ERSP Calculator User Manual

Prepared by BSEE and Genwest Systems, Inc.

February 2015

Contents

1. Introduction

The Calculator developed in this project accounts for the performance of an advancing skimming system as it encounters, contains, recovers, stores, and offloads its recovered fluids to secondary storage. The Calculator generates an "Estimated Recovery System Potential" (ERSP) value in barrels of oil recovered for each of the first three days following the instantaneous discharge of a batch oil spill, or daily for an ongoing continuous discharge of oil.

The ERSP Calculator is an HTML file, **ERSP_Calculator_20150222.html**, which runs in the following web browser versions:

PC (Win-XP, Win-7 and Win-8 environments)
- IE - 9, 10, 11 or greater
- Chrome 38 or greater
- Firefox 31 or greater
- Safari 5.1 or greater

Mac (OS 10.6 and greater)
- Safari 8.0 or greater
- Chrome 38 or greater
- Firefox 35 or greater

You can download it from the following location:

http://www.bsee.gov/Technology-and-Research/Oil-Spill-Response-Research/Projects/Project-673/

This User's Guide provides additional guidance to the user on the various data inputs that must be entered into the ERSP Calculator regarding the skimming configuration being evaluated, and further explains the Calculator results.

The ERSP Calculator was developed by Genwest Systems, Inc. in consultation with U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE) and the United States Coast Guard.

1a. The ERSP Calculator's Purpose and Intended Use

The ERSP Calculator is primarily a planning tool for estimating the potential for mechanical recovery of spilled oil by an advancing skimming system. You can use the Calculator to evaluate the ERSP of a skimming system for two kinds of spill scenarios:

- **Continuous spills**, such as a well blowout, in which oil is discharged at a steady rate for a relatively long period of time.

- **Batch spills**, such as a spill from a tank vessel, storage tank, or pipeline, in which oil is discharged nearly instantaneously or over a relatively short period of time.

To use the Calculator, you enter configuration information about an advancing skimming system, such as its swath, on-board storage capacity, pump rates, and speed, you describe the circumstances of its operation, such as transit time to secondary storage (*see Section Three, ERSP Calculator Inputs*). The Calculator then estimates the amount of oil that the system could collect during the operating period of each of the first three days after a major batch spill begins, or during the operating period for each day of a continuous spill response (see *Section Four, ERSP Calculator Results*). These estimates of the oil collected are termed the “Estimated Recovery System Potential” (ERSP) for the given skimming system configuration. The use of the calculator tool in both spill scenarios is further demonstrated and explained in *Section Five, Using the ERSP Calculator*.

The ERSP Calculator was also developed with the intent of reinforcing incentives for creating and acquiring more effective oil recovery systems. In addition to evaluating the potential of an advancing oil spill skimming systems to meet various regulatory planning requirements, you can also explore how to configure a skimming system to best encounter, recover, store, and offload oil more efficiently. By comparing different configurations, you may discover that increasing swath width, adding a second discharge pump, or increasing onboard storage may increase your system’s daily recovery potential. This experimentation is helpful in understanding the effects of different configurations on a system’s recovery potential, and provides incentives for developing more effective skimming systems.

1b. Advancing Skimming System Components

The ERSP Calculator was primarily designed as a planning tool for estimating the potential of advancing skimming systems. ASTM Standard F 1780-97, Standard Guide for Estimating Oil Spill Recovery System Effectiveness, defines an advancing skimmer *as a system designed to sweep out the spill area of oil*. Advancing skimmers may be independent or attached to containment boom to increase sweep width. In some cases, the skimmer may not be attached to the boom, but positioned in the pocket of the boom for skimming. As long as the skimmer operates while the system is moving, it is considered to be an advancing skimming system. Some skimming systems may be used both in advancing and stationary modes. Advancing modes are especially critical in recovering spills in open water, while stationary systems are necessary for recovering oil spills in areas where the movement and removal of oil is tightly constrained by barriers such as shorelines. Figure 1 below identifies the major components of an advancing skimming system:

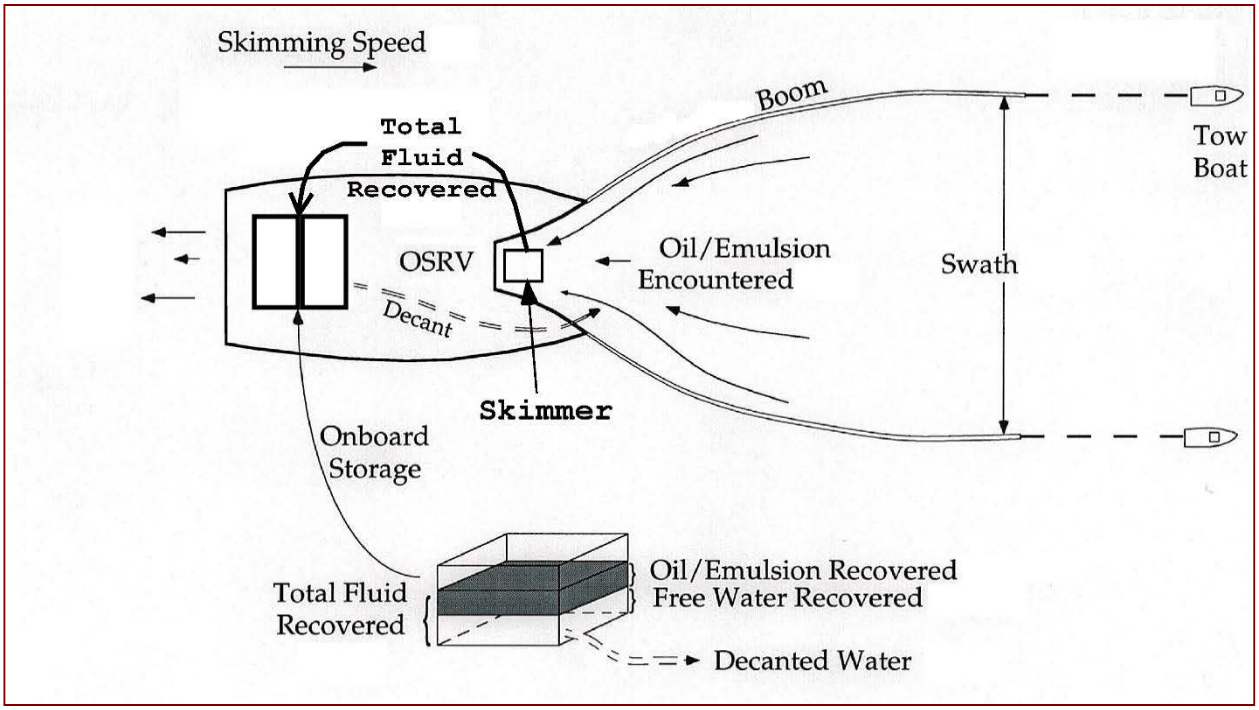


Figure 1. Advancing Skimming Recovery System Components.

Below are short descriptions of the various components of an advancing skimming system:

Supporting Platform Vessel – Labeled as OSRV in the diagram. This is the supporting platform for all the basic components of a skimming system including the following: containment boom, skimmer device, onboard storage, decant and offloading pumps; and (if present) berthing, messing, navigation, propulsion elements.

Containment Boom – Encounters and concentrates the oil/emulsion from the oil slick. Encounter rate is a function of the Skimming Speed, the Swath, and the oil thickness

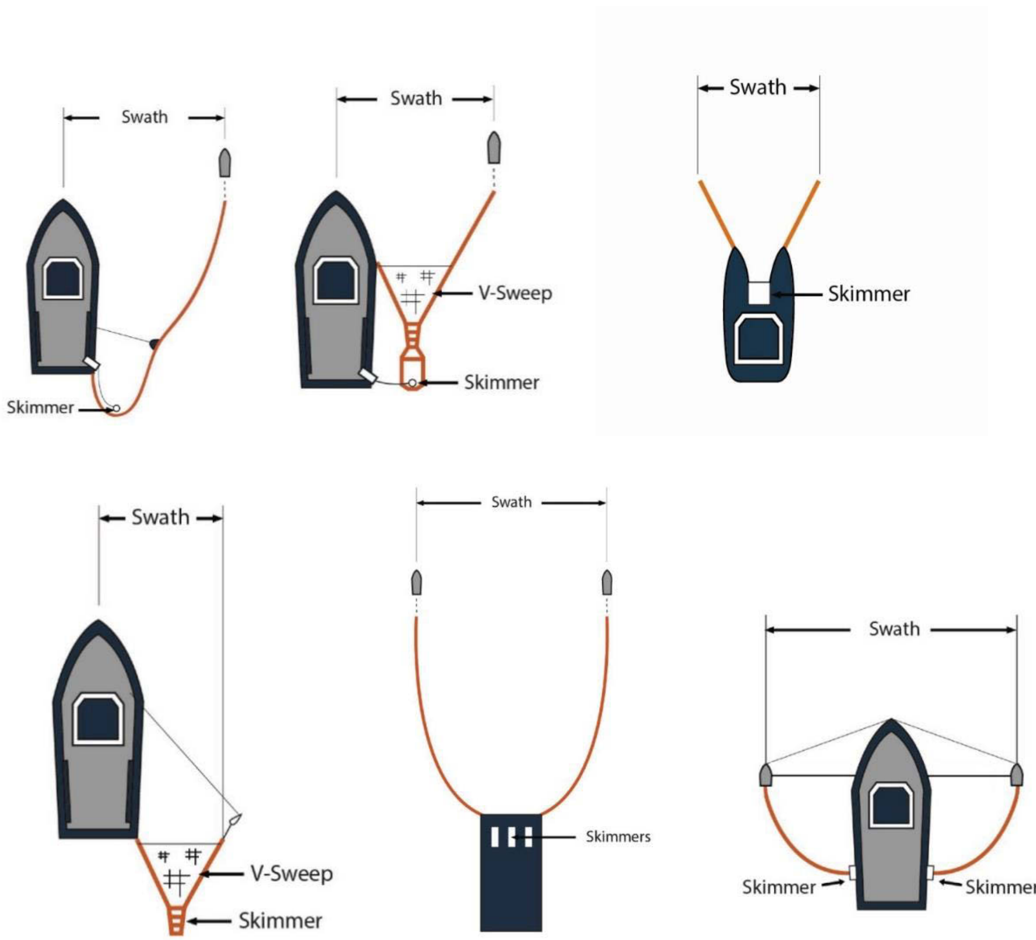
Skimmer Device – Captures oil, emulsion, and free water (a function of the Recovery Efficiency) and transfers the Total Fluid Recovered to Onboard Storage. A portion of the oil/emulsion encountered is lost behind the system (a function of the Throughput Efficiency).

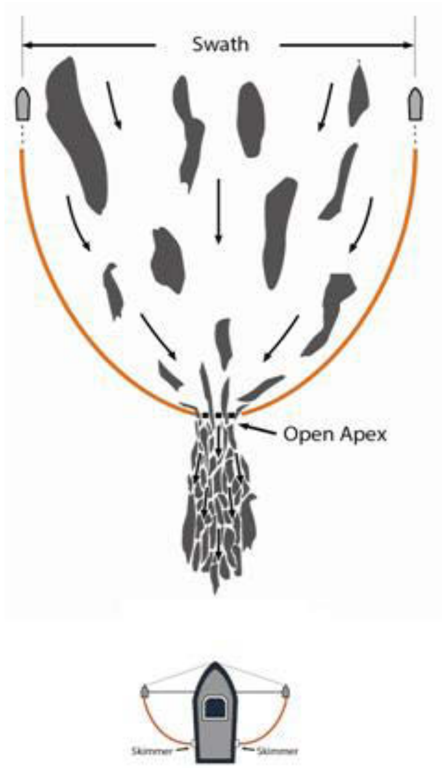
Onboard Storage – Includes tankage built into the OSRV to receive the total fluids recovered. It could also include barges or other storage that is physically connected to the OSRV so that the Skimmer can discharge directly into it. Where permitted, a portion of the free water recovered can be decanted ahead of the skimming system after settling (and physical separation and heating depending on the capability of the system). When the Onboard Storage is full, the system transits to the location of secondary storage, rigs for transfer, offloads to secondary storage, derigs and transits back to the spill site to resume skimming operations.

Pumps –Depending on the type of skimmer a subcomponent could be a pump. Also included in this component category are the pump(s) used to decant a portion of the recovered free water (if enabled) and the discharge pump(s) used to transfer recovered product from Onboard Storage to Secondary Storage.

Secondary Storage - While not shown in the diagram, secondary storage is considered a component of each skimming system. As each system fills its onboard storage it transits to the location of secondary storage.

The following diagrams illustrate some of the possible configurations of advancing skimming systems.





Enhanced Skimming Configurations

Enhanced skimming adds a U-shaped configuration of boom with an open apex towed ahead of the skimming system. The added boom configuration increases the system's effective swath width, and concentrates the oil/emulsion for containment and recovery by the skimmer. This configuration increases a system's areal coverage and oil encounter rates. Enhanced skimming will require additional personnel, tow boats and enough additional boom to achieve the desired swath using a gap ratio of 1:3 (e.g. a 300 foot swath would require a minimum of 900 linear feet of boom).

Figure 2. Open apex enhanced skimming configuration example

2. Assumptions and Limitations as a Planning Tool

The ERSP Calculator was developed to provide an encounter-rate based estimate of daily recovery potential for advancing skimming systems operating in open waters, in warm or cold climates, without the effects of ice, debris or extreme weather conditions. The calculator accommodates a broad range of skimming system configurations and addresses response activities including the accessing, containment and recovery of oil. The calculator also accounts for the storage and possible decanting of recovered free water, the transiting of a skimming system to and from secondary storage, and the offloading of recovered fluids. The goal was to provide a computer tool that could facilitate the calculation of a "Planning Standard", not a "Performance Measure".

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.

The following is a list of assumptions and limitations inherent to the design of the ERSP Calculator, that are readily acknowledged as conditions accepted in order to keep the Calculator a simple and easy to use planning tool:

- ***Ambient Conditions:*** Estimates made by the Calculator assume that conditions are generally conducive to effective skimming operations. Its output is designed to serve as a guide for planning the deployment of skimming systems and estimating their recovery potential in order to meet plan holder needs.
- ***Default Values:*** Generally, conservative default values are built into the Calculator. A default value is conservative if it is more likely to be an underestimate than an overestimate.
- ***Skimming Downtime:*** No downtime due to maintenance or repair is considered.
- ***Oil Types:*** The Calculator does not differentiate outputs based on the type of oil or product being recovered. 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 non-persistent Group I type oils, such as gasoline or diesel fuel. Group I oils tend to NOT form stable emulsions. Group I oils also tend to form much thinner slicks than Group II, III, and IV oils even in very large discharge quantities.
- ***Use of Constant TFRR Values:*** Skimming systems are assumed to be collecting at a constant recovery rate. Actual recovery of oil/emulsion by skimmers is likely to be more intermittent in nature (as necessary to accumulate sufficient thicknesses of oil) in order to maximize the efficiency of recovery operations. At any point the Total Fluid Recovery Rate (TFRR) cannot exceed Maximum Total Fluid Recovery Rate of the system. If this occurs, the Calculator will reduce the Swath so that the TFRR = Maximum Total Fluid Recovery Rate.
- ***Skimming in Waters with Restricted Maneuverability:*** The ERSP calculator does not discern between ocean or offshore operating areas and inshore operating areas. While the ERSP algorithms apply equally in all areas, skimming systems with large swath widths and large tethered storage arrangements are likely to be less effective in inshore operating areas, where water depths and restricted maneuverability are likely to become a critical factor. It is up to the ERSP Calculator user to apply operational knowledge and common sense in selecting values for their skimming configuration that match the needs of the operating environment (as opposed to entering values for poorly matched configurations that would maximize the ERSP at the expense of operational feasibility).
- ***Three Day Window for Calculating ERSP for a Batch Spill Scenario:*** The three-day ERSP calculation period for batch spill scenarios was selected for several reasons. After the first three days, there is a reduced availability of oil because the majority of the oil has weathered and spread to the point where continued on-water skimming operations may become an ineffective response option. Another factor is the operational reality that three days after an incident

has occurred, most of the necessary response resources would be on-scene or ordered, and spill specific response planning would be in place.

- ***Oil Spreading and Thickness Values:*** Computer models, such as the Response Options Calculator (ROC) developed by Genwest, along with other sophisticated models described in the EDRC project final report, were used to establish nominal oil thicknesses for each of three days following a major spill (typically thousands to tens of thousands of barrels). The ROC predicts that, in a batch spill, oil thicknesses within the slick generally will decline over time. The spreading and weathering of a broad range of oil types and volumes were simulated under varying wind/sea conditions and water temperatures. The analysis of the results of these simulations revealed nominal representative thickness values that are used to estimate the oil encounter rates for each day of a significant spill. The results of hundreds of computer simulations suggested that 12 hours after the discharge of a large oil spill (assumed mid-day on Day 1), the nominal oil/emulsion thickness could be estimated at 0.1 inch. The mid-day thicknesses for each of Days 2 and 3 could be represented by 0.05 inch (after 36 hours) and 0.025 inch (after 60 hours). In the ERSP Calculator the Operating Period is defined as the length of time in hours each day (centered on noon) where conditions allow a skimming system to conduct removal operations. Real-world oil/emulsion thicknesses can span several orders of magnitude for the many different oil types and environmental conditions that could actually occur during a spill. However, the three selected values reflect reasonable representative thicknesses which are used for the Operating Period in each of the first three days for the recoverable portion of a batch discharge of oil for "planning" purposes. For significant continuous discharges, the nominal oil/emulsion thickness for the designated Operating Period in Day 1 (.1 inch) of a batch spill is used for each day of the response to a continuous spill.
- ***Use of Best Practices for Skimming:*** The ERSP Calculator assumes responders will use best practices, for example, the use of airborne spotters and remote sensors in order to actively direct and keep skimming systems continuously operating in the thickest available concentrations of recoverable oil. ERSP also assumes that personnel are available and trained to deploy and effectively operate the skimming system in the manner necessary to achieve the maximum potential.
- ***Emulsification:*** Many oil releases involve emulsified oil (emulsions of water in oil). During real oil spills, emulsification proceeds at different rates and to different degrees depending on such things as oil type and environmental conditions. Based on a number of simulations, the Calculator specifies the percentage of emulsification as 35% in Operating Period 1, 55% in Operating Period 2, and 75% in Operating Period 3 for batch releases, 35% for all operating periods of a continuous release. In any ERSP Calculator run, the recovered fluids are assumed to be a mix of oil/emulsion and free water. However, ERSP is a calculated estimate of the volume of oil recovered.

- ***Asset Mobilization:*** It is assumed that the skimming system is rigged and ready to operate with empty Onboard Storage at the beginning of each Operating Period. The ERSP Calculator does not account for the time necessary at the beginning of a spill for notification, mobilization, and transit time to the location of the oil slick. These factors need to be addressed separately in each plan as required by the relevant agency regulations.
- ***Offloading in between Operating Periods:*** At the end of each Operating Period it is assumed that any fluids remaining in onboard storage will be removed before the next Operating Period begins. If the Calculator determines that this offloading cannot be done in the time available between Operating Periods, then a Simulation Note (Simulation Notes are described in more detail below) will be generated **-** "Offload not achievable between Operating Periods **-** Reduce Operating Period [hrs]**".** Using the same system configuration, the user can reduce the Operating Period and recalculate until the Note no longer appears. Adding Discharge Pump capacity or making other configuration changes could also impact the required offload time.

3. ERSP Calculator Inputs

This section provides a general description, and in many cases, amplifying guidance, for each of the input fields and the variables that a user must enter into the Calculator. The graphic below is an illustration of the input screen that a user will see and use to enter their skimming system information into the Calculator.

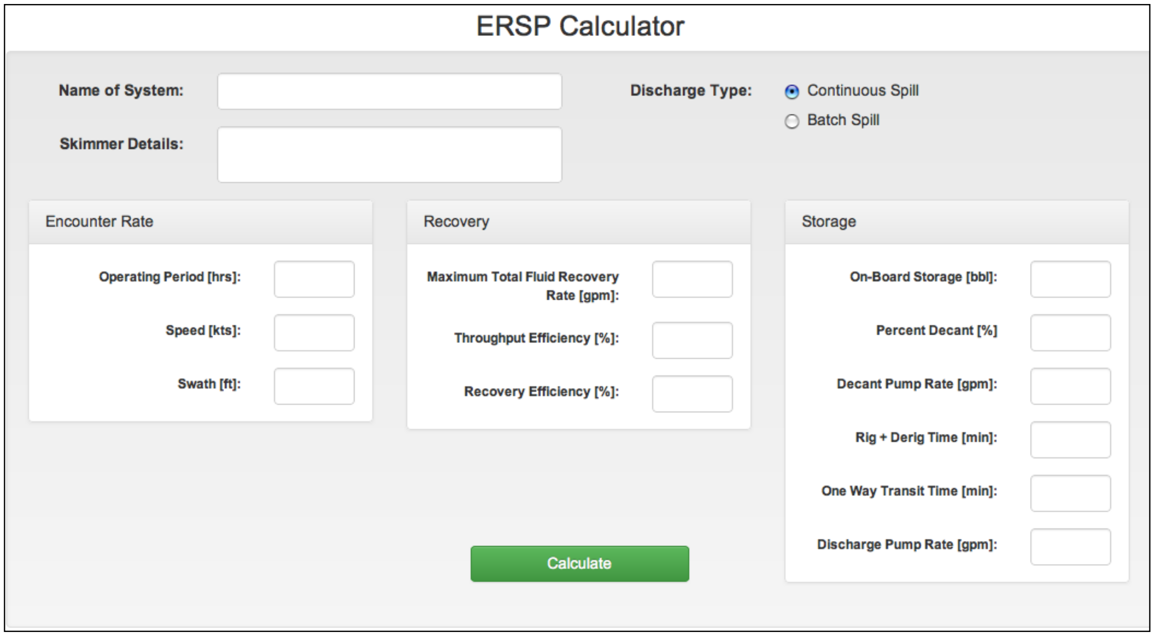


Figure 3. ERSP Calculator Input Screen

<u>Discharge Type (Continuous Spill and Batch Spill):</u>

The user must identify the type of spill for which the system is being evaluated. This selection will determine the format of the output that the ERSP Calculator will display.

<u>Skimming System Identifiers:</u>

These screens are useful for both planners and regulators to identify and track the ERSP Calculator input and output data associated with major equipment configurations.

- <u>Name of System</u>: Entry field for the name or other form of identifier for the skimming system (up to 48 characters).
- <u>Skimmer Details</u>: Enter configuration details including the type of platform, skimmer, pump, and boom being used and other key information to identify this simulation.

The Use of Default and Alternate Values: The Calculator, and its default values for many of the key inputs, was intended to be "conservative" in nature. In some cases, an advancing oil skimming system's tested performance will be able to exceed the default values for specific inputs. Plan holders or OSROs may submit requests for the use of alternate values in the ERSP Calculator to the appropriate regulatory agency. The regulatory agencies will consider each request based on the merits of the documentation provided. Operators should expect that the use of approved alternate values may be subject to validation efforts by regulators. Plan holders and OSROs may be required to satisfactorily demonstrate the practical viability of these values during equipment verification visits and PREP equipment deployment exercises.

The ERSP Calculator inputs have been grouped into three categories: Encounter Rate, Recovery, and Storage.

3a. Encounter Rate Inputs

Operating Period [hrs]:

The Operating Period, which should not be confused with an operational period for an Incident Action Plan, is the length of time (in hours) each day where conditions allow a skimming system to conduct removal operations. For Batch spills the Calculator assumes that the first Operating Period is centered on 12 hours after the spill occurs, the second Operating Period is centered on 36 hours after the spill occurs, and the third Operating Period centers on 60 hours after the spill occurs (see diagram below).

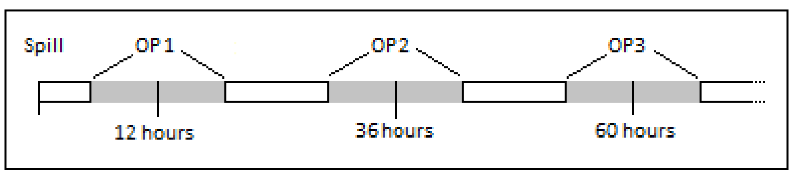


Figure 4. Operating Period

- The Default Operating Period to be used is 12 hours.

Alternative values for the length of the Operating Period may be requested when an operator has available through contract or other approved means the appropriate remote sensing technologies to operate effectively into periods of darkness and also the necessary logistical arrangements to operate safely in an extended manner. Requests for an extension of the Operating Period would be evaluated on a case-by-case basis by the appropriate regulatory agency.

The ERSP Calculator assumes that the skimming system begins each Operating Period configured for skimming operations with empty on-board storage. As such, any requested extension of the Operating Period must take into account the downtime necessary to accommodate the required offload cycle, including the transit, rig + derig, and offloading activities, which the ERSP Calculator assumes to be completed each night before the start of the next day's operating period.

For example, let's assume an operator has a suite of remote sensing capabilities and sufficient logistical support to operate during periods of darkness, and has a one way Transit Time to or from secondary storage of 30 minutes (x2), a Rig + Derig Time of 30 minutes, and a maximum offload time of 3 hrs. Any request for an extension of the Operating Period must take into consideration a possible minimum downtime of 4.5 hours for a full offloading cycle. As such, in this case the maximum operating period that may be requested would be 19.5 hours (24 hours minus the 4.5 hour offload cycle, affording the 12 hour default period plus an additional 7.5 hours).

Speed [kts]:

This is the skimming speed relative to the oil slick. For most advancing skimming systems, recommended maximum speeds are up to 0.75 knot, although some recent boom designs can efficiently contain oil at speeds of 3 knot or more. Higher speeds should be demonstrated in field tests or documented as described in ASTM F 2084-01, Standard Guide for Collecting Containment Boom Performance Data in Controlled Environments. Speed should not be *above first-loss/current velocity* in F 2084.

- The default entry value for Speed is 0.75 knot to indicate that the skimming system travels at a speed of 0.75 knot relative to the oil slick.
- For Calculator users contemplating the use of a higher skimming speed for their system, regulatory agencies will consider requests for the use of alternative values based on the supporting documentation submitted for speeds up to a 3 knot maximum value.

Swath [ft]:

The Swath is the width over which the skimming system encounters the oil slick. There is no default value for this input field. Many skimming systems have a "standard" Swath, which is operationally efficient to deploy and operate, and users should anticipate using these values in their planning, especially if that is how their tactics manuals and training indicate their systems will be used during a spill.

When planning for the use of skimming systems which will operate primarily in restricted waters where skimmer maneuverability and access to oil will be an issue, Swath widths should be reduced appropriately, and entered in widths that are appropriate for use in such conditions.

Increasing the swath, using an appropriate configuration in the right conditions, may significantly increase a skimming system's potential for recovery. The ERSP Calculator computes a Maximum Effective Swath (MES) for every skimming system based on the oil slick thickness for that Day, the Speed of the system, and the Maximum Total Fluid Recovery Rate. At the Maximum Effective Swath, the skimming system is recovering total fluids at the maximum possible rate. The actual swath used by the Calculator algorithm for each Operating Period is limited to a maximum value equal to the MES.

Deployment of enhanced skimming configurations, as described earlier in Section 1b, is a potential means to increase the Swath of various skimming systems.

- For enhanced skimming, a user may enter the widest swath that can be effectively deployed up to the recommended maximum Swath of 1,000 feet.

Deployment of enhanced skimming configurations will require trained personnel and additional boom, tow boats, and associated gear. A separate set of supporting equipment should be available for each skimming system where enhanced skimming swath input values will be used. Plan holders using enhanced skimming configurations should anticipate that regulators may require demonstrations of the equipment and trained personnel required to conduct these enhanced skimming operations during preparedness verifications (or preparedness assessment visits) and PREP deployment exercises.

3b. Recovery Inputs

Maximum Total Fluid Recovery Rate [gpm]:

This is the maximum rate at which fluids (meaning the recovered product, consisting of oil, water in oil emulsion, and free water) can be processed by the skimming component of the system. The value for the Maximum Total Fluid Recovery Rate should not be confused with a skimmer's nameplate recovery rate as calculated under ASTM F2709-08, which is a recovery rate for pure oil. The Maximum Total Fluid Recovery Rate value required by the ERSP Calculator can be determined using the following methods in order of preference:

- ASTM F631–99 (Reapproved 2008), Standard Guide for Collecting Skimmer Performance Data in Controlled Environments, provides quantitative data in the form of total fluid and oil recovery rates, throughput efficiencies, and recovery efficiencies under controlled conditions that are designed for testing skimming systems in the advancing mode. The data generated (as described in section 12.2.2 and 13.2.11 of ASTM F631-99) for the fluid recovery rate (oil/emulsion and water) can be used, after being converted to gallons per minute.
- ASTM F2709-08, Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimming Systems, provides quantitative results from measurements of the performance of stationary skimming systems. The data generated for stationary skimming devices under ASTM F2709-08 may be applied to and used for skimmers in an advancing mode when the advancing skimming device is operating in quiescent conditions that would be similar to operating in a stationary environment (i.e. operating in a protected area that is advancing, such as the sheltered containment pocket of a J-boom).
  To determine the Maximum Total Fluid Recovery Rate using F2709-08:
    - As provided for in Paragraph 7.2.12 of the Standard, "measure and record the total volume of fluid (oil or oil and water) in the dedicated collection tank(s)"
    - Note the start and end time of each test as described in paragraph 8.5.
    - Calculate the Total Fluid Recovery Rate for each test by dividing the total volume of fluid by the elapsed time for that test.
    - Select the average Total Fluid Recovery Rate from the three tests for use in the ERSP Calculator.
    - The value used here for total fluid recovery rate should not be confused with the *nameplate recovery rate* as defined in ASTM F2709-08, where the Nameplate Recovery Rate is synonymous with the amount of pure oil recovered, also referred to as the oil recovery rate (ORR).
- If the performance data for the maximum fluid recovery rate is not available from test data generated using an appropriate ASTM standard, you should use the maximum skimming capacity of the skimmer device as stated by the manufacturer.

Throughput Efficiency [%]:

For the purposes of the ERSP Calculator, Throughput Efficiency (TE) is the percentage of oil/emulsion taken onboard, out of the total volume of oil/emulsion encountered. It is a measure of the effectiveness of the containment component of the skimming system and its ability to prevent entrainment or loss of the oil encountered. TE can be entered into the Calculator using the following methods:

- The TE of a skimming system can be specified using the results of testing done under ASTM F631-99 as per Paragraphs 3.1.13 and 13.2.22 (as the average value of TE in all individual tests performed).
- In the absence of ASTM F631-99 test results, the default value for TE is 75%.

Recovery Efficiency [%]:

The Recovery Efficiency value in the ERSP Calculator is a measure of the amount of oil/emulsion recovered compared to the total fluids recovered, expressed as a percentage. ASTM F1780-97 explains that a skimmer will recover free water along with the recovered oil, and that the amount of free water recovered is a measure of the efficiency of the skimmer system. Skimmer RE values can vary widely based on their designed recovery method. Skimming RE values can also change due to oil type and ambient environmental conditions. RE values can be estimated for comparative planning purposes using the following methods in order of preference:

- ASTM F631-99. Paragraphs 3.1.9 and 13.2.20 of ASTM F 631-99 provide for measuring Oil Slick Recovery Efficiency (RE) as the ratio, expressed as a percent of the volume of oil slick (oil and emulsion) recovered to the volume of total fluids recovered. The Oil Slick Recovery Efficiency value generated by F 631-99 can be used for RE in the ERSP Calculator.
- ASTM F2709-08. In Paragraph 3.1.5 of ASTM 2709-08, *recovery efficiency is defined as* “the ratio, expressed as a percentage, of the volume of oil recovered to the total volume of fluids recovered.” As such, RE in this case measures only pure oil (and does not include emulsion). RE values calculated using Paragraph 8.8 of ASTM 2709-08 will therefore result in a conservative value in that regard. In comparison, RE as defined in the F 631-99 includes emulsions in estimating the amount of the oil slick recovered.
- When test data using ASTM F 631-99 or ASTM F 2709-08 is not available, the default value of RE for an oleophilic skimmer is 75%. The default value for all other skimmers is 50%.

3c. Storage Inputs

On-board Storage [bbl]:

Enter the volume in barrels of On-board Storage. This could be tankage built into the skimming system platform vessel or other storage physically tethered to the skimming system such as a mini-barge.

Percent Decant [%]:

Decanting is the process of removing a percentage of recovered free water from the available Onboard Storage tanks prior to offloading the recovered fluids to secondary storage. Decanting of free water typically will be performed after a suitable settling time and the free water will be discharged back into the containment area forward of where active skimming is occurring. An effective decanting arrangement should increase the efficient use of onboard storage, where the amount of oil/emulsion that can be recovered is increased and the amount of free water retained is decreased before the system must be offloaded to secondary storage. Decanting is a permitted activity that may not be appropriate or approved for some operating areas.

- When calculating the ERSP for a skimming system to be used in an area where decanting is not expected to be approved, a default value of 0 (zero) percent should be used.
- When calculating the ERSP for a skimming system that will be used in an area where decanting is expected to be readily permitted (such as most offshore areas or locations specifically identified in Area Contingency Plans and Regional Contingency Plans), the following applies:

    - For systems with Onboard Storage consisting of multiple tanks, and with a suitable decant pump, the default value is 40% Decant.
    - If the skimming system also incorporates a suitable mechanical oil/water separation device OR heating coils in the Onboard Storage tanks, the recommended default value is 45% Decant.
    - If the skimming system incorporates a suitable mechanical oil/water separation device AND heating coils in the Onboard Storage tanks, the recommended default value is 50% Decant.

Decant Pump Rate [gpm]:

Enter the decant pump rate in gallons per minute. The Decant Pump should be rated using ASTM F1607 -99 (2013), Standard Guide for Reporting of Test Performance Data for Oil Spill Response Pumps. The recommended viscosity range to be tested is Category 1 – 1 to 1000 cSt. For simplicity, the Calculator determines the necessary average Decant Rate based on the rate at which free water is recovered and the specified % Decant and applies this continuously. In reality, a settling time would apply before decanting begins. If the computed Decant Rate is greater than the specified Decant Pump Rate, a Simulation Note is generated – "**Calculated Decant Rate is greater than Decant Pump Rate".** If this note is displayed it will be necessary to lower the % Decant value entered or specify a larger Decant Pump Rate and then recalculate.

Rig + Derig Time [min]:

Rig + Derig Time includes the time needed at the secondary storage site to tie up to secondary storage, connect hoses, complete paperwork and other necessary activities, and then to later disconnect hoses and lines after offloading has been completed. Rig + Derig Time is added to the calculated Offload Time and is only applied once. Rigging/derigging typically requires 15 minutes to an hour.

- The default entry value is 30 minutes (which provides 15 minutes for rigging and 15 minutes for derigging, or any other rig + derig combination that would total 30 minutes).

One WayTransit Time [min]:

This is the time necessary for the system to transit between the area where it has been actively skimming and the area where recovered fluids will be offloaded to secondary storage. Any time spent 1) changing the configuration from skimming to rigging for transit, and 2) changing back to a skimming configuration after returning to the spill site, should be added into the Transit Time.

- One Way Transit Time as entered into the ERSP Calculator is the time necessary for a "one way" transit to the secondary storage site. The Calculator will apply the One Way Transit Time twice in its algorithms in order to calculate the round trip travel times necessary for offloading.
- The One Way Transit Time value is NOT the time necessary for the system to initially mobilize and travel from its staging area to the site of the spill.
- The default entry value is 30 minutes (this entails an initial 30 minute transit time to the secondary storage site, and a second 30 minute transit time to return to the spill after the offload is complete).

Discharge Pump Rate [gpm]:

This is the rate (in gallons per minute) at which the recovered fluids stored in the skimming system's Onboard Storage are offloaded into a Secondary Storage site. The Discharge Pump should be rated using ASTM F1607. The recommended viscosity range to be tested is Category 3 – 10001 to 100000 cSt. The Total Offload Cycle Time for Full Tank(s) is computed using the Discharge Pump Rate.

4. ERSP Calculator Results

ERSP Calculator results are output in the form of both graphics and tabular data. Simulation Notes are generated by the Calculator to alert the user that adjustments to input data may be necessary. See Section 4e for a complete description of Simulation Notes.

Simulation Notes:

If the entered Swath > MES, the calculator uses the Swath = MES for that day.

Figure 5. Simulation Notes

The graphical data is presented in the form of summary data followed by bar charts depicting the breakdown of fluids recovered (less any free water decanted) and a recovery cycle timeline during each Operating Period. Batch spills will have a set of bar charts for three consecutive days, while a continuous spill will have only one bar chart that would assume to be repeated for each day of the ongoing discharge of oil.

Estimated Recovery System Potential (ERSP)	Operating Period 1	Operating Period 2	Operating Period 3	3-day Total
(Total Volume of Oil Recovered in Operating Period)	2,403 bbl	1,157 bbl	369 bbl	3,929 bbl

Figure 6. Summary Data

Each recovery bar below depicts the volumes of oil, water in emulsion, and free water that is recovered, retained onboard, and offloaded to secondary storage. The overall length of each bar during a batch spill is relative to the total volume of the fluids recovered and retained during the initial Operating Period.

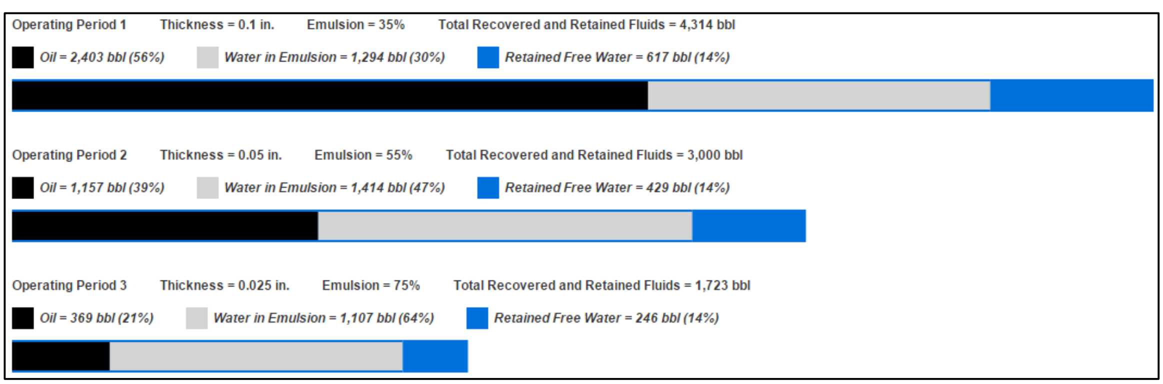


Figure 7. Recovery Bar Chart

The final graphical bar chart is the Recovery Cycle Timeline, which depicts the recovery and offloading activities for each Operating Period in a linear fashion on an hourly timescale. The Recovery Cycle begins each day with the skimming system's onboard storage empty, as it is assumed that any recovered fluids onboard at the end of any active skimming each day will be offloaded at night prior to commencing the next operational period of skimming. A complete fill and offload cycle is shown on the bar chart as the time necessary to fill up the onboard storage with recovered fluids (green), time to transit between the spill site and the secondary storage offloading location (red), and the time necessary to rig and derig transfer hoses and conduct the offload (orange).

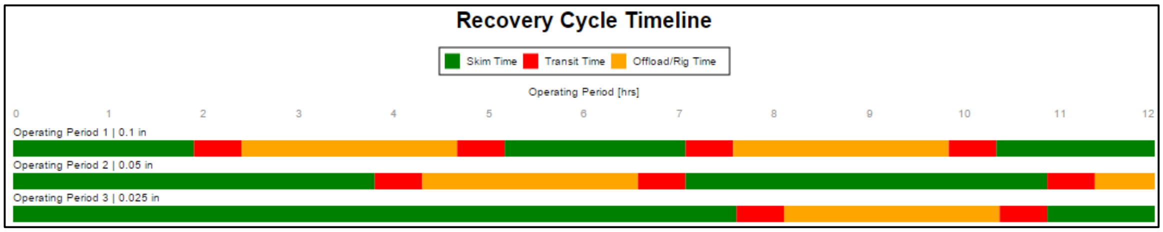


Figure 8. Recovery Cycle Timeline Bar Chart

The following figure shows the tabular data outputs, which presents additional planning details relating to encounter rate, recovery, and storage-related aspects of the skimming system. The column labels also show the oil slick thickness and the emulsification values that were used by the ERSP Calculator for each Operating Period (OPs).

Operating Period: Encountered Product (Oil/Emulsion) Thickness: % of Water in Oil/Water Emulsion:	Op. Period 1 0.1 in 35%	Op. Period 2 0.05 in 55%	Op. Period 3 0.025 in 75%
Encounter Rate Results			
Maximum Effective Swath (MES)	135 ft	269 ft	539 ft
Swath Used For Calculation	100 ft	100 ft	100 ft
Oil/Emulsion Encounter Rate	631 gpm	316 gpm	158 gpm
Areal Coverage Rate	0.23 acres/min	0.23 acres/min	0.23 acres/min
Area Covered in Operating Period (Acres)	76 acres	106 acres	122 acres
Area Covered in Operating Period (Sq. Miles)	0.12 sq mi	0.17 sq mi	0.19 sq mi
Recovery Results			
Total Fluid Recovery Rate	631 gpm	316 gpm	158 gpm
Emulsion Recovery Rate	473 gpm	237 gpm	118 gpm
Oil Recovery Rate	308 gpm	107 gpm	30 gpm
Free Water Recovery Rate	158 gpm	79 gpm	39 gpm
Storage Results			
Water Retained Rate	79 gpm	39 gpm	20 gpm
Decant Rate	79 gpm	39 gpm	20 gpm
Time to Fill Onboard Storage	1.9 hr	3.8 hr	7.6 hr
Total Offload Cycle Time for Full Tank(s)	3.27 hr	3.27 hr	3.27 hr
Time for One Full Cycle (skimming, transit, rig + derig, offload, transit)	5.17 hr	7.07 hr	10.87 hr
Skimming Time in Operating Period	5.47 hr	7.6 hr	8.73 hr
Skimming Time in Operating Period (%)	46 %	63 %	73 %
Total Number of Fills in Operating Period	2.9	2	1.1
Volume Results			
Total Volume Oil/Emulsion + Free Water Retained in Operating Period	4,314 bbl	3,000 bbl	1,723 bbl
Total Volume of Oil/Emulsion Recovered in Operating Period	3,697 bbl	2,571 bbl	1,477 bbl
Total Volume of Free Water Recovered & Retained in Operating Period	617 bbl	429 bbl	246 bbl
Total Volume of Water in Emulsion Recovered in Operating Period	1,294 bbl	1,414 bbl	1,107 bbl
ERSP = Total Volume of Oil Recovered in Operating Period	**2,403 bbl**	**1,157 bbl**	**369 bbl**

Figure 9. ERSP Tabular Outputs

4a. Encounter Rate Results

<u>Maximum Effective Swath (ft):</u>

A skimming system is operating at its greatest potential for oil recovery when the rate of total fluids being encountered and taken onboard is the same as the system's maximum skimming capacity. The Total Fluid Recovery Rate is a function of Speed, Thickness, Swath, TE, and RE. Setting the Total Fluid Recovery Rate equal to the maximum skimming capacity of the system and then solving the equation for Swath Width determines the Swath at which the system achieves its maximum skimming capacity. This swath width is known as a system's Maximum Effective Swath (MES). Any Swath greater than MES will not increase recovery. Any Swath less than MES will result in a recovery less than the potential of the system.

<u>Swath Used For Calculation (ft):</u>

The entered Swath will be used in the calculator if it is less than or equal to the MES. Any Swath entry greater than the MES will be reduced to the MES for calculations.

<u>Oil/Emulsion Encounter Rate (gpm):</u>

This is the rate at which oil/emulsion is encountered by the skimming system and is a function of the oil slick Thickness, the Speed of the skimming system, and the Swath.

<u>Areal Coverage Rate (acre/min):</u>

This is the rate at which the skimming system "sweeps the oil slick" in units of acres per minute. It is a function of Speed and Swath.

<u>Area Covered in Operating Period (acres):</u>

The total area in acres covered by the system in the Operating Period while actually skimming.

<u>Area Covered in Operating Period (Sq Miles):</u>

The total area in square miles covered by the system in the Operating Period while actually skimming.

4b. Recovery Results

<u>Total Fluid Recovery Rate (gpm):</u>

The computed rate at which total fluids (oil/emulsion, free water) are taken on board the skimming system.

<u>Emulsion Recovery Rate (gpm):</u>

The computed rate at which mousse (stable water-in-oil emulsion) is taken on board the skimming system.

Oil Recovery Rate (gpm):

The computed rate at which oil is taken on board the skimming system.

Free Water Recovery Rate (gpm):

The computed rate at which free water is taken on-board the skimming system.

4c. Storage Results

Water Retained Rate (gpm):

The computed rate at which the free water is recovered and retained on-board, rather than decanted.

Decant Rate (gpm):

The computed rate at which free water is decanted from the skimming system.

Time to Fill Onboard Storage (hr):

The computed time needed to fill the onboard storage with oil/emulsion and retained free water.

Total Offload Cycle Time for Full Tank(s) (hr):

The computed time needed to transit to and from secondary storage, rig + derig, and offload oil/emulsion and free water from the system's onboard storage to the secondary storage barge or facility, each time that the onboard storage has been filled.

Time for One Full Cycle (hr):

The computed total time needed to fill the system's onboard storage, reconfigure and transit to the secondary storage location (typically a barge or shore facility), offload (including rigging, derigging, transfer hose hookups, and line handling), transit back to the slick, and configure to resume skimming.

Note that Time for One Full Cycle = Time to Fill Onboard Storage + Total Offload Cycle Time for Full Tank(s)

Skimming Time in Operating Period (hr):

The total time during the Operating Period when the skimming system is actually engaged in skimming.

Skimming Time in Operating Period (%):

The total percent of the time during the Operating Period when the skimming system is actually engaged in skimming.

Total Number of Fills in Operating Period:

The total number of fills of the Onboard Storage during the Operating Period. This is displayed to the nearest tenth of a fill In the event that the Operating Period ends with a partial fill,

4d. Volume Results

Total Volume Oil/Emulsion + Free Water Retained in Operating Period (bbl):

The total volume of fluids recovered and retained by the skimming system during the Operating Period, including oil/emulsion and free water, in barrels.

Total Volume Oil/Emulsion Recovered in Operating Period (bbl):

The total volume of oil/emulsion recovered and retained by the skimming system during the Operating Period, in barrels.

Total Volume of Free Water Recovered & Retained in Operating Period (bbl):

The total volume of free water recovered and retained during the Operating Period, in barrels.

Total Volume of Water in Emulsion Recovered in Operating Period (bbl):

The total volume of water in stable emulsion recovered during the Operating Period, in barrels.

ERSP (Total Volume Oil Recovered in Operating Period) (bbl):

The total volume of oil recovered in each Operating Period, in barrels.

4e. Simulation Notes

Depending on the values you enter, one or more of the following simulation notes will display whenever you run a scenario in the Calculator. Some notes are simply notifications, while others alert you to a potential problem that will require you to revise your entries.

Simulation Note	Explanation
If the entered Swath > MES, the calculator uses the Swath = MES for that day.	Displays for all scenarios, to alert you that if you have entered a swath wider than the maximum effective swath (MES), the calculator will use MES to compute its estimates, rather than the swath you entered. When the swath is equal to MES, total fluids (oil/emulsion and free water) are recovered at the Total Fluid Recovery Rate, and the system encounters and collects fluids at its maximum potential. When the entered Swath is less than the MES, the entered Swath is used for calculations.
Swath used for calculation may not be achievable.	Displays if the swath used for calculation is more than 1,000 feet, as may happen if you enter a swath value larger than 1,000 feet. This alert tells you that this swath is unusually wide and may not be operationally achievable. To correct this problem, a value of 1000 or less should be entered for the swath width.
Calculated Decant Rate is greater than Decant Pump Rate – Reduce Percent Decant [%] value	Displays if the computed Decant Rate is greater than the Decant Pump Rate. To correct this problem, enter a smaller value for Percent Decant or add decant pump capacity.
Offload not achievable between Operating Periods - Reduce Operating Period [hrs].	Displays if the time needed to offload the system's onboard storage exceeds the time available between operating periods. To correct this problem, enter a smaller value for the Operating Period or change the system configuration to allow sufficient time for the last offload cycle.

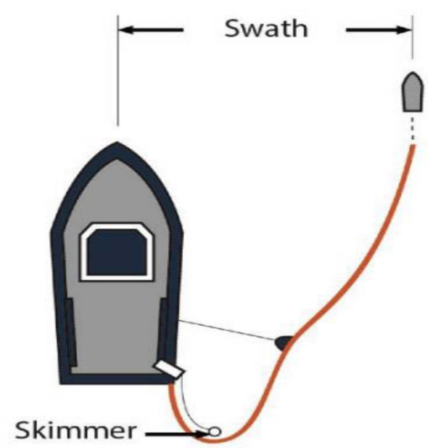
5. Using the ERSP Calculator

You can use the ERSP Calculator to evaluate the oil recovery potential of a skimming system for two different types of spill scenarios:

- A **continuous** spill, such as an oil exploration or production well blowout, in which oil continues to flow from the source for multiple days, and slick thickness does not decrease over time.

- A **batch** spill, in which oil spills for a relatively short time before the source is secured or all the oil available to spill has been discharged. Examples of batch type spills would include discharges from most vessels, storage tanks, and pipelines.

This section will use the skimming system shown at the right, which includes a large Oil Spill Response Vessel (OSRV) and an over-the-side weir skimmer positioned at the apex of a bridled J-boom, to illustrate the use of the ERSP Calculator. First, we will look at the process of using the calculator to estimate the ERSP for this system in a continuous discharge scenario, and then switch to a batch spill scenario.



Starting the ERSP Calculator

For either type of spill scenario, you can access the ERSP Calculator by double-clicking on the ERSP_Calculator_20150222.html file, which will open up the Calculator in your default web browser.

5a. Calculating ERSP for a Continuous Spill Scenario

In order to evaluate a skimming system's potential to recover oil during a well blowout:

- If not already selected, click the "**Continuous Spill"** radio button to indicate that you want to estimate ERSP for this example of a continuous oil spill scenario.

Entering input values

- In the **Name of System** box, enter the identifier for this skimming system configuration. This example uses "Manatee."

- The **Skimmer Details** box can be used to enter descriptive information about the skimming system configuration, including the OSRV length, skimmer type, and amount of boom.

Encounter Rate:

- In the **Operating Period** box, enter 12.
- Set **Speed** to .75 to indicate that this skimming system travels at a speed of .75 knots relative to the oil slick.
- Set **Swath** to 250 feet. Swath is the width in feet over which oil is encountered and concentrated by the collection boom as it is towed across the water surface. For this example, the system's 250-foot swath extends from the bow of the OSRV to the bow of the smaller boom-tending boat that accompanies it.

Recovery Capability:

- Enter 800 in the **Maximum Total Fluid Recovery Rate** box.
- Enter 75 in the **Throughput Efficiency (%)**, box.
- Enter 50 in the **Recovery Efficiency (%)** box for a weir type skimmer.

Temporary Storage:

- Enter 2500 (without any commas) in the **On-Board Storage** box, as the skimming system can store up to 2,500 bbl of recovered fluids on board.
- Set **Percent Decant** to 50 to indicate that the skimming system is decanting 50% of the free water (water that is not bound up in oil-water emulsion) that it takes on board. Note that this skimming system utilizes multiple tanks for Onboard Storage, has mechanical oil/water separation capabilities, and has heating coils installed in the storage tanks.
- Enter 250 in the **Decant Pump Rate** box as the rated capacity of the pump used to decant free water from the onboard storage tanks.
- Enter 30 in the **Rig + Derig Time** box.
- Enter 30 in the **One Way Transit Time** box.
- Enter 500 in the **Discharge Pump Rate** box as the rated capacity of the pump used to offload the on-board storage tank(s) to secondary (backup) storage.

The Calculator input screen should now look like this:

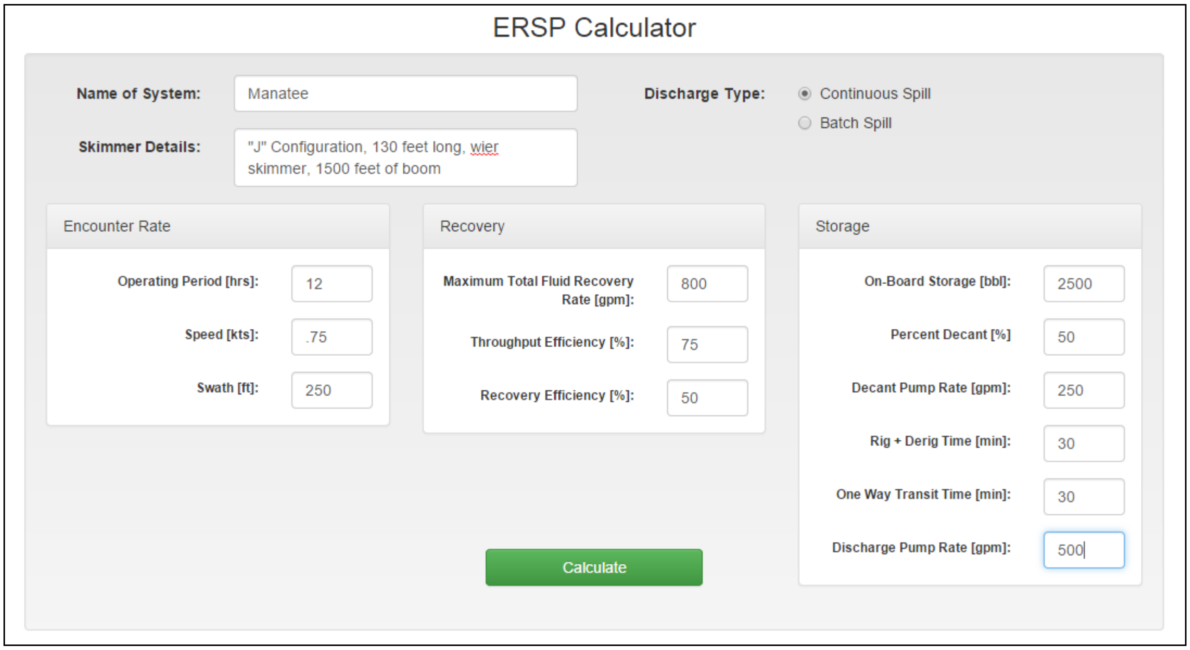


Figure 10. ERSP Input Screen for Manatee Continuous Spill.

Click **Calculate**. The ERSP Outputs for this skimming system configuration will then be displayed.

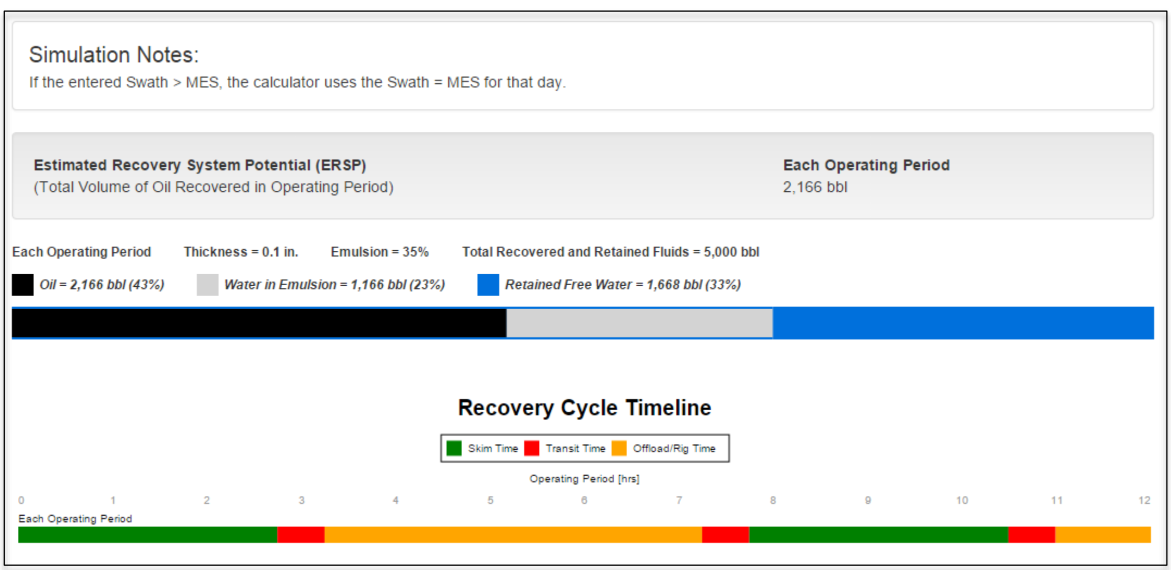


Figure 11. ERSP Graphical Outputs for Manatee Continuous Spill

Operating Period: Encountered Product (Oil/Emulsion) Thickness: % of Water in Oil/Water Emulsion:	Daily 0.1 in 35%
Encounter Rate Results	
Maximum Effective Swath (MES)	113 ft
Swath Used For Calculation	113 ft
Oil/Emulsion Encounter Rate	533 gpm
Areal Coverage Rate	0.2 acres/min
Area Covered in Operating Period (Acres)	69 acres
Area Covered in Operating Period (Sq. Miles)	0.11 sq mi
Recovery Results	
Total Fluid Recovery Rate	800 gpm
Emulsion Recovery Rate	400 gpm
Oil Recovery Rate	260 gpm
Free Water Recovery Rate	400 gpm
Storage Results	
Water Retained Rate	200 gpm
Decant Rate	200 gpm
Time to Fill Onboard Storage	2.92 hr
Total Offload Cycle Time for Full Tank(s)	5 hr
Time for One Full Cycle (skimming, transit, rig + derig, offload, transit)	7.92 hr
Skimming Time in Operating Period	5.83 hr
Skimming Time in Operating Period (%)	49 %
Total Number of Fills in Operating Period	2
Volume Results	
Total Volume Oil/Emulsion + Free Water Retained in Operating Period	5,000 bbl
Total Volume of Oil/Emulsion Recovered in Operating Period	3,332 bbl
Total Volume of Free Water Recovered & Retained in Operating Period	1,668 bbl
Total Volume of Water in Emulsion Recovered in Operating Period	1,166 bbl
ERSP = Total Volume of Oil Recovered in Operating Period	**2,166 bbl**

Figure 12. ERSP Tabular Output for Manatee Continuous Spill

For this skimming system configuration, the calculated ERSP value is 2,166 barrels of oil for each day during a continuous spill. During the twelve hour Operating Period, you can expect this system, as configured, to fill up its onboard storage twice, requiring one offloading period during the day and another offloading period during the night time hours. In this simulation, the skimming device recovered 3,332 barrels of oil/emulsion mixed with 1,668 barrels of free water (after decanting) thus requiring 5000 barrels of secondary storage each day to operate this skimming system in its current configuration. For this system to achieve this ERSP potential, the system needs to actively decant throughout the Operating Period in order to remove 50% of the free water that was recovered along with the oil/emulsion.

Note that the actual value for the Swath used by the ERSP calculation is 113 feet, not the 250 foot Swath value that was entered. This is because the Maximum Effective Swath (MES) for this continuous spill scenario was calculated to be 113 feet. As such, a Swath of 113 feet will feed this skimming configuration, as defined by all the other input variables, at maximum recovery capacity.

5b. Calculating ERSP for a Batch Spill Scenario

On the ERSP Calculator input screen, click on the "**Batch Spill**" radio button to calculate the ERSP for the same skimming system in a batch spill scenario. In this case, the spill occurs over a short period of time, and the thickness of the available oil is reduced while the emulsification increases for each of the next two Operating Periods.

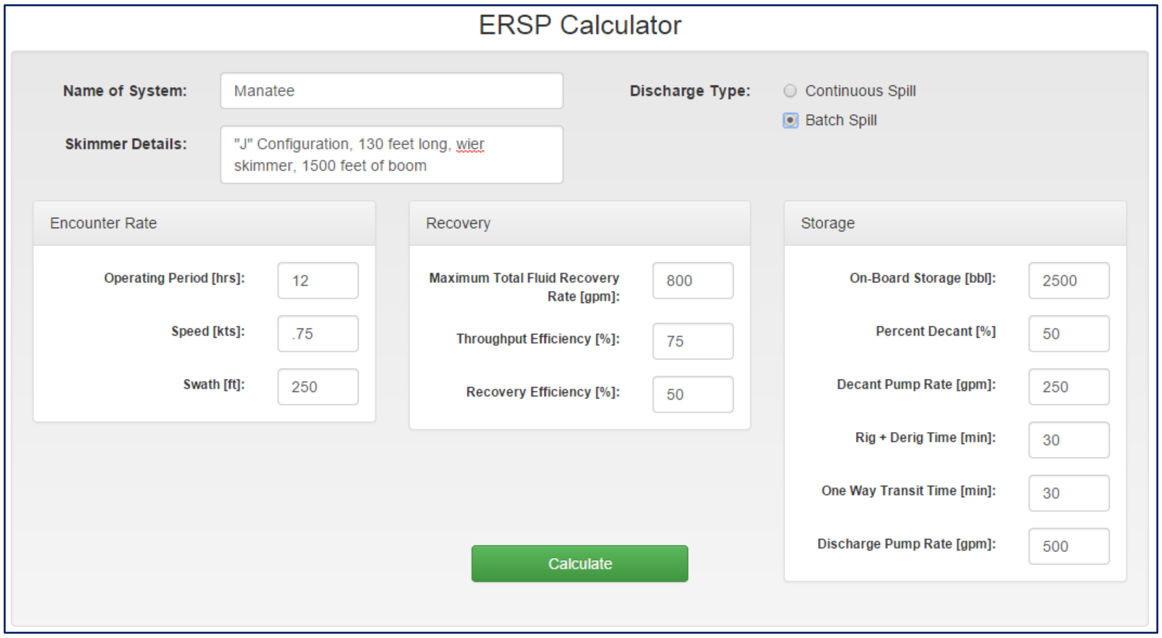


Figure 13. ERSP Input Screen for Manatee Batch Spill

The Calculator provides estimates for the ERSP of the skimming system over the three Operating Periods that occur in the first 72 hours immediately following the discharge. If the skimming system configuration and operating parameters remain unchanged during this period, the resulting ERSP values most likely will decrease with each subsequent day due to the decreased availability of oil for skimming and the increasing emulsification. In this example, the calculated ERSP values of 2166 bbls in the first Operating Period, 1499 bbls in the second Operating Period, and 555 bbls in the third Operating Period (shown below) reflect this reality. The ERSP Calculator also shows that an increasing percentage of fluids recovered over time is water-in-emulsion, which also has the effect of lowering the system's ERSP over time as well.

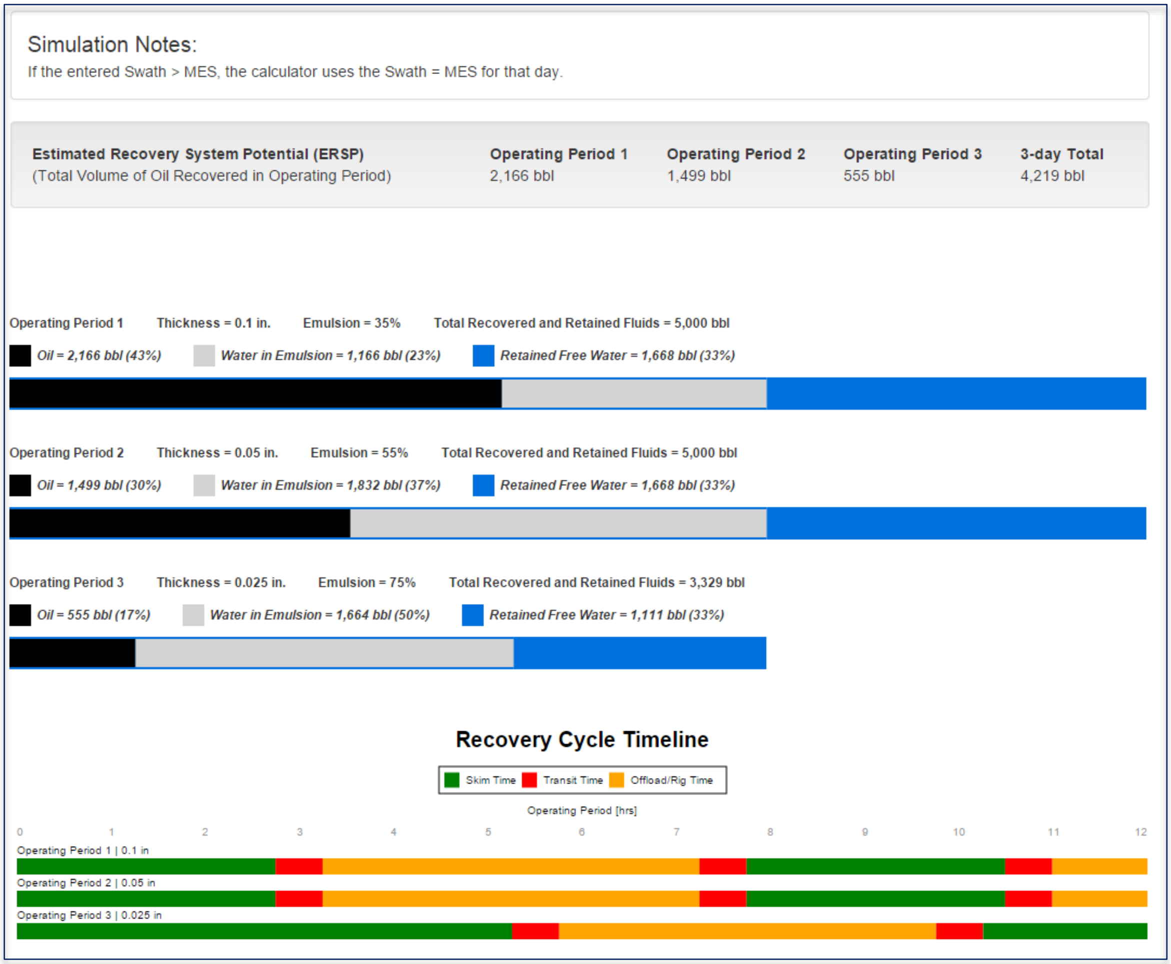


Figure 14. ERSP Graphical Outputs for Manatee Batch Spill

The ERSP Calculator also shows a breakdown of estimated skimming and offloading times required each day in the tabular data below. Not surprisingly, the time required to fill the onboard storage increases in the third Operating Period due to the use of the input Swath which is less than the MES for the third Operating Period.

Operating Period: Encountered Product (Oil/Emulsion) Thickness: % of Water in Oil/Water Emulsion:	Op. Period 1 0.1 in 35%	Op. Period 2 0.05 in 55%	Op. Period 3 0.025 in 75%
Encounter Rate Results			
Maximum Effective Swath (MES)	113 ft	225 ft	451 ft
Swath Used For Calculation	113 ft	225 ft	250 ft
Oil/Emulsion Encounter Rate	533 gpm	533 gpm	296 gpm
Areal Coverage Rate	0.2 acres/min	0.39 acres/min	0.44 acres/min
Area Covered in Operating Period (Acres)	69 acres	138 acres	183 acres
Area Covered in Operating Period (Sq. Miles)	0.11 sq mi	0.21 sq mi	0.29 sq mi
Recovery Results			
Total Fluid Recovery Rate	800 gpm	800 gpm	444 gpm
Emulsion Recovery Rate	400 gpm	400 gpm	222 gpm
Oil Recovery Rate	260 gpm	180 gpm	55 gpm
Free Water Recovery Rate	400 gpm	400 gpm	222 gpm
Storage Results			
Water Retained Rate	200 gpm	200 gpm	111 gpm
Decant Rate	200 gpm	200 gpm	111 gpm
Time to Fill Onboard Storage	2.92 hr	2.92 hr	5.26 hr
Total Offload Cycle Time for Full Tank(s)	5 hr	5 hr	5 hr
Time for One Full Cycle (skimming, transit, rig + derig, offload, transit)	7.92 hr	7.92 hr	10.26 hr
Skimming Time in Operating Period	5.83 hr	5.83 hr	7 hr
Skimming Time in Operating Period (%)	49 %	49 %	58 %
Total Number of Fills in Operating Period	2	2	1.3
Volume Results			
Total Volume Oil/Emulsion + Free Water Retained in Operating Period	5,000 bbl	5,000 bbl	3,329 bbl
Total Volume of Oil/Emulsion Recovered in Operating Period	3,332 bbl	3,332 bbl	2,218 bbl
Total Volume of Free Water Recovered & Retained in Operating Period	1,668 bbl	1,668 bbl	1,111 bbl
Total Volume of Water in Emulsion Recovered in Operating Period	1,166 bbl	1,832 bbl	1,664 bbl
ERSP = Total Volume of Oil Recovered in Operating Period	**2,166 bbl**	**1,499 bbl**	**555 bbl**

Figure 15. ERSP Tabular Output for Manatee Batch Spill.

Optimizing Your Skimming Configuration: Adjusting input values such as Swath during a batch spill and recalculating.

The Calculator can be used to adjust variables and examine expected system performance. These calculations can be made to compare anticipated performance on the same day between different configurations, or to evaluate the impact of a configuration change as the available oil decreases over time from one operating period to the next. Note in Figure 15 above, that as the slick thins over the three days, using a swath that is narrower than the Maximum Effective Swath in Operating Period 3 reduces predicted performance on that day. Increasing the input Swath value to the estimated MES in Operating Period 3 will increase performance on that day.

1. Without changing any other inputs, change the Swath to 451 feet (the predicted MES for Operating Period 3), and then recalculate to update your results.

2. Review the “Swath Used for Calculation” values for Operating Periods 1, 2, and 3, in the second row of the table. Notice that these swath values are now equal to the predicted MES values for each of those days (shown in the row above). Like MES, they become wider on each successive day of the spill as the slick thins.

Operating Period: Encountered Product (Oil/Emulsion) Thickness: % of Water in Oil/Water Emulsion:	Op. Period 1 0.1 in 35%	Op. Period 2 0.05 in 55%	Op. Period 3 0.025 in 75%
Encounter Rate Results			
Maximum Effective Swath (MES)	113 ft	225 ft	451 ft
Swath Used For Calculation	113 ft	225 ft	451 ft
Oil/Emulsion Encounter Rate	533 gpm	533 gpm	533 gpm
Areal Coverage Rate	0.2 acres/min	0.39 acres/min	0.79 acres/min
Area Covered in Operating Period (Acres)	69 acres	138 acres	275 acres
Area Covered in Operating Period (Sq. Miles)	0.11 sq mi	0.21 sq mi	0.43 sq mi
Recovery Results			
Total Fluid Recovery Rate	800 gpm	800 gpm	800 gpm
Emulsion Recovery Rate	400 gpm	400 gpm	400 gpm
Oil Recovery Rate	260 gpm	180 gpm	100 gpm
Free Water Recovery Rate	400 gpm	400 gpm	400 gpm
Storage Results			
Water Retained Rate	200 gpm	200 gpm	200 gpm
Decant Rate	200 gpm	200 gpm	200 gpm
Time to Fill Onboard Storage	2.92 hr	2.92 hr	2.92 hr
Total Offload Cycle Time for Full Tank(s)	5 hr	5 hr	5 hr
Time for One Full Cycle (skimming, transit, rig + derig, offload, transit)	7.92 hr	7.92 hr	7.92 hr
Skimming Time in Operating Period	5.83 hr	5.83 hr	5.83 hr
Skimming Time in Operating Period (%)	49 %	49 %	49 %
Total Number of Fills in Operating Period	2	2	2
Volume Results			
Total Volume Oil/Emulsion + Free Water Retained in Operating Period	5,000 bbl	5,000 bbl	5,000 bbl
Total Volume of Oil/Emulsion Recovered in Operating Period	3,332 bbl	3,332 bbl	3,332 bbl
Total Volume of Free Water Recovered & Retained in Operating Period	1,668 bbl	1,668 bbl	1,668 bbl
Total Volume of Water in Emulsion Recovered in Operating Period	1,166 bbl	1,832 bbl	2,499 bbl
ERSP = Total Volume of Oil Recovered in Operating Period	**2,166 bbl**	**1,499 bbl**	**833 bbl**

Figure 16. ERSP Tabular Output for Manatee Batch Spill with Added Swath.

3. Review the values for ERSP in the bottom table row. With the maximum effective swath now used on each of the three days, the ERSP increases in the third Operating Period.

4. Review the Recovery Cycle Timeline below, and note how the predicted skim times (shown in green) for Operating Period 3 have shortened from the previous scenario and now match the other times to fill for OP 1 and OP 2 because the MES is now used on all days.

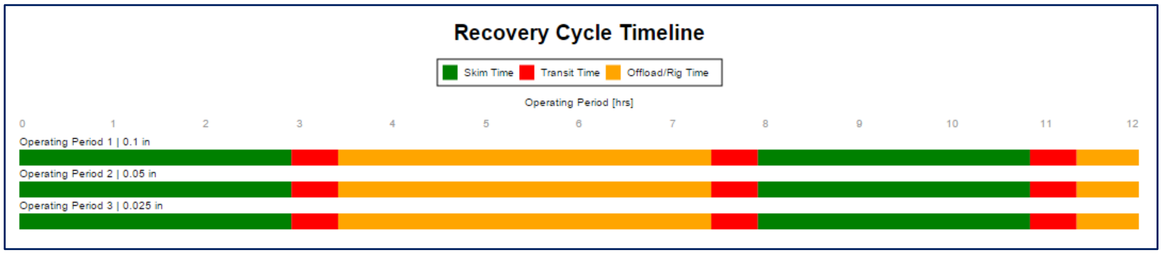


Figure 17. ERSP Recovery Cycle Timeline for Manatee Batch Spill with Added Swath.

In the same way users can visualize how changes to input parameter values can affect ERSP Calculator results. When performing these "what if" comparisons it is suggested that only one input parameter be changed at a time.

6. Equations Used in Calculations

In the ERSP Calculator, the following equations are used to estimate rates, times, areal coverage, and volumes.

Oil/Emulsion Encounter Rate (ER)

Oil/Emulsion Encounter Rate (ER) is the rate at which oil/emulsion is encountered by a skimming system, in gallons per minute.

$$ER = 63.13 \times Swath \times Speed \times Thickness$$

where Swath is the lesser of the input Swath or the MES in feet, Speed is the input system speed relative to the water in knots, Thickness is the average thickness of the oil/emulsion entering the system's swath in inches and 63.13 is a conversion factor for knots, feet, and inches to gallons per minute.

Areal Coverage Rate (ACR)

Areal Coverage Rate (ACR) is the rate at which a skimmer system covers area in acres per minute.

$$ACR = \frac{(Swath\ x\ Speed)}{430}$$

where Swath is the lesser of the input Swath or the MES in feet, Speed is the input system speed relative to the water in knots, and 430 is a conversion factor from knots and feet to acres per minute.

Acres Covered in Operating Period (AOP)

Acres Covered in Operating Period (AOP) is the total area covered by the skimming system during each Operating Period, in acres.

$$\mathrm{AOP} = \frac{(\mathrm{STO} \times \mathrm{ACR})}{60}$$

where STO (Skimming Time in Operating Period) is the total time during the Operating Period that the skimming system is engaged in skimming, in hours, and ACR is the Areal Coverage Rate of the skimming system in acres per minute.

Square Miles Covered in Op Period (MOP)

Square Miles Covered in Op Period (MOP) is the total area covered by the skimming system during the Operating Period, in square statute miles.

$$MOP = \frac{AOP}{640}$$

where AOP is the Acres Covered In Operating Period by the skimming system and 640 is the number of acres per square statute mile.

Emulsion Recovery Rate (ERR)

Emulsion Recovery Rate (ERR) is the rate at which stable water-in-oil emulsion (“mousse”) is taken on board the skimming system, in gallons per minute.

$$ERR = (ER \times TE)$$

where ER is the Oil/Emulsion Encounter Rate in gallons per minute, and TE is the entered Throughput Efficiency in percent.

Oil Recovery Rate (ORR)

Oil Recovery Rate (ORR) is the rate at which encountered oil is taken on board the skimming system, in gallons per minute.

$$ORR = ERR \times (1 - PE)$$

where ERR is the Emulsion Recovery Rate in gallons per minute, and PE is the Percent Emulsion.

Total Fluid Recovery Rate (TFRR)

Total Fluid Recovery Rate (TFRR) is the rate at which all fluids (i.e., oil/emulsion, and free water) are taken on board the skimming system, in gallons per minute (gpm).

$$TFRR = \frac{(ER \times TE)}{RE}$$

where ER is the Oil/Emulsion Encounter Rate in gallons per minute, TE is the entered Throughput Efficiency in percent, and RE is the entered Recovery Efficiency in percent.

Rate Water Taken Onboard (RWTO)

Rate Water Taken Onboard (RWTO) is the rate at which free water (water not bound up in emulsion) is taken on board the skimming system, in gallons per minute.

$$RWTO\ = (TFRR - ERR)$$

where TFRR is the Total Fluid Recovery Rate in gallons per minute, and ERR is the Emulsion Recovery Rate, in gallons per minute.

Alternatively,

$$RWTO\ = (TFRR)\ x\ (1 - RE)$$

where TFRR is the Total Fluid Recovery Rate in gallons per minute, and RE is the Recovery Efficiency in percent.

Water Retained Rate (WRR)

Water Retained Rate (WRR) is the rate of retention of free water taken on board the skimming system, in gallons per minute, after any decanting has been completed.

$$WRR\ = TFRR \times (1 - RE) \times (1 - Percent\ Decant)$$

where TFRR is the Total Fluid Recovery Rate in gallons per minute, RE is the entered Recovery Efficiency in percent, and Percent Decant is the entered percentage of free water taken on board that is decanted.

Decant Rate (DR)

Decant Rate (DR) is the computed rate at which free water is decanted from the skimming system, in gallons per minute.

$$DR = (RWTO\ \times Percent\ Decant)$$

where RWTO is the rate at which free water (water not bound up in emulsion) is taken on board the skimming system, in gallons per minute, and Percent Decant is the entered percentage of free water taken on board that is to be decanted. If the computed Decant Rate is greater than the entered Decant Pump Rate, a Simulation Note to that effect is generated.

Time to Fill Onboard Storage (TFOS)

Time to Fill Onboard Storage (TFOS) is the time needed to fill the system's onboard storage with oil/emulsion and free water, in hours.

$$TFOS = \frac{(0.7 \times OS)}{(ERR + RWTO - DR)}$$

where OS is the On-Board Storage in barrels, ERR is the Oil/Emulsion Recovery Rate in gallons per minute, RWTO is the Rate Water Taken Onboard in gallons per minute, and DR is the Decant Rate, in gallons per minute.

Maximum Effective Swath (MES)

Maximum Effective Swath (MES) is the computed swath of a response system required to match the computed TFRR to the system's entered Maximum Total Fluid Recovery Rate (MTFRR). Therefore when the Swath is equal to MES, the TFRR is equal to the MTFRR, previously known as Nameplate.

$$MES = \frac{(MTFRR \times RE)}{(63.13 \times Speed \times Thickness \times TE)}$$

where MTFRR is the entered Maximum Total Fluid Recovery Rate in gallons per minute, RE is the entered Recovery Efficiency in percent, Speed is the entered skimming Speed in knots, Thickness is the average thickness of the oil/emulsion entering the system's Swath, in inches, and TE is the entered Throughput Efficiency in percent.

Total Offload Cycle Time for Full Tank(s) (TOCT)

Total Offload Cycle Time for Full Tank(s) (TOCT) is the time needed to transit to secondary storage, rig + derig, offload the entire contents of the system's onboard storage, and return to the spill area, in hours.

$$TOCT = \left(RDT + (2 \times TT) + \frac{(42 \times OS)}{(DPR)}\right)/60$$

Where OS is the amount of Onboard Storage in barrels, DPR is the Discharge Pump Rate in gallons per minute, RDT is the Rig + Derig Time in minutes, and TT is the one way Transit Time in minutes.

Note: The ERSP Calculator assumes that the last complete or partial offloading can take place during hours of darkness between Operating Periods. A Simulation Note alerts you if the time between Operating Periods is insufficient to complete the last offload cycle.

Time for One Full Cycle (TOFC)

Time for One Full Cycle (TOFC) is the total time (in hours) needed to fill onboard storage, transit to secondary storage, offload (including Rig + Derig Time), and transit back to the oil slick to resume skimming.

$$TOFC = TFOS + TOCT$$

where TFOS is the Time to Fill Onboard Storage, in hours and TOCT is the Total Offload Cycle Time for Full Tank(s), in hours.

Total Number of Fills in Operating Period (FOP)

The Total Number of Fills in Operating Period (FOP) is a function of the Operating Period (OP), the Time to Fill Onboard Storage (TFOS), and the Time for One Full Cycle (TOC).

$$If\ TFOS\ \geq\ OP \text{ then set } FOP = \frac{OP}{TFOS}$$

else

NOTE: MIN(x,y) yields the lesser of x and y

INT(alpha) = the integer part of alpha

Where *alpha* = $\frac{OP}{MIN(TOC,OP)}$

$$FOP = MIN(\Big(\big(alpha - INT(alpha)\big) \times MIN(TOC, OP)\Big), TFOS) \div TFOS + INT(alpha))$$

Skimming Time in Operating Period (STO)

Skimming Time in Operating Period (STO) is the total time during the Operating Period that the skimming system is engaged in skimming, in hours.

$$STO = TFOS\ \times FOP$$

where TFOS is the Time to Fill Onboard Storage, in hours and FOP is the Total Number of Fills during an Operating Period.

Skimming Time in Operating Period % (STO%)

Skimming Time in Op Period % (STO%) is the percentage of the Operating Period during which the skimming system is engaged in skimming.

$$STO\% = \frac{STO}{OP}$$

where STO is the Skimming Time in Operating Period in hours, and OP is the duration of the Operating Period, in hours.

Total Volume of Oil/Emulsion + Free Water Retained in Operating Period (VOEW)

Total Volume of Oil/Emulsion + Free Water Retained in Operating Period (VOEW) is the total volume of liquids recovered and retained by the skimming system during each Operating Period, in barrels.

$$VOEW = FOP \times OS$$

where FOP is the Total Number of Fills in Operating Period, and OS is the Onboard Storage capacity in barrels.

Total Volume of Free Water Recovered & Retained in Operating Period (VOFW)

$$VOFW = WRR \; x \; 1.43 \; x \; STO$$

Where WRR is the Water Retained Rate, 1.43 is the conversion factor for gpm to bbl per hour, and STO is the Skimming Time in Operating Period in hours.

Total Volume of Oil/Emulsion Recovered in Operating Period (VOE)

Total Volume of Oil/Emulsion Recovered in Operating Period (VOE) is the total volume of oil and emulsion recovered and retained by the skimming system during an operating period, in barrels.

$$VOE = VOEW - VOFW$$

Where:
VOEW is the Total Volume of Oil/Emulsion, + Free Water Retained in the Operating Period, in barrels and VOFW is the Total Volume of Free Water Recovered & Retained in Operating Period.

Estimated Recovery System Potential (ERSP)

$$ERSP = VOE \; x \; (1 - Emulsion \; percent)$$

Where VOE is the Total Volume of Oil/Emulsion Recovered.