and advancing skimmers (e.g., a wide river like the Hudson River or Ohio River, or a moderate-sized lake).

Waterways classified as “open-water” also include nearshore areas requiring shoreside collection techniques that are also applicable to more confined waterways. In the Inland ERSP Calculator, the calculations for spills in open-water locations include both the application of the Open-Water Recovery Calculator Module and the Shoreside Recovery Estimation Tool Module (Figure 5).

²⁸ Rowe et al. 2019.



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Waterway flow was divided into two main types:

- 1) Flow, in which there is generally some degree of detectable current; and
- 2) Stagnant, in which the water is not generally moving (e.g., a small pond or creek with virtually no current).

Wind fetch is an important factor when there are higher wind speeds and durations, as well as larger fetch distances that may cause waves to form. Wave height is affected by wind speed, duration, and fetch distance. However, the team determined that unless the wind speed is at least 20–40 knots (kts) and the fetch distance is tens of miles for several hours, the effect on wave height would be inconsequential. Only in the largest lakes or widest river areas might there ever be waves that would impede mechanical recovery efforts.²⁹ The presence of sufficient wind fetch factors to cause higher waves also generally only occur on a situational basis (i.e., during times of unusually high winds). Wind fetch factors are generally associated with open-water areas. In addition, response resource criteria for river/canal and inland areas already require boom and recovery equipment that could withstand at least one-foot waves (Sea State 1) or three-foot waves (Sea State 2), respectively.³⁰ For these reasons, the team opted to eliminate wind fetch as a waterway classification factor. Wind as a factor that drives spilled oil across the water surface is considered separately in the Inland ERSP Calculator. It acts in conjunction with speed for open-water recovery with advancing skimming systems in open water, and with current for shoreside recovery to determine the encounter rate.

The waterway classifications for the Inland ERSP Calculator are shown in Figure 7.

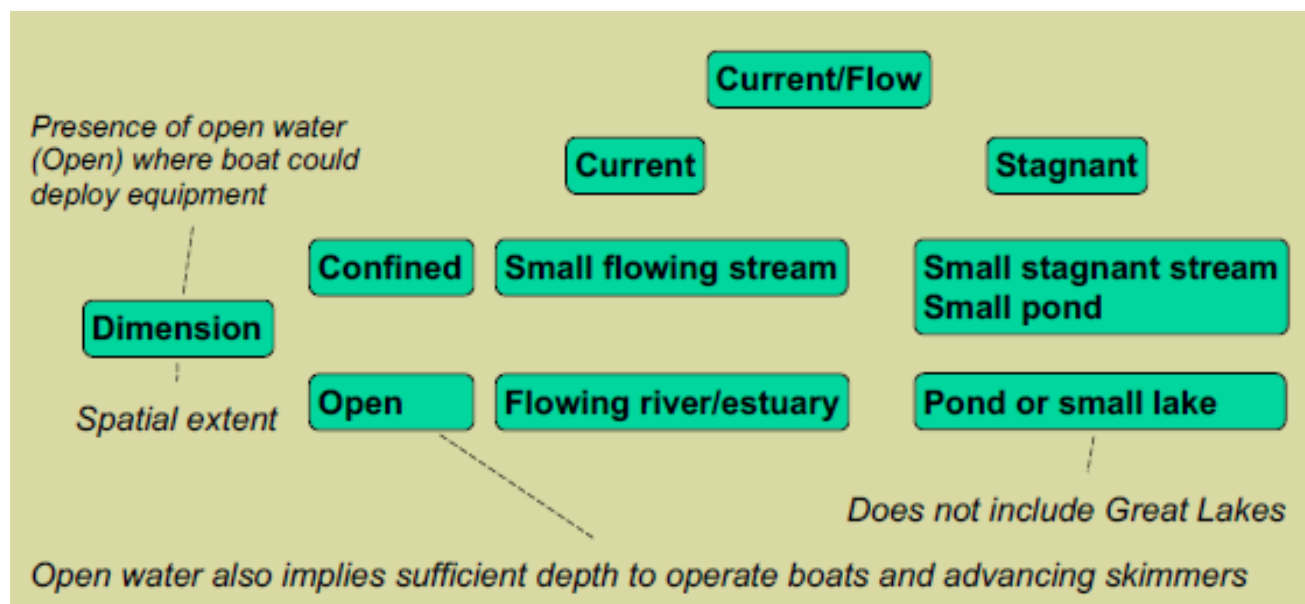


Figure 7. Waterway classifications for inland ERSP calculator.

²⁹ Wave heights over three feet tend to compromise booming, allowing oil to splash over or escape under the booms, which reduces the effectiveness of the booming. In addition, some skimmers cannot operate well in higher sea states (wave heights).

³⁰ NOAA 2017; CERC 1984



3.4 Identification of Essential Inputs

The team identified two basic inputs the user will use to identify the types of oil spills: 1) discharge-related inputs and 2) site-specific operational inputs.

3.4.1 Discharge-Related Inputs

Discharge-related inputs to the Inland ERSP Calculator include two major categories: discharge-related factors and oil behavior-specific factors.

The discharge-related factors are defined as the volume of the release as well as its duration. The volume or magnitude of the release could be considered as a specific hypothetical volume or as a general category, such as Average Most-Probable Discharge (AMPD), Maximum Most-Probable Discharge (MMPD), or Worst-Case Discharge (WCD). Alternatively, the volume discharge categories will be defined as small, moderate, or large with specific volume categories in orders of magnitude. For example, volume discharges will be defined in tens of barrels (bbl), thousands of bbl, and hundreds of thousands of bbl. The duration of the release is relevant in the case of continuous releases where oil is spilled at a certain rate over a period of time (e.g., in a well blowout).

The oil behavior-specific inputs are based on oil type, which is simplified to Oil Group (I–IV). Note that the Inland ERSP will not include Group V oils as they are non-floating substances that could not be recovered with conventional skimming systems. Based on the oil type, the fate of the oil is determined, including the degree to which it evaporates, emulsifies, dissolves or disperses, spreads on the water surface, and/or adheres to shoreline substrates. The “weathering” process- primarily evaporation, dissolution, and emulsification- changes the nature and amount of oil available for recovery on the water surface. The oil-behavior factors are summarized in Figure 8.

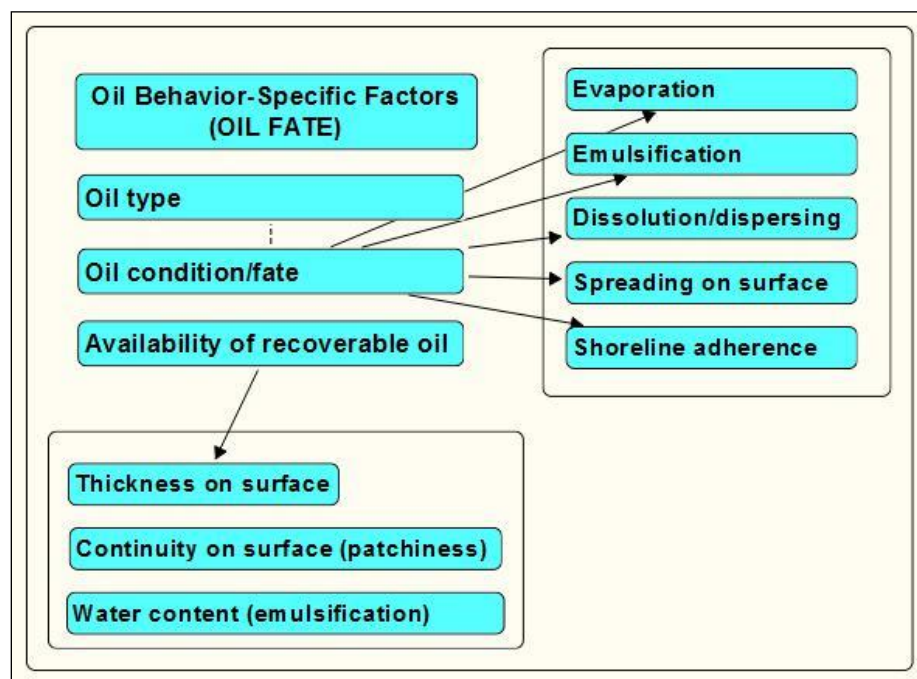


Figure 8. Oil behavior-specific factors for inland ERSP calculator.

3.4.2 Site-Specific Inputs

The team identified site-specific factors as those that would ultimately affect the encounter rate based mainly on the site characteristics rather than on the equipment characteristics. The three main inputs were:

- 1) Recovery period (hours per day of skimming operations and/or night/darkness restrictions);
- 2) Current (presence or absence of current); and
- 3) Workable swath (for shoreside collection, on-water collection in shallow water) based on site configurations as opposed to equipment specifications.

The last two of these factors are also essentially incorporated into the classification of the waterway, although not quantified therein.

In addition, the team identified situational constraints that could affect encounter rate, namely: mobilization time, transit time to the site, accessibility of the site, and high-wind or sea-state conditions (related to wind fetch). The team considered these factors to be too geo-specific and grouped them under factors that will be incorporated into the Customization Module and could be applied by the user for the development of specific Oil Spill Response Plans (OSRPs).

The site-specific factors are summarized in Figure 9.



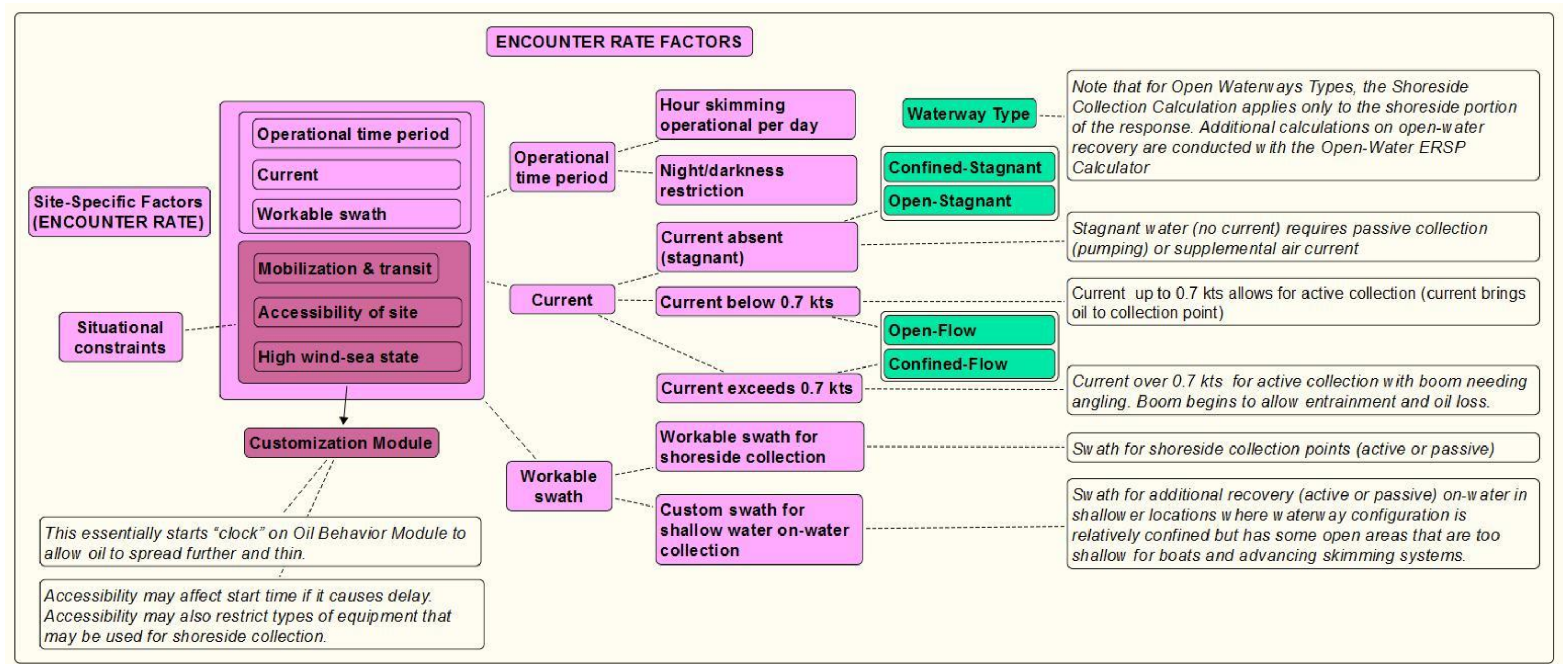


Figure 9. Site-specific factors for inland ERSP calculator.

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3.5 Incorporation of Recovery-System Factors

The team classified the recovery factors related to the equipment rather than the site conditions as “recovery system-specific factors.” The two main components are the recovery factors from the skimming components of the system and the storage factors. These are roughly analogous to the factors in the Offshore ERSP Calculator in that they include throughput efficiency and recovery efficiency.

Skimming involves recovering a mixture of oil and water. The maximum total fluid recovery rate of a skimming system is a measure of the total amount of fluids that can be processed by a skimmer in a certain time (e.g., bbl per hour). The fluids include recovered oil, emulsion, and free water.³¹ The throughput efficiency is a measure of the percentage of oil and/or emulsion taken on board (not counting free water) relative to the amount of oil/emulsion encountered by the skimmer. The recovery efficiency is a measure of the percentage of oil/emulsion recovered by the skimming system compared to the total fluids recovered (including free water). The relationship between these three recovery factors is shown in Figure 10.

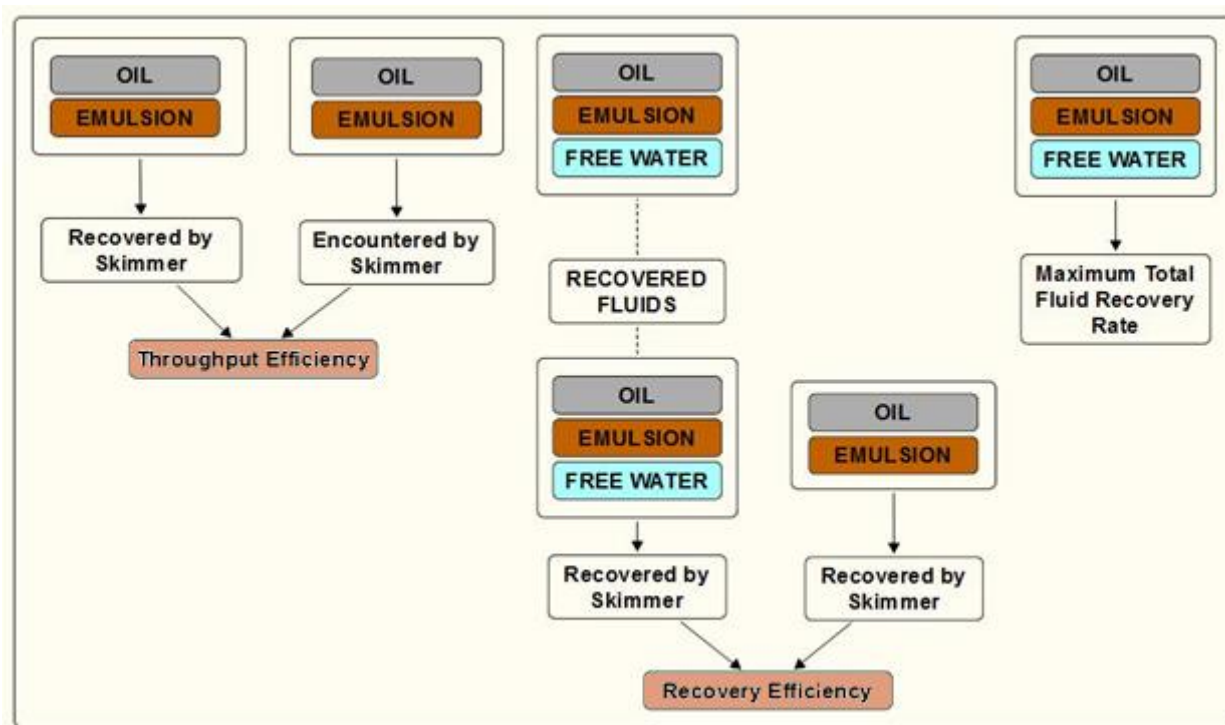


Figure 10. Relationship between recovery factors in inland ERSP calculator.

Decanting is not incorporated into the Shoreside Collection Estimation Tool. Storage capacity and limitations are, however, important factors in inland recovery operations. The recovery system-specific factors are summarized in Figure 11. Decanting is generally not permitted in most inland waterways (except with special authorization); thus, further reasoning for its exclusion from the Shoreside Collection Estimation Tool. This change represents a modification to the existing Offshore ERSP Calculator that is applied in the Open-Water Recovery Calculator Module within the Inland ERSP Calculator.

³¹ The term “free water” is used to distinguish the water from that which is incorporated into emulsion, which is a mixture of oil and water droplets.

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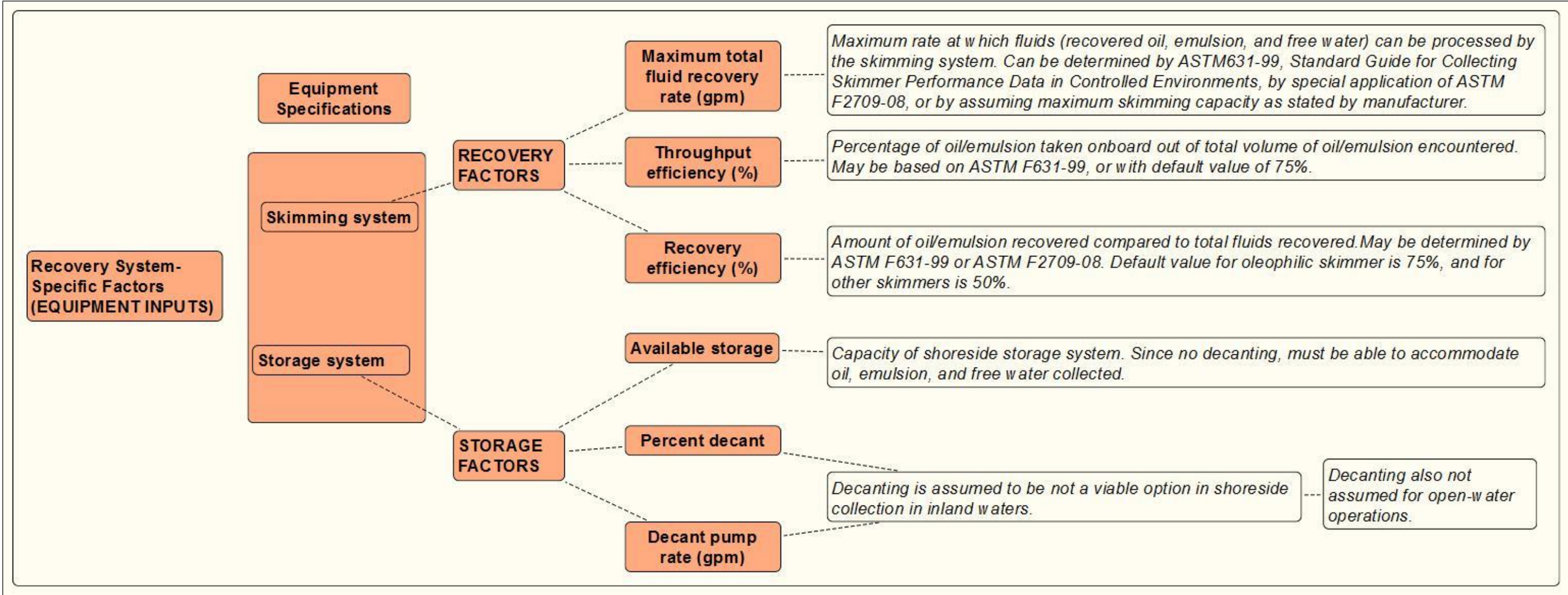


Figure 11. Recovery system-specific factors for inland ERSP calculator.

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3.6 Relationship between Scenario Inputs, Recovery Factors, and Tools

The scenario inputs (waterway classification, discharge factors, oil behavior factors, and site-specific factors) determine the encounter rate and are required to determine the availability of recoverable oil. The recovery system-specific factors determine recovery system capability. Depending on the classification of the waterway, a user can apply different parts of the Inland ERSP Calculator (Figure 12). The Inland ERSP Calculator is applied for estimation of recovery potential for response planning. The Customization Module (pink boxes in diagram) may be applied for geo-specific OSRP development. It incorporates more specific aspects of the site, as well as the proximity of responders to the hypothetical spill site.

The waterway types and the applicable tools are summarized in Table 4. For the Open-Water classifications (Open-Flow and Open-Stagnant), both the Open-Water Recovery Calculator Module (blue boxes in diagram) and the appropriate Shoreside Recovery Estimation Tool Module (yellow boxes in diagram) – either the Shoreside Passive Collection Calculator (for Open-Stagnant) or the Shoreside Active Collection Calculator (for Open-Flow) – will be applied. There will be two distinct recovery operations involved on the open water and at the shoreside, as these operations involve different types of skimming systems. Note that an individual spill scenario may involve portions of the response that involve more than one type generic waterway classification. For example, oil spilled into a confined waterway may flow downstream into a different waterway (or a different portion of the same waterway) that is more open. The Inland ERSP Calculator is not designed to estimate the recovery for a specific spill scenario. A response planner would need to view the two portions of this hypothetical spill response as separate entities. The user may employ the Customization Module to calculate different portions of recovery capability for different parts of the response.



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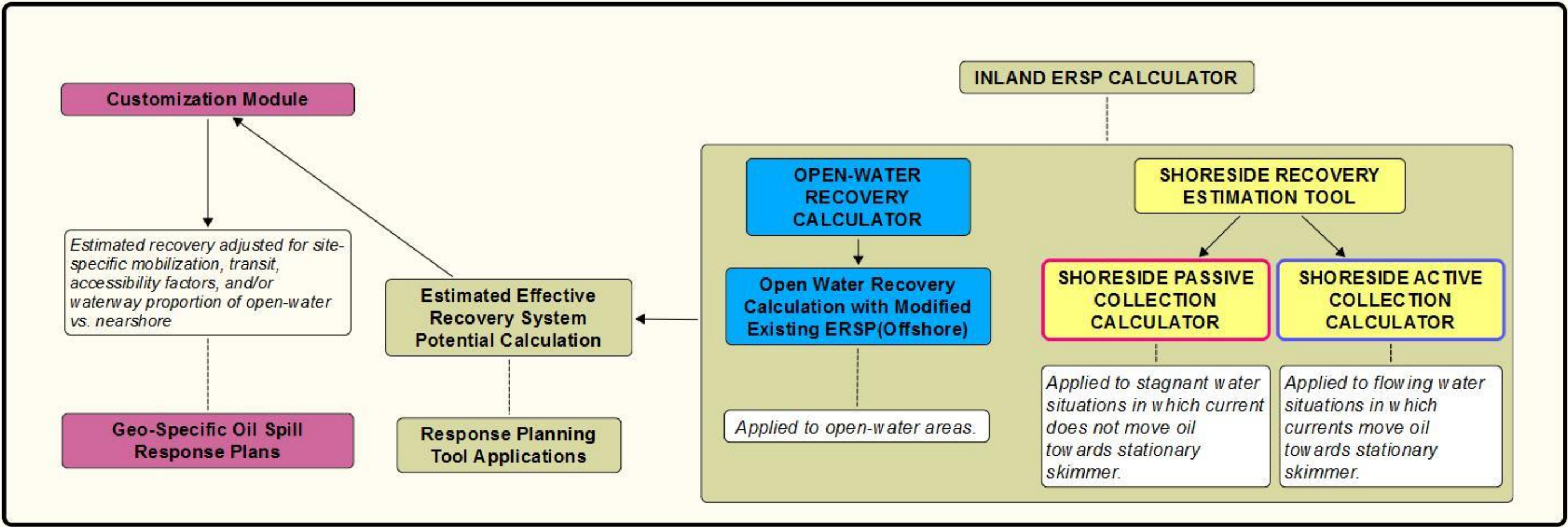


Figure 12. Recovery calculation tools.

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Table 4. Inland ERSP calculator tool application by waterway classification.

Waterway Classification	Open-Water Recovery	Shoreside Recovery
Open-Flow	Open-Water Recovery Calculator Module	Shoreside Active Collection Calculator
Open-Stagnant	Open-Water Recovery Calculator Module	Shoreside Passive Collection Calculator
Confined-Flow	None applied	Shoreside Active Collection Calculator
Confined-Stagnant	None applied	Shoreside Passive Collection Calculator

The ways in which the scenario inputs and recovery factors are captured in the recovery calculation tools is summarized in Figure 6.

3.7 Scenario-Type Specification for Recovery Calculations

The Inland ERSP Calculator requires a specification of a “scenario type” in the calculation process. While there is a broad spectrum of possible spill scenarios, the team applied three basic factors to define generic spill scenarios for the use in the response planning tool:

- 1) Waterway classification (four types: Confined-Flow, Confined-Stagnant, Open-Flow, and Open-Stagnant);
- 2) Oil type (four types: Group I, Group II, Group III, and Group IV); and
- 3) Magnitude of release (three types: AMPD, MMPD, and WCD).

The release type could be further classified as a “batch spill” or a “continuous spill.” This distinction would come into play with respect to determining the different amounts of recoverable oil after the first day. For batch spills, the availability of recoverable oil decreases with weathering over time, depending on the oil type. For continuous spills, the recoverable oil decreases with weathering, but fresh oil is added on a continuing basis. This more unusual circumstance for inland environments is handled separately in the Inland ERSP Calculator algorithms. The “default” spill is considered to be a batch spill in which the oil is spilled over a short period of time (generally minutes to hours, rather than days to weeks, as in a continuous release).

The scenario definition process is diagrammed in Figure 13. A “scenario” for the Inland ERSP Calculator is based on a combination of Waterway Classification, Oil Type, and Release Magnitude. With four Waterway Classifications, four Oil Types, and three Release Magnitudes, there are 48 hypothetical generic scenarios. For the user, the process is simplified. Rather than having to consider one of 48 scenarios, the user has to make only three selections—one waterway type, one oil type, and one release magnitude.

The Inland ERSP Calculator simplifies the definition of the scenario to three major factors. The major distinguishing factors in the scenarios are the Oil Type and Waterway Type. The Release Magnitude determines the amount of equipment that is applied.



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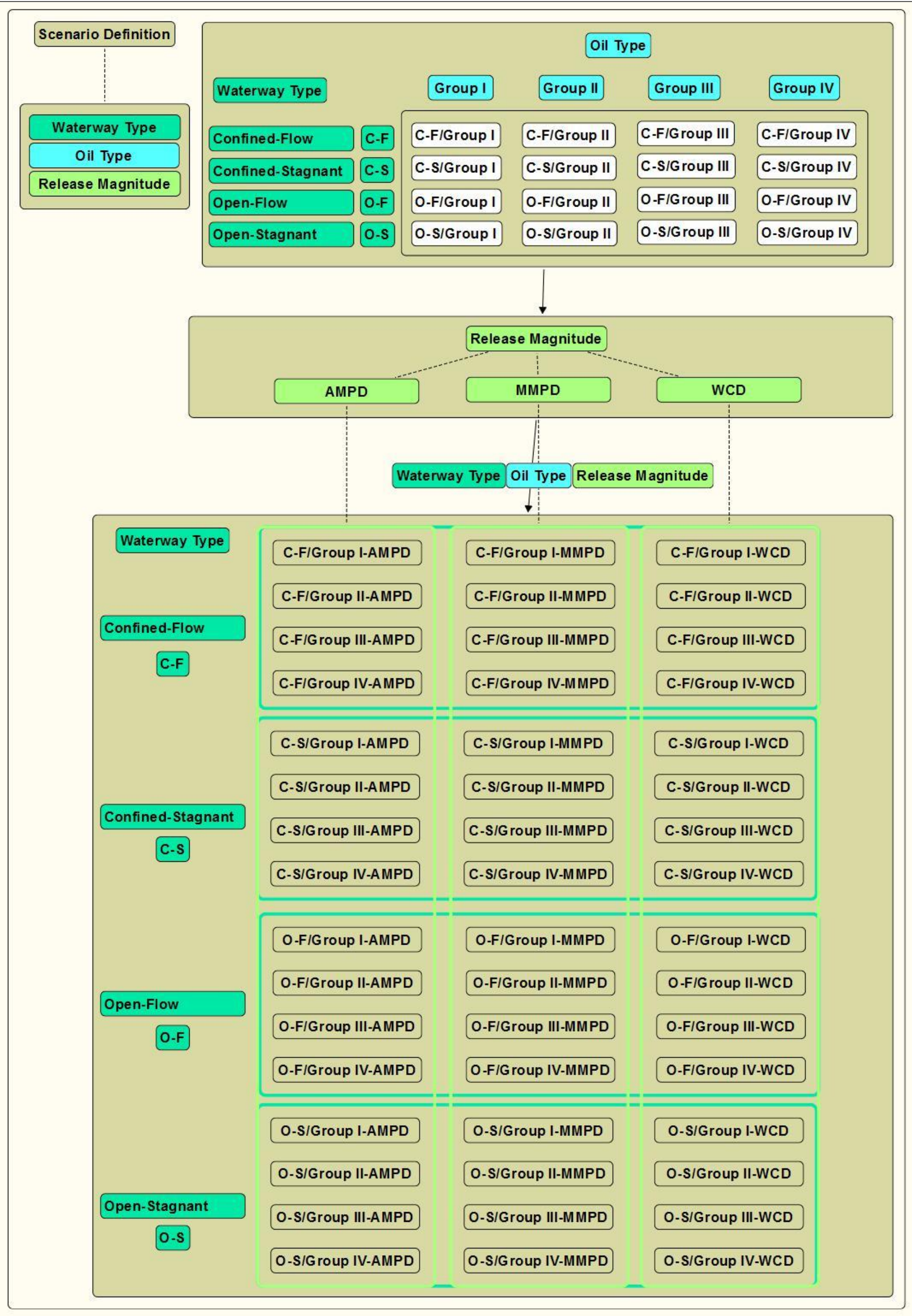


Figure 13. Inland ERSR calculator scenario definition process.



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3.8 Oil Behavior Incorporation into Recovery Estimations

The existing Offshore ERSP Calculator does not distinguish between oil types in its application. In the Offshore *ERSP Calculator User Manual*, it states:

“The Calculator is a planning tool, not an incident-specific response model. During an actual response, consider using models that account for oil type, oil weathering, environmental conditions, and other factors specific to that incident. ERSP is not designed for use as a measure of actual performance.”³²

According to the manual, its design assumptions most closely approximate the spreading and emulsion characteristics of Group II, III, and IV oils. As a result, the calculator is a less accurate predictor for the availability of light Group I type oils (e.g., gasoline or diesel fuel). In addition, the Offshore ERSP Calculator does take into account that there would be less oil available for recovery after the first day (unless it is a continuous release) and adjusts the amount for Day 3.

In the White Paper³³, the “availability of recoverable oil” was cited as a significant factor in oil recovery. In the oil budgets prepared after spill response operations are completed, mechanical recovery is often reported as the percentage recovered mechanically based on the total amount of oil spilled³⁴. The amounts of oil chemically dispersed or burned are similarly calculated. The remaining oil is then apportioned into oil that evaporated, was deposited on shorelines, and remains in the environment. From the interviews with subject matter experts that are documented in the White Paper³⁵, the team concluded that in order to reflect the effectiveness of mechanical recovery equipment in a more realistic manner, the amount of oil recovered should be considered relative to the amount that could conceivably be recovered. For example, if 10,000 bbl of oil spilled, 20 percent evaporated (i.e., would not be available for mechanical recovery), and 4,000 bbl of oil were recovered by skimming systems, the recovery under the traditional “oil budget” approach would be calculated as 40 percent. If only the available oil were considered, the recovery would be calculated as 50 percent.³⁶

The incorporation of oil behavior into the Inland ERSP Calculator represents a significant departure from the approach of the Offshore ERSP Calculator. The oil behavior modification (in the Oil Behavior Module) is applied both to the Open-Water Recovery Calculator Module and to the Shoreside Recovery Estimation Tool calculators (Shoreside Active Collection Calculator and Shoreside Passive Collection Calculator).

The Inland ERSP Calculator takes into account the differing properties and behavior of the four oil groups. This allows the Inland ERSP Calculator to factor in the amount of recoverable oil in a more accurate manner than was done with the Offshore ERSP Calculator. The amount oil available for recovery by skimming (i.e., the recoverable oil) is a function of the degree of evaporation, dissolution, dispersion, and emulsification (i.e., oil weathering) that occurs over time. This differs significantly between the oil groups. There are a number of ways in which oil weathering effects are factored into response planning tools.

³² BSEE and Genwest Systems 2015.

³³ Rowe et al. 2019.

³⁴ Lehr et al. 2010.

³⁵ Rowe et al. 2019.

³⁶ Oil budget method: 4,000 bbl recovered/10,000 bbl spilled = 40%. Recoverable oil method: 4,000 bbl recovered/10,000-2,000 bbl available = 50%.



3.8.1 Recoverable Oil Estimates in Current Planning Tables

The concept of estimating recoverable oil (i.e., oil floating on the surface that could conceivably be recovered with mechanical equipment) was previously incorporated into the *Guidelines for Determining and Evaluating Required Response Resources for Facility Response Plans*³⁷ in that “natural dissipation” (evaporation, dissolution, and dispersion) was calculated in a generic manner, as in Table 5. The values for “% Floating Oil to Recover” represent the percentages of oil that should be considered “recoverable” on the water surface.

Table 5. Removal capacity planning table.³⁸

Spill Location	Rivers and Canals			Nearshore/Inland/Great Lakes			Offshore		
On-Water Oil Recovery	3 Days			4 Days			6 Days		
Oil Group	% Natural Dissipation	% Floating Oil to Recover	% Oil on Shore	% Natural Dissipation	% Floating Oil to Recover	% Oil on Shore	% Natural Dissipation	% Floating Oil to Recover	% Oil on Shore
I	80	10	10	80	20	10	95	5	0
II	40	15	45	50	50	30	75	25	5
III	20	15	65	30	50	50	60	40	20
IV	5	20	75	10	50	70	50	40	30

According to Table 5, for the “Rivers and Canals” and “Nearshore/Inland/Great Lakes” areas, the estimated amount of oil floating on the water surface that may be available for recovery varies from 10 percent to 50 percent depending on the oil type and location classification. These estimates of recoverable oil are based on estimates of natural dissipation based on oil type and assumptions of the amount of oil that would be on the shore. In actual spill situations, the amount of oil on the shore would be dependent on the geo-specific configurations of the waterways, the location of the oil release in relation to the shoreline, and the currents and winds that would transport the oil to the shore over the time periods assumed (three or four days).

3.8.2 Approach to Recoverable Oil in Response Options Calculator (ROC)

The Response Options Calculator (ROC)³⁹ includes algorithms to calculate oil weathering and spreading to estimate oil thickness for recovery operations over time, as shown in Figure 14.⁴⁰ ROC combines and updates NOAA’s ADIOS and Spill Tools Programs and includes new algorithms for oil slick spreading (Figure 15). The model was not designed for specific geographic locations, but allows for some environmental inputs that affect weather processes, including water temperature and wind speed. The user can select a variety of oil types.

³⁷ 33 CFR § 154 (Appendix C). Also: 40 CFR § 112 (Appendix E).

³⁸ Based on: 33 CFR § 154 (Appendix C Table 2); 40 CFR § 112 (Appendix E Table 2).

³⁹ Dale 2011; Genwest Systems 2011.

⁴⁰ Galt 2009; Galt and Overstreet 2009.



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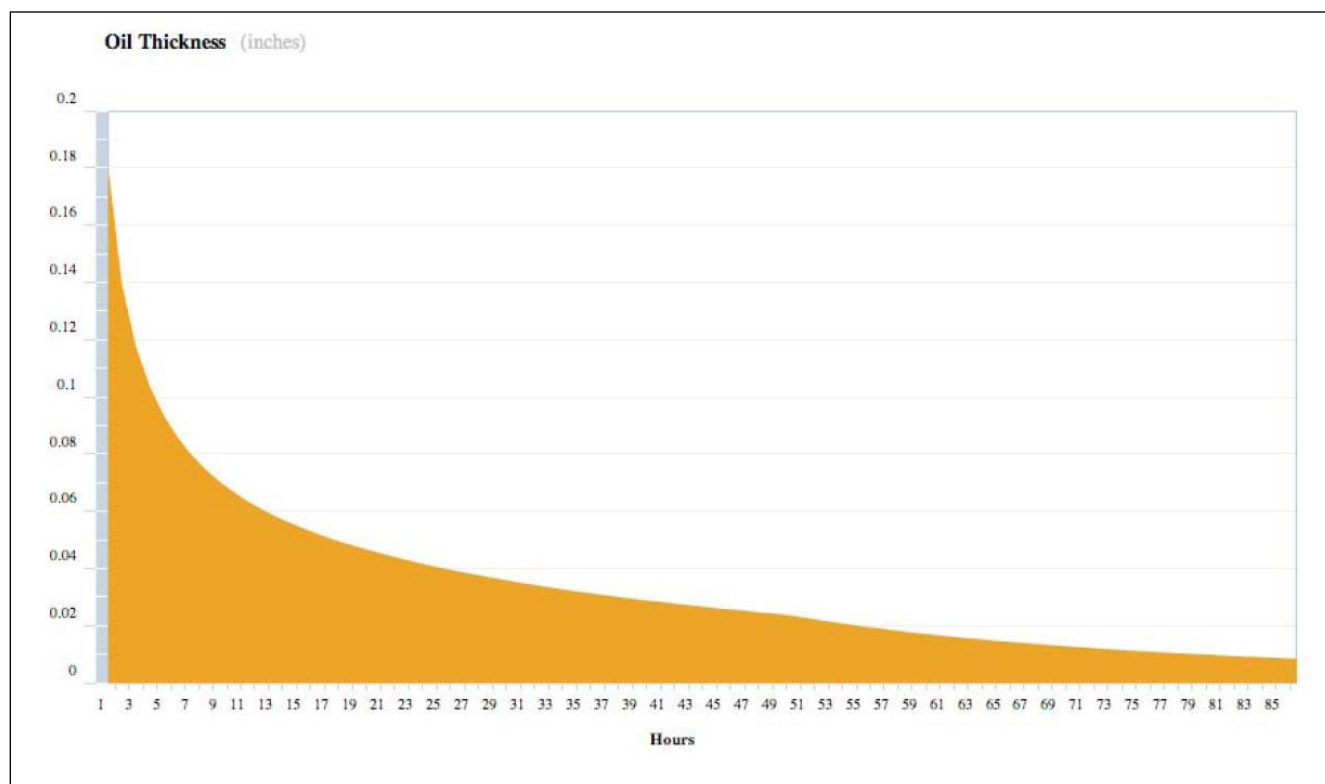


Figure 14. Oil thickness over time (Example) from Response Options Calculator (ROC).⁴¹

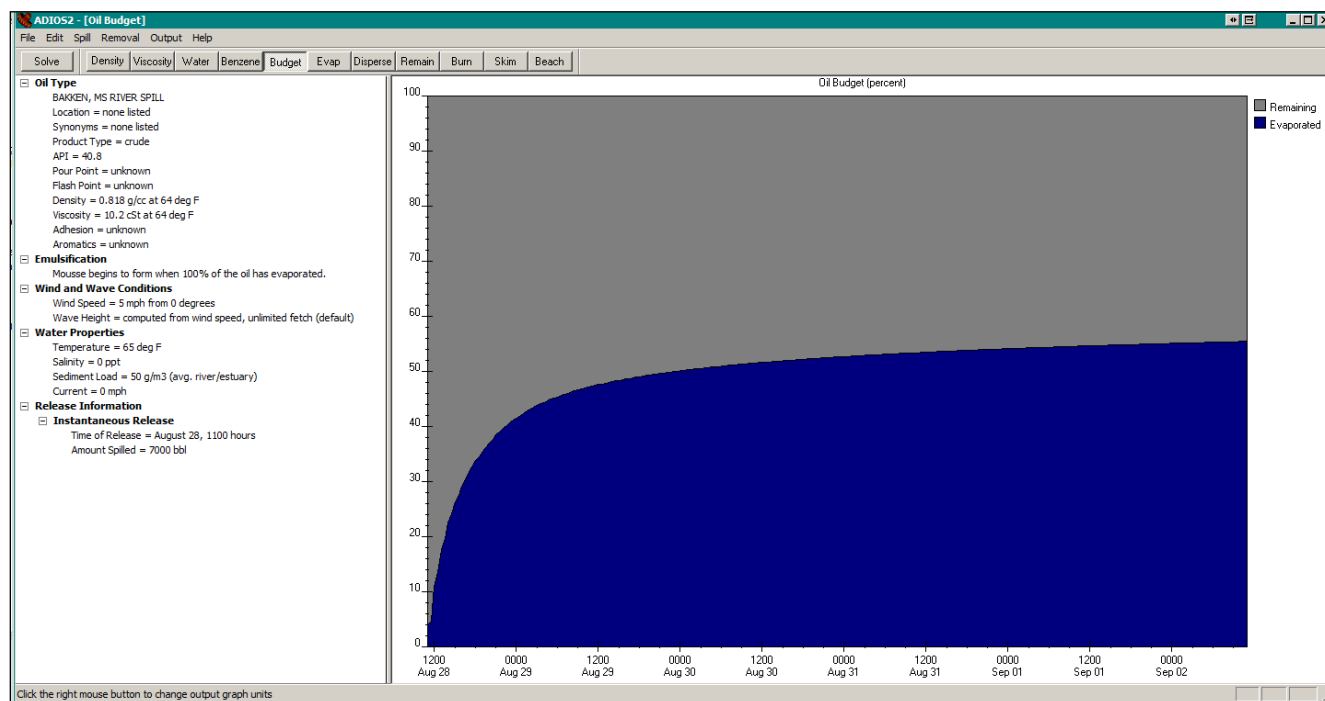


Figure 15. Example of ADIOS oil budget output for 7,000-bbl Bakken crude spill (Group II Oil).⁴²

⁴¹ Source: Genwest Systems 2011.

⁴² <https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/adios.html>

Inland ERSP Preliminary Factors, Requirements and Conceptual Model

3.8.3 Approach to Recoverable Oil in Offshore ERSP Calculator

The existing Offshore ERSP Calculator approaches the issue of recoverable oil indirectly. Based on research and the development of algorithms for weathering,⁴³ estimates for oil thickness on the water surface were developed for Day 1, Day 2, and Day 3 for application in the Offshore ERSP Calculator (Figure 16).

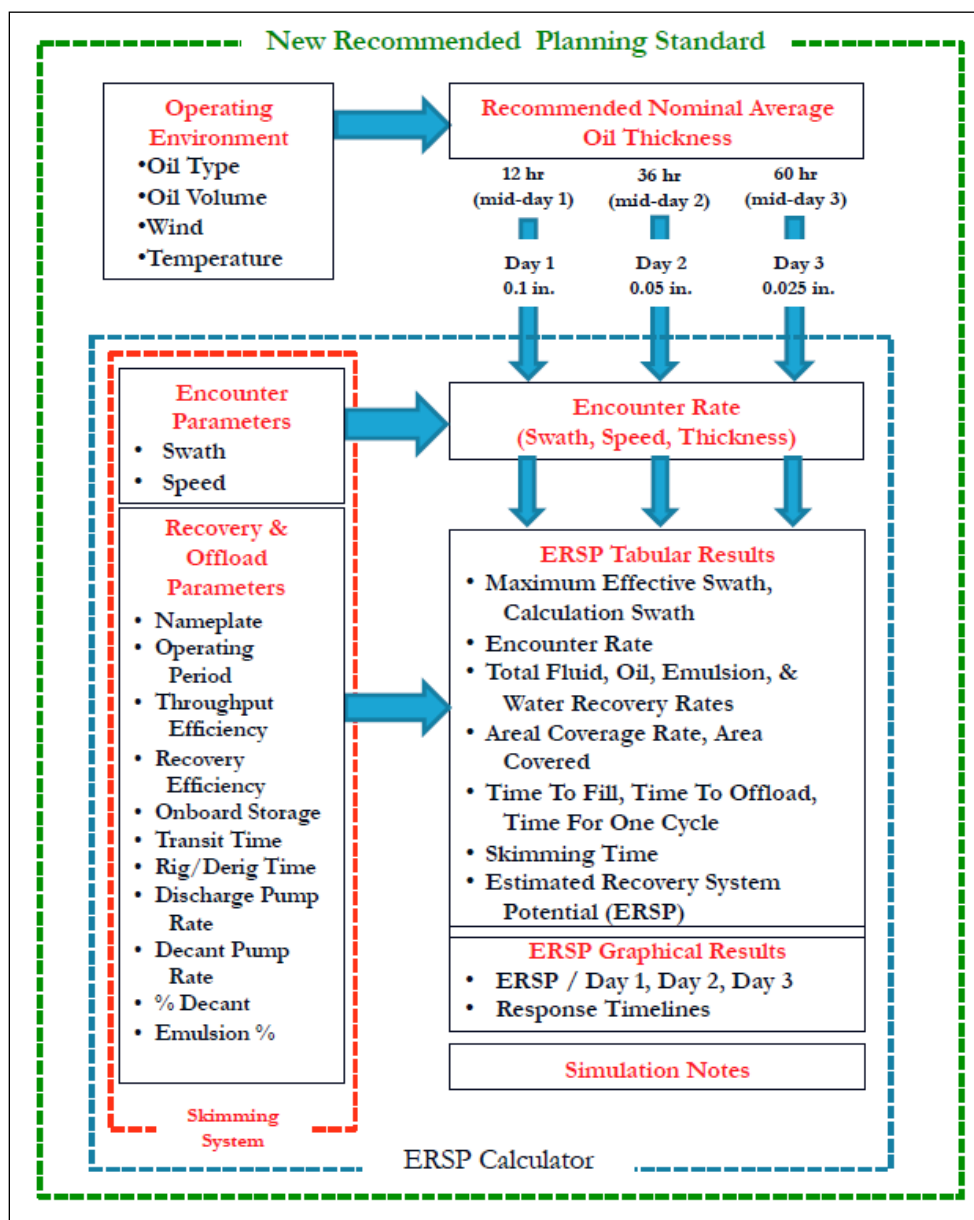


Figure 16. Recommended oil thicknesses for application in offshore ERSP calculator.⁴⁴

The Offshore ERSP Calculator uses these oil thicknesses to calculate the encounter rate and estimated recovery for the three-day time window (Days 1–3) with less oil available by the third day due to weathering and spreading.

⁴³ Genwest Systems 2012; Galt 2009; Galt and Overstreet 2009.

⁴⁴ Source: Genwest Systems 2012.



3.8.4 Oil Behavior Module in the Inland ERSP Calculator

In the Inland ERSP Calculator, the estimated amount of oil available for recovery is a vital component (Figure 17). For this reason, the team opted to incorporate an “Oil Behavior Module” into the conceptual model for the Inland ERSP Calculator.

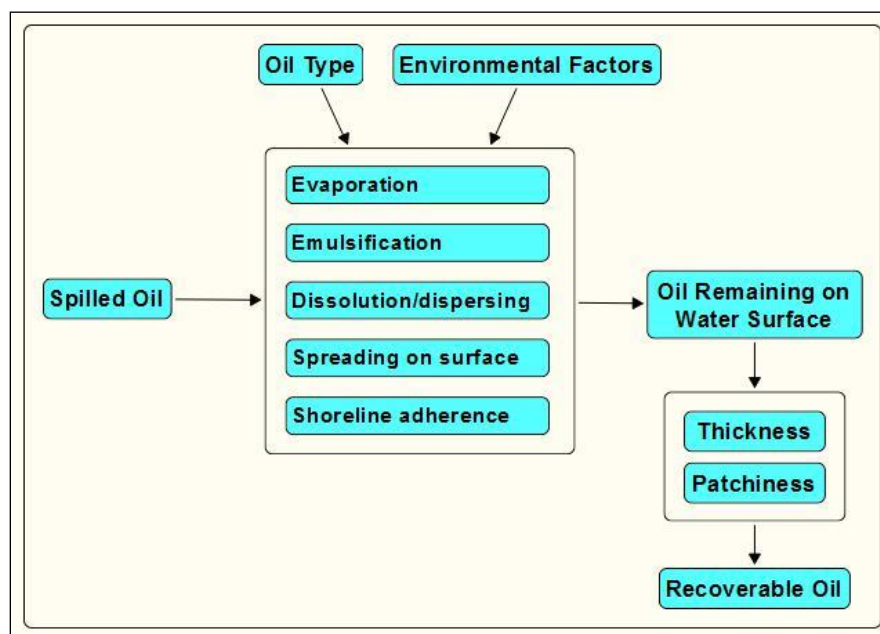


Figure 17. Determining the estimated amount of oil available for recovery.

The Oil Behavior Module will perform three major functions:

- 1) Calculate the amount of oil remaining on the water surface for potential recovery based on weathering;
- 2) Calculate the degree of emulsification; and
- 3) Estimate the degree of “patchiness” on the water surface.

The calculations on weathering and emulsification are based on representative oils for the four oil types—Group I, Group II, Group III, and Group IV. These calculations could be performed using the types of algorithms described for the ROC or ADIOS, as simplified in the Offshore ERSP Calculator. These calculations provide an estimate of the amount (or percentage) of oil remaining after weathering, and, in the case of ROC and the Offshore ERSP Calculator, a generic estimate of oil thickness on the water surface. These estimates do not address the issue of the continuity or discontinuity (“patchiness”) of the oil on the water surface as it spreads.

Alternatively, the availability of oil could be addressed by applying simple tables of estimated recoverable oil availability by Oil Group as in the existing Response Planning Standards (see Table 5).⁴⁵ These tables notably include an estimate of oil on the shoreline, which is an important process that essentially “removes” oil from the water surface, removing it from potential mechanical recovery. The estimates of oil on the shoreline are arbitrary estimates based on the generic spill locations (e.g., rivers/canals and nearshore/inland/Great Lakes). The availability of recoverable oil, including weathering processes and emulsification, may also be addressed by modeling of representative Group I–IV oils with RPS’ SIMAP (Spill Impact Model

⁴⁵ 33 CFR § 154 (Appendix C Table 2); 40 CFR § 112 (Appendix E Table 2).

Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Application Package) oil spill modeling system⁴⁶. The SIMAP three-dimensional physical fates model calculates the distribution (as mass and concentrations) of whole oil and oil components on the water surface, on shorelines, in the water column, and in sediments. Oil fate processes included are oil spreading (gravitational and by shearing), evaporation, transport, randomized dispersion, emulsification, entrainment (natural and facilitated by dispersant), dissolution, volatilization of dissolved hydrocarbons from the surface water, adherence of oil droplets to suspended sediments, adsorption of soluble and sparingly-soluble aromatics to suspended sediments, sedimentation, and degradation. Patchiness is a more difficult factor to quantify as it depends on geo-specific environmental conditions, such as winds. However, the team will review historical data to identify generic estimates of patchiness based on oil type to the extent possible. This modeling would allow the team to develop curves or formulae that could be incorporated into the algorithms to estimate the amount of oil available for recovery over time.

Figure 18 shows a diagram of the components of the Oil Behavior Module of the Inland ERSP Calculator.

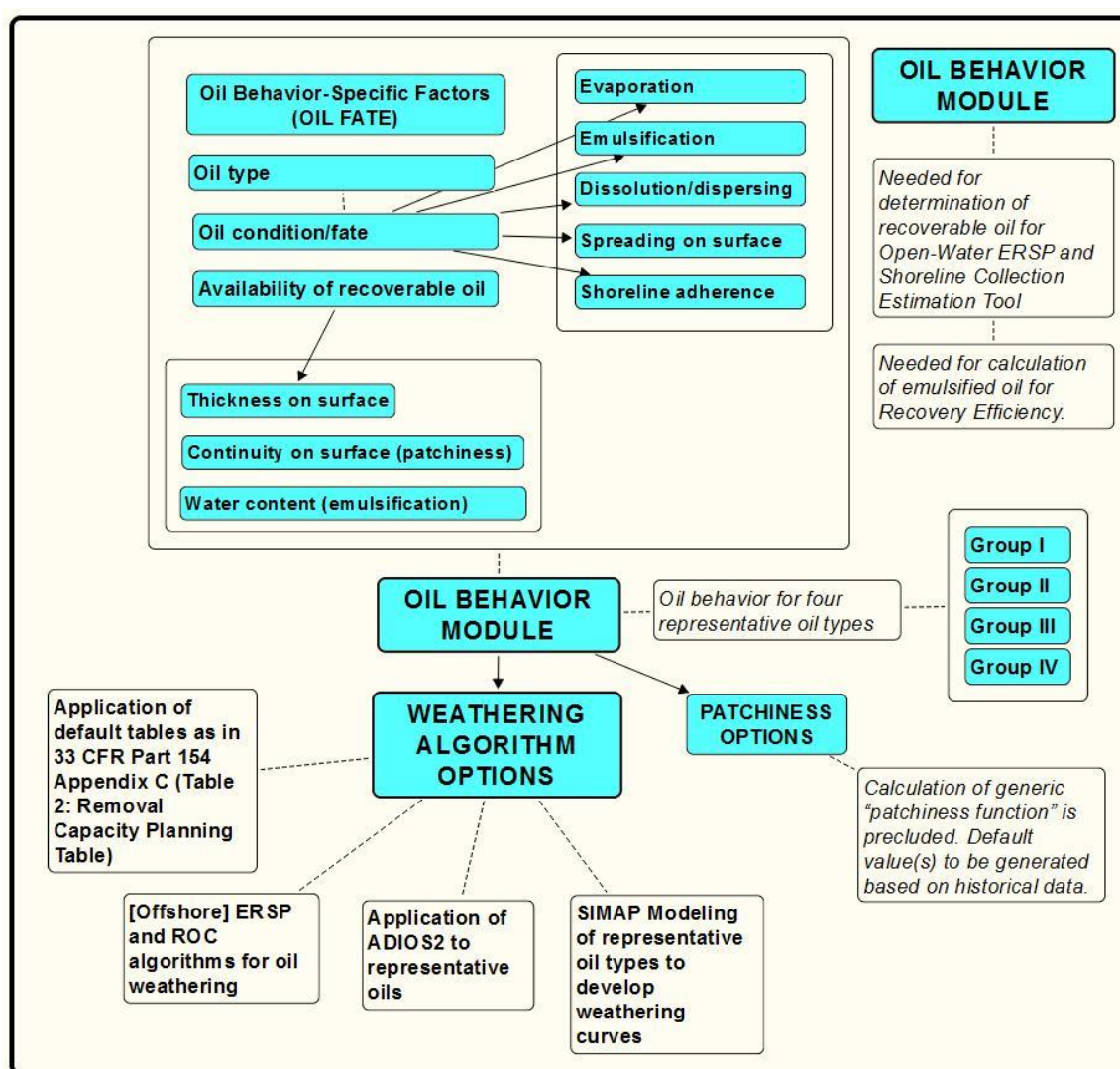


Figure 18. Oil behavior module components and approaches.

⁴⁶ French-McCay et al. 2018; French-McCay 2009.

3.9 Algorithm Approach for Open-Water Recovery Calculator Module

The Open-Water Recovery Calculator Module of the Inland ERSP Calculator is intended for application in open-water areas of inland waterways. It addresses only the oil recovery operations that would take place on open water with the use of advancing skimming systems, much as would occur in an offshore setting. For all inland spill applications, there would need to be a concurrent application of the Shoreside Collection Calculator for the operations in the shallower waters against the shore. In other words, for nearly all spill situations in open-water waterways, there would also be some recovery operations that occur at the shoreside. The recovery capabilities for the open-water and shoreside recovery operations need to be calculated independently as they require different types of equipment and approaches. For specific spill scenarios or specific geographic locations, the proportion of open-water versus shoreside recovery equipment may be estimated by applying the Customization Module.

The Open-Water Recovery Calculator Module is essentially equivalent to that used in the Offshore ERSP Calculator with two notable modifications:

- 1) The addition of the Oil Behavior Module to estimate recoverable oil based on weathering, emulsification, and continuity/patchiness processes; and
- 2) The assumption that decanting would not be permitted in inland waterways.

3.10 Algorithm Approach for Shoreside Recovery Estimation Tool

The Shoreside Recovery Estimation Tool encompasses two distinct parts, one for flowing water (Shoreside Active Collection Calculator) and another for stagnant water (Shoreside Passive Collection Calculator).

For flowing water (current) situations, the team will adapt the existing Offshore ERSP Calculator by modifying the skimmer speed function to instead include the current (and, if appropriate wind) that would bring the oil to the stationary skimming system (non-advancing skimming system) at collection points nearshore. The swath width will essentially be the width of the configuration of booms in the collection points.

Strong currents can cause significant limitations to the effectiveness of booms due to entrainment, and overall recovery performance due to effects on throughput efficiency.⁴⁷ Fast-water booming strategies, such as angling the boom relative to the current flow, may counter this effect to some extent. For waterways with currents that exceed 0.7 kts, the calculator will have a means to incorporate this factor. Algorithms already developed for quantifying the reduction in boom effectiveness and boom-angling for higher currents⁴⁸ will be incorporated into the Shoreside Recovery Estimation Tool module.

For stagnant water, the approach will be similar, except that the current or speed will need to be set at “zero” and alternate means of quantifying pumping rates will need to be incorporated into the algorithm.

⁴⁷ Michel et al. 1994.

⁴⁸ API 2016.



3.11 Essential Dichotomy within Inland ERSP Calculator

Because of the significant differences in recovery operations in open-water and shoreside portions of inland waterways, the team concluded that it was essential to split the two types of operations with different calculating approaches. The skimming equipment is generally different—advancing and non-advancing (stationary) systems. They will not be “combined” in calculating the overall response requirements for an inland spill setting. For OSROs, the skimming equipment will be considered independently. Sufficient booming to cover both open-water and shoreside operations would need to be calculated separately if there is overlap in the type of boom that may be deployed for these operations.

In the Inland ERSP Calculator, the four basic waterway types—Open-Flow, Open-Stagnant, Confined-Flow, and Confined Stagnant—all assume that there is some degree of shoreside operations involved. For the Open-Flow and Open-Stagnant environments, there may be varying “percentages” of equipment that may be required for open-water operations versus shoreside operations. In general, the wider the waterway, the more open-water system capability may be required. However, for a specific waterway or a specific spill scenario, there may be varying proportions of open-water versus shoreside equipment that is required. Even within a single waterway, such as the Hudson River, there may be different response operations required at different points along the 150-mile river. In the event of a large spill that is moved by tides and currents, there may be some portions of the spill response in narrower parts of the river that require 75 percent of the response to be in shoreside areas and 25 percent in more open areas in the middle of the river. Further downstream, in wider parts of the river, the situation may be reversed with 75 percent of the recovery required in open-water areas and 25 percent at shoreside. As a response planning tool, the Inland ERSP Calculator is not designed to address specific spill scenarios or locations. Unlike for the Offshore ERSP Calculator, there are far too many geo-specific variations in the broad category of “inland waterways.”

To address this limitation, the user may apply the characteristics of an individual waterway or spill scenario by applying the Customization Module. For example, the user may designate the “percentage open-water operations” in the Customization Module as a way to calculate recovery under specific conditions. The user may derive estimates of relative proportions of oil in open-water or shoreside areas from past spill experience or through trajectory and fate modeling for geo-specific spill scenarios.

3.12 Incorporation of Factors into Inland ERSP Calculator

Table 6 provides a summary of how the factors outlined in Rowe et al. (2019) and Section 2.5 are incorporated into the model.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

Table 6. Factors incorporated into inland ERSP calculator conceptual model.

Factor	Mode of Incorporation into Inland ERSP Calculator
Current Velocity	Essential input for Open-Water Recovery Calculator and for Shoreside Recovery Estimation Tool
Oil Collection Points	Included as part of swath width for Shoreside Recovery Estimation Tool
Accessibility to Spill Site	Potential input for Customization Module but not part of either Open-Water Recovery Calculator or Shoreside Recovery Estimation Tool
Skimmer Class/Type	Determines inputs for Equipment Specifications in Open-Water Recovery Calculator and for Shoreside Recovery Estimation Tool
Temporary Storage	Essential input for Open-Water Recovery Calculator and for Shoreside Recovery Estimation Tool
Product Fate	Included as part of Oil Behavior Module
Inland Feasibility of Advancing Skimmer Systems	Assumed for Open-Water Recovery Calculator
Inland Feasibility of Non-Advancing Skimmer Systems	Assumed for Shoreside Recovery Estimation Tool
Great Lakes/Open Waters Issues	Open water addressed in Open-Water Recovery Calculator; Great Lakes removed from waterways covered by Inland ERSP Calculator
River/Restricted Water Issues	Waterway configuration addressed as part of generic waterway classification
Sea State	Sea state assumed to be issue only on certain large lakes or wide rivers under episodic wind events; equipment currently rated for Inland and River/Canal use is assumed to withstand wave heights that would be encountered.
Swath Width	Essential input for Open-Water Recovery Calculator and for Shoreside Recovery Estimation Tool
Water Depth	Assumed to be sufficient for Open-Water Recovery Calculator and assumed to be insufficient for Shoreside Recovery Estimation Tool
Mobilization and Transit Time	Potential input for Customization Module but not part of either Open-Water Recovery Calculator or Shoreside Recovery Estimation Tool
Oil Type	Included as part of Oil Behavior Module
Decanting	Assumed to be disallowed under most inland spill operations; aspects of storage as considered in the Offshore ERSP Calculator
Transfer-Offloading Pumps	Pumps are considered as part of the Shoreside Recovery Estimation Tool.

3.13 Overall Algorithm Approach for the Inland ERSP Calculator

The team will present the recommended algorithms for the Inland ERSP Calculator in the *Inland ERSP Operational Environment Calculator Design Document*. This report will include algorithms and, in most instances, default data values based on independent research and the interviews outlined in the White Paper⁴⁹ for the following modules:

- Open-Water Recovery Calculator Module;
- Shoreside Active Collection Calculator Module;
- Shoreside Passive Collection Calculator Module; and
- Oil Behavior Module.

⁴⁹ Rowe et al. 2019.



4 INLAND ERSP CALCULATOR REQUIREMENTS

The requirements for the Inland ERSP Calculator have been discussed throughout this description of the conceptual model; however, the following section provides a summary of each of the initial requirements. These include functional, user, system, security and data requirements. At this time, it is premature to discuss the security requirements, particularly pertaining to how the Inland ERSP code shall not be accessible or modifiable by a user; however, this will be discussed further in the next report deliverable.

4.1 Functional Requirements

On a functional level, the Inland ERSP Calculator has sufficient fidelity to be used as a mechanical oil spill response **planning tool** for oil spills on inland and nearshore waterways utilizing some aspects of the existing Offshore ERSP Calculator and modifications to the existing calculator pertaining to conditions specific to spills in inland waterways. An example modification is the inclusion of the Open-Water Recovery Calculator Module within the Inland ERSP calculator that takes into oil behavior by oil type.

Additionally, on a functional level, the team outlined the results of the White Paper⁵⁰, and explained that the aim is to steer away from incorporating factors that are too highly specific to particular spill scenarios, and away from those factors that are environmental conditions that would affect recovery performance under specific field conditions rather than those that would affect system potential. The Inland ERSP Calculator will be capable of providing response planning in a variety of inland and nearshore waterway types (e.g., small creeks or ponds and wide rivers or moderate-sized lakes) under varying environmental conditions (e.g., range of temperatures and salinity related to the weathering of the oil).

4.2 User Requirements

In terms of requirements specific to the user, the Inland ERSP Calculator is capable of being implemented in a regulation or by industry personnel to accurately plan regulatory compliance. The Inland ERSP calculates the oil spill recovery potential for shoreside collection in a stream or river, as well as on open-water for waterways that have significant width to allow for advancing skimming system operations. In the development of the conceptual model, the team considered the practicality of incorporating selected factors into the calculator and highlighted the need to categorize the environments generically in a user-friendly manner in the ultimate application. In addition to providing the generic use method of the calculator, the team will also include the Customization Module which the user can opt to use to further specify inputs for mobilization, transit time, site accessibility, and percentage of open-water areas in the waterway as a means to estimate recovery potential for specific Oil Spill Response Plans (OSRPs).

4.3 System Requirements

The conceptual model outlines the various components of the Inland ERSP Calculator: Open-Water Recovery Calculator Module (based largely on the existing Offshore ERSP Calculator) and the Shoreside Recovery Estimation Tool Module (which has two subparts applied to estimate recovery in shoreside collection areas where advancing skimmers cannot operate). The full Inland ERSP Calculator (i.e., Open-Water Recovery Calculator Module, Shoreside Recovery Estimation Tool Module with its two subcomponents, and the Customization Module) will be implementable by the user on a webpage accessed

⁵⁰ Rowe et al. 2019.



from a desktop, laptop, or hand-held device. In addition, if the developed software can be downloaded onto a laptop, surface pad, or smartphone as an “application” or “app,” a user could conduct calculations in the field without the need for an internet connection.

4.4 Data Requirements

In the course of developing the Inland ERSP Calculator conceptual model, the team conducted research on the various factors to be incorporated into the model to provide default values the user can opt to utilize.

In order to identify the appropriate oil spill scenario (one of 48 combinations of waterway type-spill volume-oil type), the user must select:

- Waterway classification (i.e., Confined-flow, Confined-Stagnant, Open-Flow, and Open-Stagnant);
- Specific volume of oil discharge (e.g., tens of barrels [bbls], thousands of bbls, hundreds of thousands of bbl) and/or magnitude of release (three types: AMPD, MMPD, and WCD); and
- Oil type: Oil Group I-IV.

On the user interface, these inputs will have drop-down menus that will allow the user to select specific values. There would be no specific default values for these inputs.

To conduct the calculations for a specific type of skimming equipment, the user will need to either select an equipment type from a drop-down menu that links to a database of pre-determined default values for maximum total fluid recovery, throughput efficiency, and recovery efficiencies for typical response equipment. Alternatively, the user may enter custom inputs for these values for skimming systems that are not in the skimming system database.

The user also needs to specify operating period, skimmer advancing speed or current, and swath width. For these inputs, the user will have the option of using default values or entering custom values.

The user will also have the option to enter non-default input values in the Customization Module within the website or “app,” but outside the main Inland ERSP Calculator (Open-Water Recovery Calculator and Shoreside Recovery Estimation Tool), in order to modify the results based on geo-specific site characteristics inputs, including mobilization, transit time, accessibility, and percentage of open water to the site.

5 SUMMARY

This Conceptual Model Document:

- Stresses the overall purpose of the Inland ERSP Calculator as a response planning tool rather than a performance tool for specific spill scenarios or locations;
- Reviews the factors that would affect inland recovery operations as considered in the White Paper;⁵¹
- Explains the selection (incorporation or exclusion) of the significant factors for inclusion in the Inland ERSP Calculator;

⁵¹ Rowe et al. 2019.



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- Presents the overall conceptual model and its components, Open-Water ERSP Calculator and Shoreside Recovery Estimation Tool; and
- Presents the Oil Behavior Module as an essential component of the Inland ERSP Calculator to estimate recoverable oil and degree of emulsification.

The algorithms for the various components of the Inland ERSP Calculator will be presented in a separate document outlining the model design.

5.1 Purpose of Inland ERSP Calculator as Response Planning Tool

The framework for developing the conceptual model for the Inland ERSP Calculator is centered on the premise that the calculator is primarily a response planning tool for oil spills. Its intended use is to estimate the potential mechanical oil removal capability of a skimming system based on its encounter rate, configuration, swath width, pumping rate, operating time, and storage capacity under generally favorable environmental conditions. The calculator does not take into account such environmental factors as debris, ice, sediment, extreme weather conditions, site accessibility issues, or any extenuating circumstances that may significantly reduce the effectiveness of mechanical recovery operations under geo-specific field conditions. **Note:** As a response planning tool, the Inland ERSP Calculator is specifically not designed for application as a measure or predictor of actual oil spill recovery performance in the field.

5.2 Customization Module

The team relegated mobilization, transit time, and site accessibility to inclusion only in the Customization Module. These factors would clearly affect recovery performance in actual spill scenarios. However, the OSRO Classification already addresses mobilization as part of its planning standard. The calculated recovery rates from the Inland ERSP Calculator are based on the assumption that the site was accessed and the equipment deployed as per the standard time factors. The user has the option to apply the Customization Module to estimate differences in outcome based on varying mobilization and transit times, as well as accessibility.

5.3 General Model Concept for Inland ERSP Calculator

The Inland ERSP Calculator addresses the need for estimating the recovery capability of different types of mechanical recovery systems in inland waterways. The term “inland waterways” encompasses a large variety of different configurations, magnitudes, and flow conditions. This variety presents a significant challenge with respect to developing a more generic tool with applications across many different waterway types. By comparison, the Offshore ERSP Calculator addresses only open-water situations. The team developed a conceptual model for the Inland ERSP Calculator that defines inland waterways in a relatively generic manner by focusing on the two factors that would most affect the type of equipment required for mechanical recovery operations—degree of open-water conditions and the degree of current or flow. The Inland ERSP Calculator also incorporates a Customization Module that allows the user to define certain variables, notably the time of the commencement of response operations and degree of open-water conditions, to allow for its application for more geo-specific situations.

The Inland ERSP Calculator is basically a two-part model that calculates on-water recovery with advancing skimming system and shoreside recovery with non-advancing or stationary skimming systems. Waterways



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are generically divided into Open-Flow, Open-Stagnant, Confined-Flow, and Confined-Stagnant. The two portions of the calculator (open-water and shoreside) are applied for Open-Flow and Open-Stagnant, and only the shoreside portion is applied for the two confined waterways types. Flow and stagnant conditions determine the degree to which current applies in the calculator. The amount of recoverable oil and the degree of emulsification are calculated by oil group (Oil Groups I–IV) with the Oil Behavior Module.

The Inland ERSP Calculator incorporates significant portions of the existing Offshore ERSP Calculator with respect to the approach of calculating oil recovery based on the amount of recoverable oil, swath width, throughput efficiency, and recovery efficiency for open-water areas. The Inland ERSP Calculator also adapts the approach of the Offshore ERSP Calculator to shoreside conditions by considering the current flow that moves oil towards the skimmers in shoreside collection points rather than the speed of the advancing skimmer. However, there are some significant departures from the Offshore ERSP Calculator in that the Inland ERSP Calculator takes into account oil behavior by oil group to better quantify the amount of recoverable oil.



6 REFERENCES

- American Petroleum Institute (API). (2016). *Options for Minimizing Environmental Impacts of Inland Spill Response*. API Technical Report 425. 112 p.
- ASTM. (2018). *ASTM F1780-18, Standard Guide for Estimating Oil Spill Recovery System Effectiveness*. ASTM International, West Conshohocken, PA.
- BSEE and Genwest Systems, Inc. (2015). *ERSP Calculator User Manual*. Prepared by Bureau of Safety and Environmental Enforcement (BSEE) and Genwest Systems, Inc. February 2015. 45 p.
- BSEE and Genwest Systems, Inc. (2016). *Recovery System Evaluation Tool (ReSET) User Manual*. Prepared by Bureau of Safety and Environmental Enforcement (BSEE) and Genwest Systems, Inc. March 2016. 10 p.
- Buchholz, K., A. Krieger, J. Joeckel, G. Reiter, A.H. Walker, D.S. Etkin, J. Rowe, D. French McCay, and R. Balouskus. (2016). *Task 2: Oil Spill Response Equipment Capabilities Analysis (Volume II)*. U.S. Department of the Interior Bureau of Safety and Environmental Enforcement (BSEE). *Oil Spill Response Plan (OSRP) Equipment Capabilities Review*, BPA No. E14PB00072. Available on-line at: <https://www.bsee.gov/volume-ii-osrp-response-equipment-capabilities-analysis>.
- CEDRE. (2015). *Aerial Observation of Oil Spills at Sea*. Prepared by CEDRE on behalf of International Petroleum Industry Environmental Conservation Association (IPIECA), International Maritime Organization (IMO), and International Association of Oil and Gas Producers (IOGP). IOGP Report No. 518. February 2015. 56 p.
- CERC. (1984). *Shore protection manual*, Vol. I. Coastal Engineering Research Center, Department of the Army, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS, 1105p plus 134pp in appendices. Available on-line at: <http://ft-sipil.unila.ac.id/dbooks/S%20P%20M%201984%20volume%201-1.pdf>, accessed October 2019.
- Chapman, Inc. (1992). *Test Protocol for Oil-Spill Containment Booms*. Prepared for the Minerals Management Service, Technology Assessment and Research Branch. Test Protocol 14-35-30551. February 1992. 101 p.
- Dale, D. (2011). *Response Options Calculator (ROC) Users Guide*. Genwest Systems, Inc. May 2011. 72 p.
- French-McCay, D.P. (2009). State-of-the-Art and Research Needs for Oil Spill Impact Assessment Modeling. In: *Proceedings of the 32nd AMOP Technical Seminar on Environmental Contamination and Response*, Emergencies Science Division, Environment Canada, Ottawa, ON, Canada, pp. 601-653.
- French-McCay, D., M. Horn, Z. Li, K. Jayko, M. Spaulding, D. Crowley, and D. Mendelsohn, 2018. Modeling Distribution Fate and Concentrations of Deepwater Horizon Oil in Subsurface Waters of the Gulf of Mexico. Chapter 31 in: *Oil Spill Environmental Forensics Case Studies*, S. Stout and Z. Wang (eds.), Elsevier, ISBN: 978-O-12-804434-6, pp. 683-736.
- Galt, J.A. (2009). *Oil Weathering: Technical Documentation and Recommended Use Strategies*. Genwest Systems, Inc. 48 p.



Inland ERSP Preliminary Factors, Requirements and Conceptual Model

- Galt, J.A., and R. Overstreet. (2009). *Development of Spreading Algorithms for the ROC*. Genwest Systems, Inc. 68 p.
- Genwest Systems, Inc. (2011). *Response Options Calculator (ROC) Technical Documentation*. May 2011. 45 p.
- Genwest Systems, Inc. (2012). *EDRC Project Final Report*. Prepared for Bureau of Safety and Environmental Enforcement (BSEE) by Genwest Systems, Inc., and Spiltec. December 2012. 158 p.
- Hansen, K.A. (2014). Responding to oil spills in ice. *Proceedings of the 2014 International Oil Spill Conference*: 1,200–1,214.
- International Tanker Owners Pollution Federation (ITOPF). (2012). *Use of Skimmers in Oil Pollution Response*. ITOPF Technical Information Paper #5. 16 p.
- Lehr B., S. Bristol, and A. Possolo (Oil Budget Calculator, OBC). (2010). Deepwater Horizon oil budget calculator: A report to the national incident command. The Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team. [accessed 1 April 2012].
http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc_Full_HQ-Print_111110.pdf.
- Michel, J., S. Christopherson, and F. Whipple. (1994). *Mechanical Protection Guidelines*. Prepared by Research Planning, Inc., for National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division and US Coast Guard National Strike Force. 87 p.
- NOAA (2017). NOAA Ocean Science Education: Currents – Ocean Currents. Available online at: <https://oceanservice.noaa.gov/education/kits/currents/03coastal1.html>, accessed October 2019.
- Rowe, J., G. McGrath, A. Morandi, D.S. Etkin, and J. Joeckel. (2019). *Preliminary Analysis of Mechanical Oil Spill Response Planning Modeling Factors: White Paper*. Prepared for US Coast Guard Research & Development Center by RPS, Environmental Research Consulting, and SEAConsult LLC. March 2019. 73 p.
- Schulze, R. (1998). *Oil Spill Response Performance Review of Skimmers*. American Society for Testing and Materials (ASTM). 151 p.
- SL Ross Environmental Research Ltd. (2005). *Transfer of Decanting Technology Research to Oil Spill Response Organizations and Regulators*. Prepared for Minerals Management Service, Technology Assessment and Research Division by SL Ross Environmental Research Ltd. June 2005. 63 p.
- Telford, A.S., and H.A. Quam. (1979). Oil recovery from under river ice. *Proceedings of the 1979 Oil Spill Conference*: 397–402.



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APPENDIX A. BACKGROUND ON NEED FOR AND EXISTING RESPONSE CALCULATORS

A.1 Background

The historic need for response calculators has been to prepare for mechanical recovery operations to be employed in a vast spectrum of oil spill scenarios. Response officials and planners must be able to, objectively and relatively simply, quantify the potential capabilities of a wide variety of different types of equipment. The use of a “response calculator” or “response planning tool” facilitates more accurate planning for equipment caches, resource management, oil spill response plans, and Oil Spill Removal Organization (OSRO) classifications.

There are a number of existing response calculators already in use by response officials and planners with their own specific application, benefits, and technical challenges. These existing tools are discussed briefly here to provide background to the development of the conceptual model for the Inland ERSP Calculator:

- Estimated Daily Recovery Capacity (EDRC).
- Offshore Estimated Recovery System Potential (ERSP).
- Response Options Calculator (ROC).
- Recovery System Evaluation Tool (ReSET).

A.2 Existing Response Calculators

A.2.1 Estimated Daily Recovery Capacity (EDRC)

With oil spills rarely occurring under ideal weather conditions or even during daylight hours, and the fact that the effectiveness of a skimmer in recovering oil decreases with increasing wave action and increasing current speed⁵², it is difficult to know how well a specific piece of equipment will work under real-world spill conditions based solely on the manufacturer's nameplate capacity. Therefore, in order to more realistically reflect the limitations of response equipment efficiency as a result of weather, sea state, current velocity, hours of operation, and visibility, USCG and BSEE incorporated an Effective Daily Recovery Capacity (EDRC). The EDRC is a calculation method established within the USCG and BSEE regulations used to assign an oil removal capability value to an individual oil skimmer. However, since the calculation omits factors such as the encounter rate and onboard storage of skimmers, it came under heavy scrutiny as an inadequate means for vessel and facility plan holders to calculate their oil spill equipment needs in the wake of the 2010 Deepwater Horizon incident.

A.2.2 Offshore Estimated Recovery System Potential (ERSP)

In September 2011, the BSEE contracted Genwest Systems, Inc. (Genwest) to conduct an objective and independent assessment of the existing EDRC planning standard. In addition, Genwest was to consider improvements that might be made to the EDRC approach and recommend new methods and guidelines to enhance or replace that method of calculating a recovery system's daily potential for removing oil spilled on water. A final report, dated 7 December 2012, was submitted to BSEE providing Genwest's assessment of

⁵² Chapman 1992.



the EDRC and a new Estimated Recovery System Potential (ERSP)⁵³ model for developing planning standards. The model was much more robust in design than EDRC and accounted for the performance of a skimming system as it accesses and contains oil, recovers and stores oil, and then transits to a backup vessel, barge, or facility to offload the recovered fluids. This model allows for the calculation of an ERSP over a three-day period, based on nominal average oil thicknesses following the release of a significant oil spill.

While the ERSP calculator might give reasonably accurate projections for oil recovery, it is dependent on the user knowing a great deal of specific information about the skimming system in question, and it does not allow for variation in the input parameters (for instance, the speed at which the boom is towed is assumed to be constant). In situations in which response systems are established and constant, it might be possible to input all of the required information, but for systems brought in and assembled in an ad hoc manner during a response, it could be difficult to obtain all of the information necessary to predict oil recovery capabilities in the short-term. Such predictions would be useful for determining if an active response is likely to meet spill cleanup needs.

The calculator attempts to compensate for situations in which nameplate capabilities cannot be achieved by allowing for the input of throughput and recovery efficiencies. The project report includes figures based on historical data which can help the user in determining theoretical recovery efficiencies if actual validated values are not available for a given skimmer. However, Genwest specifically stated that the ESRP calculator does not account for environmental factors which could greatly affect the skimmers performance (e.g., ice, debris, extreme weather conditions).

A.2.3 Response Options Calculator (ROC)

Recognizing some of the limitations of the EDRC for some of its applications, developers at Genwest Systems built the Response Options Calculator (ROC) and made it available in 2011.⁵⁴ The ROC combines a spill spreading algorithm (based on, but considerably improved, from NOAA's ADIOS2 model) a built-in oil properties database, and the Spill Tools™ method for estimating oil recovery. According to Genwest Systems⁵⁵, ROC can be used to predict on-water mechanical oil spill recovery capacity at the level of individual response systems. However, ROC does not account for the many variables of a real oil spill and includes some inherent limitations that should be considered in presenting and interpreting oil recovery results. Some of these include environmental conditions being considered in simple form and a relatively simple ROC weathering model with the deterministic nature of its calculations.

A.2.4 Recovery System Evaluation Tool (ReSET)

The Recovery System Evaluation Tool (ReSET) was developed as a supplement to the ERSP Calculator. The oil removal potential (ERSP) of each skimming system is uniquely tied to its specific operating parameters that can be quantified. With ReSET, users can vary any of these operational parameters for their oil recovery systems and examine how those changes affect their removal potential. ReSET provides users who would be designing or assembling mechanical recovery systems with feedback that may assist them in increasing the efficiency and overall effectiveness of their recovery systems.⁵⁶

⁵³ Genwest Systems 2012.

⁵⁴ Dale 2011.

⁵⁵ Genwest Systems 2009.

⁵⁶ BSEE and Genwest Systems 2016.

