Estimated Burn System Potential (EBSP) Calculator User Manual

The ERSP, EBSP, and EDSP Calculators are intended as planning tools for estimating the potential of different oil spill response systems to mitigate (recover, burn or disperse) discharged oil relative to one another. These planning tools are NOT intended to be used as models for calculating system performance during an actual oil spill, which is affected by many factors such as the distribution of oil on the water surface, oil weathering, and other ambient on-scene conditions which are not included in these Calculators.

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Contents

1. Introduction

The Calculator developed in this project accounts for the performance of an advancing controlled burn system as it encounters, concentrates, and burns oil inside of the system's burn boom. The Calculator generates an "Estimated Burn System Potential" (EBSP) value in barrels of oil burned 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 EBSP Calculator is an HTML file, **EBSP-160225. 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 the EBSP Calculator from the BSEE website. The "build" or version date of the calculator appears after the calculator name in the format -YYMMDD (see Figure 4). This date stamp can verify that you are working with the latest version of the calculator.

This User Manual provides additional guidance to the user on the various data inputs that must be entered into the EBSP Calculator regarding the burn system configuration being evaluated, and further explains the Calculator results.

The EBSP 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. Controlled Burning of Oil as a Response Option

During the response to the Deepwater Horizon Mississippi Canyon 252 Incident in the Gulf of Mexico approximately 220,000 to 310,000 barrels of oil were burned at sea in the completion of about 400 individual burns. Controlled burning of oil offers certain advantages over physical containment and recovery of oil and the use of chemical dispersants. It requires less equipment and personnel than these other response techniques. Compared to physical containment and recovery, the storage and transport of recovered material is limited to the relatively small quantity of burn residue.

Fire-resistant boom concentrates oil/emulsion to a thickness that can be ignited and burned while the boom is being towed. Filling of the boom is facilitated by airborne spotters that direct the system to the heaviest concentrations of oil/emulsion. For safety, a full fire boom can be towed away from the spill site for ignition and burning. This is done by specifying an optional offset distance. After ignition the tow speed can be varied to control the progress of the burn. Nearly all of the oil is consumed, converting the oil to its primary combustion products of carbon dioxide and water with a small percentage of smoke particulates and other unburned and residue byproducts.

1b. The EBSP Calculator's Purpose and Intended Use

The EBSP Calculator is primarily a planning tool for estimating the potential for collection and burning of spilled oil by an advancing burn system. You can use the Calculator to evaluate the EBSP of a burning 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 burning system, such as its length, draft, and speed; you describe the circumstances of its operation, such as offset time from the collection area to the burn area (*see Section 3, EBSP Calculator Inputs*). The Calculator then estimates the amount of oil that the system could collect and burn 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 4, EBSP Calculator Results*). These estimates of the oil collected and burned are termed the "Estimated Burn System Potential" (EBSP) for the given burning system configuration. The use of the calculator tool in both spill scenarios is further demonstrated and explained in *Section 5, Using the EBSP Calculator*.

The EBSP Calculator was also developed with the intent of reinforcing incentives for creating and acquiring more effective oil burning systems. In addition to evaluating the potential of advancing oil spill burning systems to meet various regulatory planning requirements, you can also explore how to configure a burning system to best encounter and burn oil more efficiently. This experimentation is helpful in understanding the effects of different configurations on a system's burn potential, and provides incentives for developing more effective burning systems.

1c. Advancing Burning System Components and Definitions

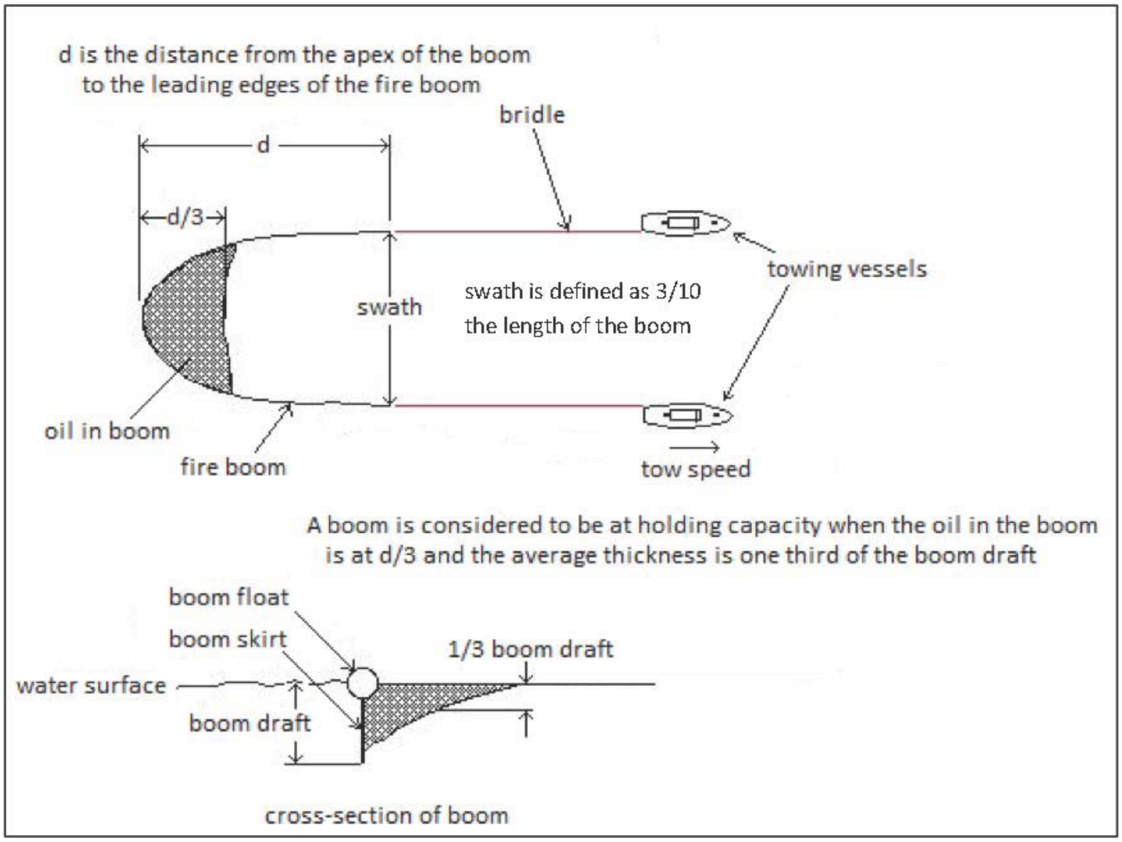


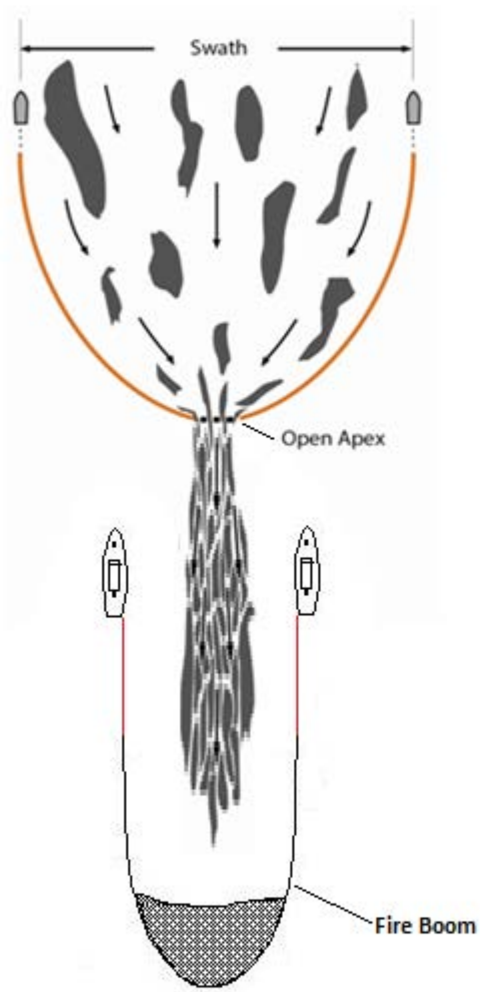
Figure 1. Advancing Burning System Components and Definitions.

The primary component of a burn "system" is the fire-resistant boom. There are several types of fire boom available including thermally resistant fabric booms, stainless steel booms, and water cooled booms. The EBSP Calculator does not differentiate between types of boom and uses only the length and draft of the fire boom in its estimates.

The ends of the fire boom are connected to towing vessels with bridles or tow lines. These bridles provide a safe working distance between the towing vessels and the leading ends of the fire boom and are typically about 300 feet long. Attachment of the bridles to the inboard side of the towing vessels minimizes the effect of vessel wake on collection and burning operations.

The towed fire boom forms a catenary into which the encountered oil/emulsion oil is concentrated at the apex. The length of the fire boom determines its holding capacity and the swath of the system as it moves through the oil slick. A boom is defined to be "full" or at its holding capacity (see below) when the oil/emulsion in the boom is 1/3 the distance from the apex to the leading ends of the boom and the average oil/emulsion thickness is 1/3 of the boom draft.

Not shown in the diagram, but included as part of the burn system, are aerial spotting components, the oil ignition team, burn residue collection/recovery operations, and any necessary command and control activities.



Enhanced Collection Configuration

Enhanced collection adds a U-shaped configuration of boom with an open apex towed ahead of the burn system. The added boom configuration increases the system's effective swath width, and concentrates the oil/emulsion for containment and burning. This configuration increases a system's areal coverage and oil encounter rates. Enhanced collection 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 collection configuration example

2. Assumptions and Limitations as a Planning Tool

The EBSP Calculator was developed to provide an encounter-rate based estimate of daily potential for advancing burning 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 burning system configurations and addresses response activities including the accessing, containment and burning of oil. The goal was to provide a computer tool that could facilitate the calculation of a “Planning Standard”, not a “Performance Measure”.

The ERSP, EBSP, and EDSP Calculators are intended as planning tools for estimating the potential of different oil spill response systems to mitigate (recover, burn or disperse) discharged oil relative to one another. These planning tools are NOT intended to be used as models for calculating system performance during an actual oil spill, which is affected by many factors such as the distribution of oil on the water surface, oil weathering, and other ambient onscene conditions which are not included in these Calculators.

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

- ***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.
- ***Ambient Conditions:*** Estimates made by the Calculator assume that conditions are generally conducive to effective burning operations. Its output is designed to serve as a guide for planning the deployment of burning systems and estimating their potential in order to meet plan holder needs.
- ***Ice:*** Burning in ice is not considered in the Calculator.
- ***Asset Mobilization:*** It is assumed that the burning system is rigged and ready to operate at the beginning of each Operating Period. The EBSP 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.
- ***Three Day Window for Calculating EBSP for a Batch Spill Scenario:*** The three-day EBSP 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 burning 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 Types:*** The Calculator does not differentiate outputs based on the type of oil or product being burned. 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.
- ***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).
  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 accessible 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.
  As such, the EBSP Calculator uses the same set of nominal representative thickness values for each of the three operating periods for an instantaneous batch spill (and the same repeating initial thickness value for each day of a continuous release) as the ERSP Calculator. Similarly, in the EBSP Calculator, the Operating Period is defined as the length of time in hours each day (centered on noon) where conditions allow a burning system to conduct operations. Using the same thickness values in both the ERSP and EBSP Calculators will allow for some direct comparisons between recovery and burning systems in their capacities to mitigate oil.
- ***Collecting and burning in Waters with Restricted Maneuverability:*** The EBSP calculator does not discern between ocean or offshore operating areas and inshore operating areas. While the EBSP algorithms apply equally in all areas, burning systems with large swath widths 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 EBSP Calculator user to apply operational knowledge and common sense in selecting values for their burning configuration that match the needs of the operating environment (as opposed to entering values for poorly matched configurations that would maximize the EBSP at the expense of operational feasibility).

- ***Use of Best Practices for Burning:*** The EBSP Calculator assumes responders will use best practices, for example, the use of airborne spotters and remote sensors in order to actively direct and keep burning systems continuously operating in the thickest available concentrations of oil. EBSP also assumes that personnel are available and trained to deploy and effectively operate the burning system in the manner necessary to achieve the maximum potential.
- ***Air Monitoring:*** It may be necessary in certain situations to conduct air monitoring during a burn. This is not considered in the Calculator.
- **Boom Holding Capacity**: The oil holding capacity of a boom is determined by its length and draft. The maximum holding capacity of a boom is assumed to be reached when the average thickness of the oil being contained inside the boom is approximately 1/3 of the boom's draft. Collection of oil beyond this thickness may cause loss through entrainment. With the containment and burn area of the d/3 and the average thickness, the volume of oil in the boom can be estimated.

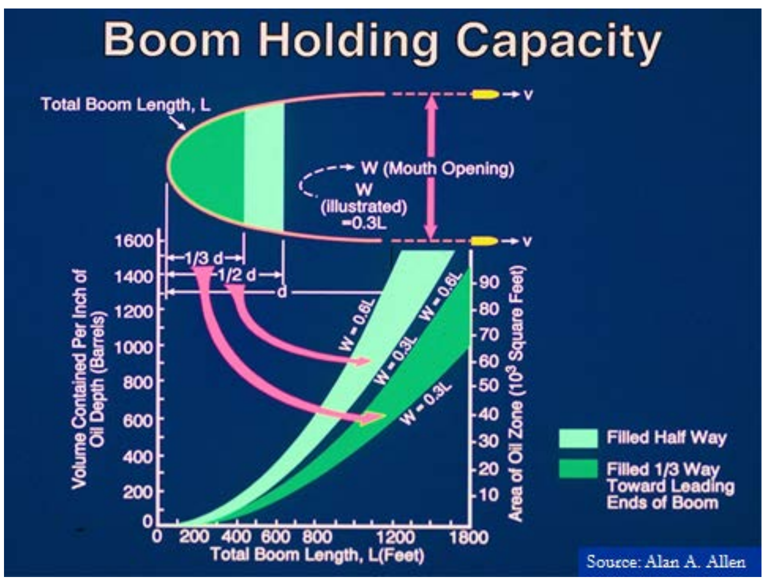


Figure 3. Boom Holding Capacity

- ***Burn Area:*** The Calculator assumes that the burn area will remain constant for a particular burning system configuration, and will be roughly equivalent to the surface area within the catenary of the fireboom located between the apex and points forward that are one third of the distance to the leading edges of the fireboom being towed. In reality, the burn area will not be uniformly spread across this area and will change over time as the burn progresses.

- ***Burn Rates:*** The Calculator uses the burn rates of 0.09 inches/min for the first Operating Period, 0.06 inches/min for the second Operating Period, and 0.04 inches/min for the third Operating Period (see Burn Rate equation in Section 6). These burn rates are based on the paper "The Use of Controlled Burning during the Gulf of Mexico Deepwater Horizon MC-252 Oil Spill Repsonse", *Allen et al*, 2011, IOSC Proceedings.
- ***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. EBSP is a calculated estimate of the volume of oil collected and burned. While EBSP data is provided for Operating Period 3 for planning purposes, it should be noted that successful ignition and sustained burning of oil that is 75% emulsified may be difficult or impossible to achieve in many circumstances.
- ***Burning Outside of Containment:*** Several times during the Deepwater Horizon burn operations involved the safe and successful burning of oil immediately outside the fire boom. The volume of oil burned in this instance is difficult to estimate and is not included in the Calculator.
- ***Burning Downtime:*** No downtime due to maintenance or repair is considered.
- ***Completion of Final Burn that occurs between Operating Periods:*** At the end of each Operating Period it is assumed that any oil remaining in the burn boom will be burned before the next Operating Period begins. If the Calculator determines that this last burn cannot be completed in the time available between Operating Periods, then a Simulation Note (Simulation Notes are described in more detail below) will be generated - "Burn 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.
- ***Collection of Burn Residue:*** At the end of each burn operation, an assessment must be made regarding the need to collect any burn residue that may remain on the water's surface. The Calculator allows for an hour of time at the end of each burn cycle to assist in the transition to the residue recovery operation, which is a separate and independent operation requiring additional resources not specified here.

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3. EBSP 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 burning system information into the Calculator.

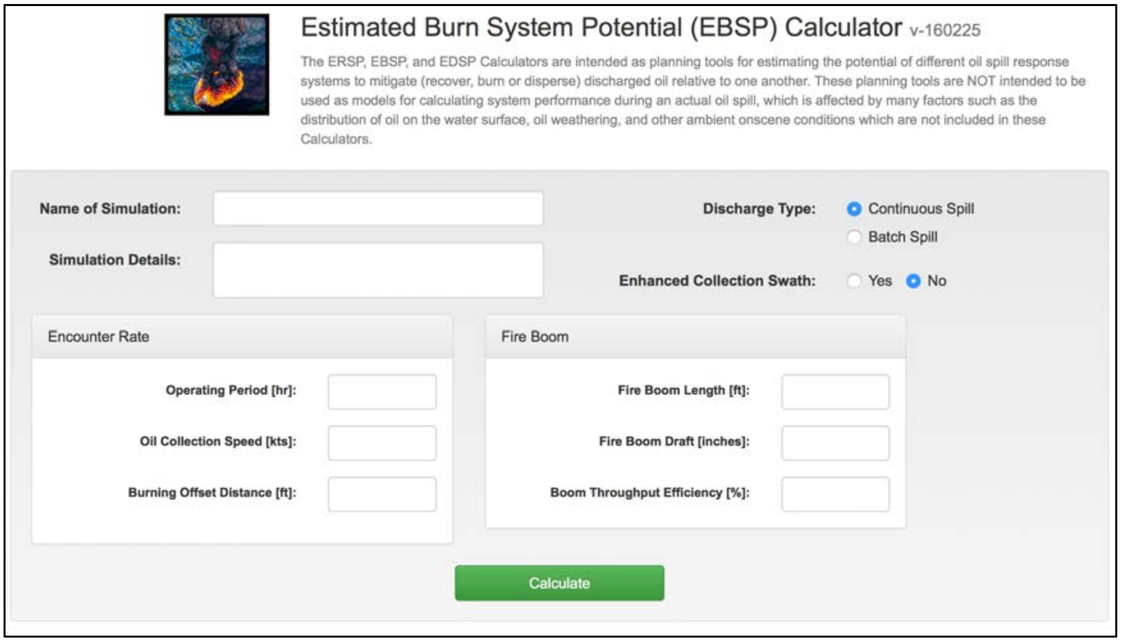

Figure 4. EBSP Calculator Input Screen

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

Identify the type of spill for which the system is being evaluated. This selection will determine the format of the output that the EBSP Calculator will display.

<u>Burning System Identifiers:</u>

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

- <u>Name of Simulation</u>: Entry field for the name or other form of identifier for the burn system (up to 48 characters).
- <u>Simulation Details</u>: Enter configuration details including the type of burn 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 key inputs, was intended to be "conservative" in nature. In some cases, an advancing burn 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 EBSP 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 EBSP Calculator inputs have been grouped into two categories: Encounter Rate, and Fire Boom.

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 burn system to conduct collection and burn 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).

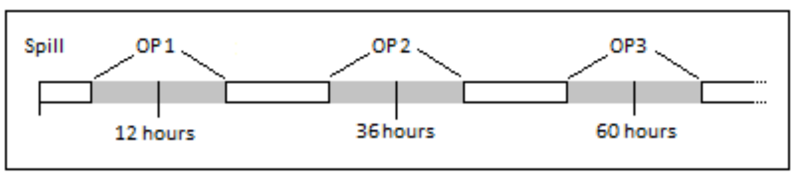

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Figure 5. Operating Period

- 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 EBSP Calculator assumes that the burn system begins each Operating Period configured for collection operations. As such, any requested extension of the Operating Period must take into account the downtime necessary to accommodate the required burn cycle, including the offset activities, which the EBSP Calculator assumes to be completed each night before the start of the next day's operating period.

Oil Collection Speed [kts]:

This is the collection speed relative to the oil slick. For most advancing burning systems, recommended maximum speeds are up to 0.75 knot. 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 burning system travels at a speed of 0.75 knot relative to the oil slick.
- For Calculator users contemplating the use of a higher collection speed for their system, regulatory agencies will consider requests for the use of alternative values based on the supporting documentation submitted.

Burning Offset Distance [ft]:

This is the distance the filled boom is towed away from the remaining oil slick before it is ignited. Typically this number is somewhere between 1000 and 2000 feet. This distance along with the speed is what determines the Offset Time.

Enhanced Collection Swath Width [ft]:

The EBSP Calculator enables a burning system to increase its encounter rate through the use of an enhanced collection configuration. When using an enhanced collection configuration, the user must select the “Yes” radio button for “Enhanced Collection Swath”. Upon selecting the “Yes” button, an additional input field will appear in the “Encounter Rate” area of the Calculator input screen.

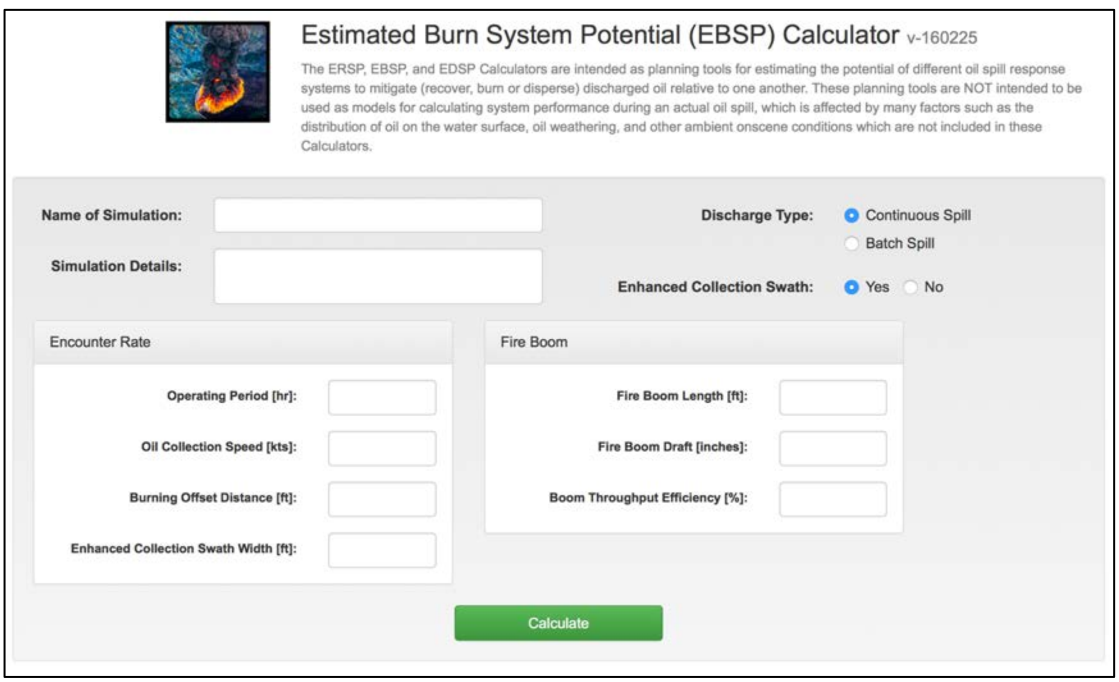

Figure 6. EBSP Calculator Input Screen With Enhanced Collection

The user must then input a value for the Enhanced Collection Swath that will be used in advance of the burning system. The Enhanced Collection Swath Width is a separate value from the swath of the burn boom itself, and for the enhanced collection system to be effective in increasing the encounter rate over that which the burn boom would collect on its own, the enhanced collection swath width must be greater than the calculated swath of the burn boom. There is no default value for the enhanced collection swath width input field.

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

When planning for the use of burning systems which will operate in restricted waters where burn system maneuverability and access to oil will be an issue, Swath Widths should be reduced appropriately, and entered in amounts that are appropriate for use in such conditions. The use of enhanced collection systems and swath widths in restricted waters, will be, in most cases, not practicable. Regulators may not allow credit for the use of enhanced collection systems in such circumstances.

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

3b. Fire Boom Inputs

Fire Boom Length [ft]: This input value should be the total length of fire boom towed behind two vessels that collects and contains the oil to be burned. The length should be measured from end to end at the point where the towing bridles connect to each end of the boom.

Fire Boom Draft [in]: This input value is the measure of the fire boom skirt in inches that is submerged below the surface of the water that would be perpendicular to the ocean's surface and is capable of containing oil.

- The recommended minimum value for fire boom draft in open water conditions is 26 inches as per ASTM F2152-07.

Boom Throughput Efficiency [%]: For the purposes of the EBSP Calculator, Throughput Efficiency (TE) is the percentage of oil/emulsion collected in the fire boom, out of the total volume of oil/emulsion encountered. It is a measure of the effectiveness of the containment component of the burning system and its ability to prevent entrainment or loss of the oil encountered. The default value for TE is 75%.

4. EBSP Calculator Results

EBSP 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:
Excessive entrainment of oil likely to occur at speeds greater than 1.2 kts.

Figure 7. Example Simulation Note

The graphical data is presented in the form of summary data and a Burn Cycle Timeline during each Operating Period.

Estimated Burn System Potential (EBSP) (Total Volume of Oil Burned in Operating Period)	Operating Period 1	Operating Period 2	Operating Period 3	3-day Total
	5600 bbl	4800 bbl	3200 bbl	13600 bbl

Figure 8. Summary Data

The Burn Cycle Timeline depicts the collection, offset, burn, and residue collection activities for each Operating Period in a linear fashion on an hourly timescale

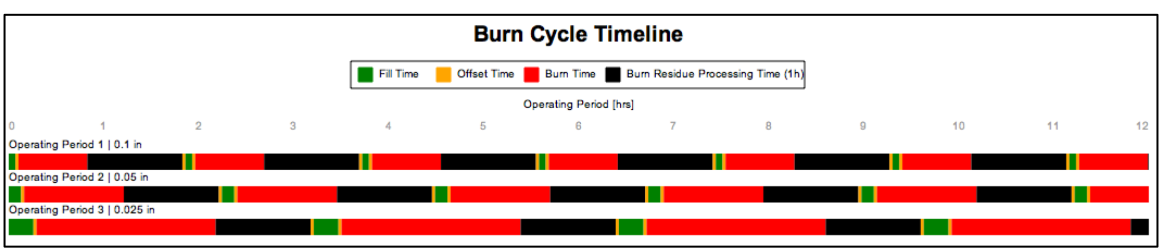

Figure 9. Burn Cycle Timeline Bar Chart

The following figure shows the tabular data outputs, which present additional planning details relating to encounter, collection and aerial coverage rates, and burning-related aspects of the system. The column labels also show the oil slick thickness and the emulsification values that were used by the EBSP Calculator for each Operating Period (OP).

Operating Period: **Encountered Product (Oil/Emulsion) Thickness:** **% of Water in Oil/Water Emulsion:**	**Op. Period 1** **0.1** **35**	**Op. Period 2** **0.05** **55**	**Op. Period 3** **0.025** **75**
Swath Calculated from Fire Boom Length	210 ft	210 ft	210 ft
Oil/Emulsion Encounter Rate	11363 gpm	5682 gpm	2841 gpm
Oil/Emulsion Collection Rate	8523 gpm	4261 gpm	2131 gpm
Fire Boom Capacity	800 bbl	800 bbl	800 bbl
Areal Coverage Rate	4.19 acre/min.	4.19 acre/min.	4.19 acre/min.
Time to Fill	0.07 hrs.	0.13 hrs.	0.26 hrs.
Offset Time	1.97 min.	1.97 min.	1.97 min.
Burn Rate	0.09 in/min.	0.06 in/min.	0.04 in/min.
Burn Time	43.5 min.	62.9 min.	113.1 min.
Number of Burn Cycles in OP	6.46	5.35	3.73
Collection Time in OP	1.3 hrs.	1.4 hrs.	3.1 hrs.
EBSP = Total Volume of Oil Burned in Operating Period	**5600 bbl**	**4800 bbl**	**3200 bbl**

Figure 10. EBSP Tabular Outputs

4a. Tabular Result Definitions

<u>Swath Calculated from Fire Boom Length:</u>

The swath is .3 times the fire boom length (See fig. 1).

<u>Oil/Emulsion Encounter Rate:</u>

This is a function of the swath, the thickness of the oil/emulsion and the speed of the collection/burn system.

<u>Oil/Emulsion Collection Rate:</u>

The encounter rate times the throughput efficiency.

<u>Fire Boom Capacity:</u>

The boom is defined to be “full” or at its holding capacity when the oil/emulsion in the boom is 1/3 the distance from the apex to the leading ends of the boom and the average oil/emulsion thickness is 1/3 of the boom draft.

Areal Coverage Rate (acre/min):

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

Time to Fill:

This is the fire boom capacity divided by the collection rate.

Offset Time:

This is the time necessary to move the full fire boom from the collection to the area where the oil can be ignited and burned safely, and return to the collection area. It is calculated as the offset distance divided by the oil collection speed.

Burn Rate:

The Burn Rate is a function of the percent emulsion of the oil. See Section 6 Equations Used in Calculations.

Burn Time: The total amount of time burning in each Operating Period.

Number of Burn Cycles in OP: The number of burn cycles decreases over successive Operating Periods due to the reduced availability of thicker oil and the additional time that is needed to fill the fire boom to its holding capacity.

Collection Time in OP: The total amount of time collecting in each Operating Period.

4b. Simulation Notes and Errors

Depending on the values you enter, one or more of the following Simulation Notes or Errors may be displayed as you run a scenario in the Calculator. Simulation Notes provide you with additional information regarding an aspect of your scenario inputs and the calculator results. Errors, on the other hand, are designed to alert you to a problem that will require you to revise your input values before the EBSP calculation can be run correctly.

Simulation Notes:

-Day 3 emulsification may make ignition and burning difficult to impossible
-Swaths > 1000 feet may not be achievable in the field
-Excessive entrainment of oil likely to occur at speeds greater than 1.2 knots
-Burn not achievable between Operating Periods – Reduce Operating Period

Errors:

-Error! Oil Collection Speed must be less than 2 knots
-Error! Boom length must be between 100 and 1000
-Error! Boom Throughput Efficiency must be greater than 0% and no greater than 100 %

5. Using the EBSP Calculator

You can use the EBSP Calculator to evaluate the potential for collection and controlled burning of spilled oil by an advancing burn 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 two towing vessels pulling 500 feet of fire boom to illustrate the use of the EBSP Calculator. First, we will look at the process of using the calculator to estimate the EBSP for this system in a continuous discharge scenario, and then switch to a batch spill scenario.

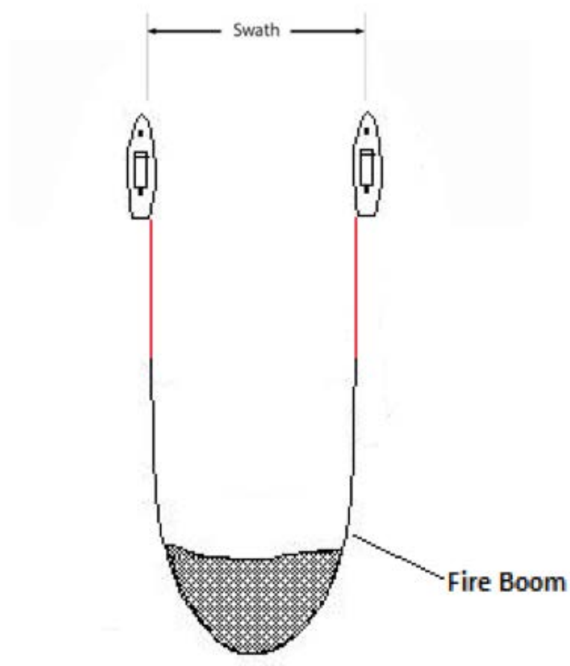

Figure 11. Fire Boom

Starting the EBSP Calculator

For either type of spill scenario, you can access the EBSP Calculator by double-clicking on the EBSP_Calculator_20150225.html file (date portion of file name will change as new builds are available), which will open up the Calculator in your default web browser.

5a. Calculating EBSP for a Continuous Spill Scenario

In order to evaluate a burn system's potential to collect and burn oil during a well blowout:

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

Entering input values

- In the **Name of Simulation** box, enter the identifier for this burn system configuration. This example uses “Burn 1”.
- The **Simulation Details** box can be used to enter descriptive information about the burn system configuration, including the tow vessel type, length and kind of boom.

Encounter Rate Group:

- 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 **Burning Offset Distance** to 1500. Offset is the distance the full boom is towed away from the remaining oil slick before it is ignited.

Fire Boom Group:

- Enter 500 in the **Fire Boom Length [ft]** box.
- Enter 16 in the **Fire Boom Draft [inches]** box.
- Enter 75 in the **Boom Throughput Efficiency (%)**, box.

The Calculator input screen should now look like this:

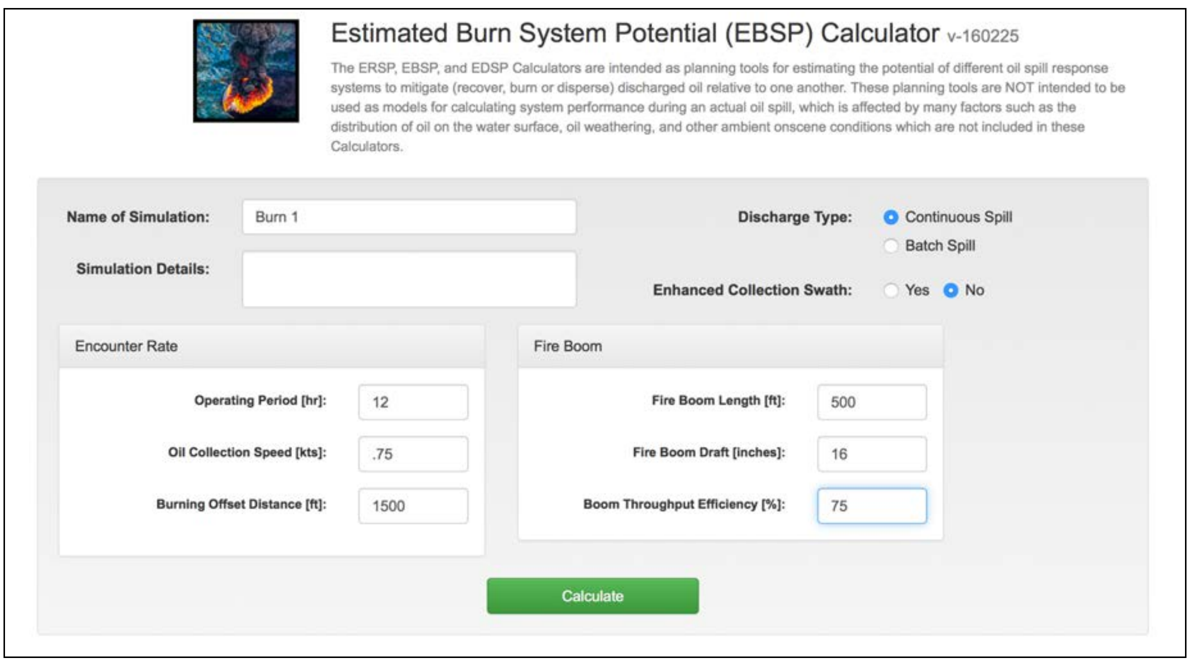

Figure 12. EBSP Input Screen for Burn 1 Continuous Spill.

Click **Calculate**. The EBSP Outputs for this burn system configuration will then be displayed.

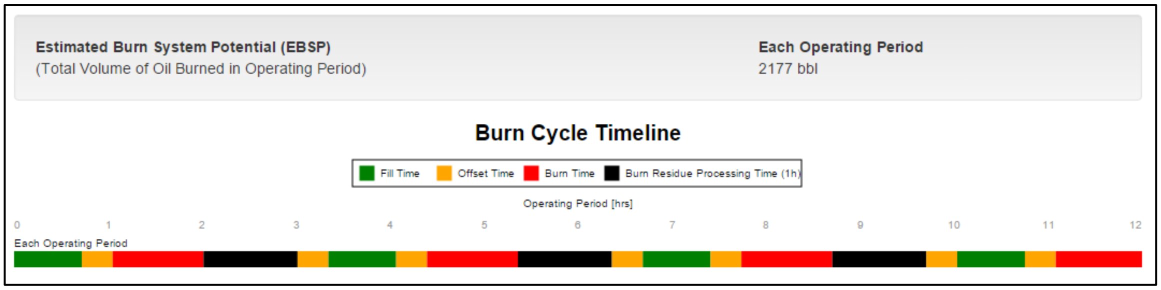

Figure 13. EBSP Graphical Outputs for Burn 1 Continuous Spill

Operating Period: **Encountered Product (Oil/Emulsion) Thickness:** **% of Water in Oil/Water Emulsion:**	**Daily** **0.1** **35**
Swath Calculated from Fire Boom Length	150 ft
Oil/Emulsion Encounter Rate	710 gpm
Oil/Emulsion Collection Rate	533 gpm
Fire Boom Capacity	544 bbl
Areal Coverage Rate	0.26 acre/min.
Time to Fill	0.72 hrs.
Offset Time	19.74 min.
Burn Rate	0.09 in/min.
Burn Time	58 min.
Number of Burn Cycles in OP	3.59
Collection Time in OP	4.1 hrs.
EBSP = Total Volume of Oil Burned in Operating Period	**2177 bbl**

Figure 14. EBSP Tabular Output for Burn 1 Continuous Spill

For this burn system configuration, the calculated EBSP value is 2,177 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 boom four times, requiring four burning periods during the Operating Period, with the fourth burn period extending past the end of the Operating Period.

5b. Calculating EBSP for a Batch Spill Scenario

On the EBSP Calculator input screen, click on the "**Batch Spill**" radio button to calculate the EBSP for the same burn system in a batch spill scenario.

<u>Entering input values</u>

- In the **Name of Simulation** box, enter the identifier for this burn system configuration. This example uses "Burn 1".
- The **Simulation Details** box can be used to enter descriptive information about the burn system configuration, including the tow vessel type, length and kind of boom.

<u>Encounter Rate Group</u>:

- 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 **Burning Offset Distance** to 1500. Offset is the distance the full boom is towed away from the remaining oil slick before it is ignited.

<u>Fire Boom Group</u>:

- Enter 500 in the **Fire Boom Length [ft]** box.
- Enter 16 in the **Fire Boom Draft [inches]** box.
- Enter 75 in the **Boom Throughput Efficiency (%)**, box.

The Calculator input screen should now look like this:

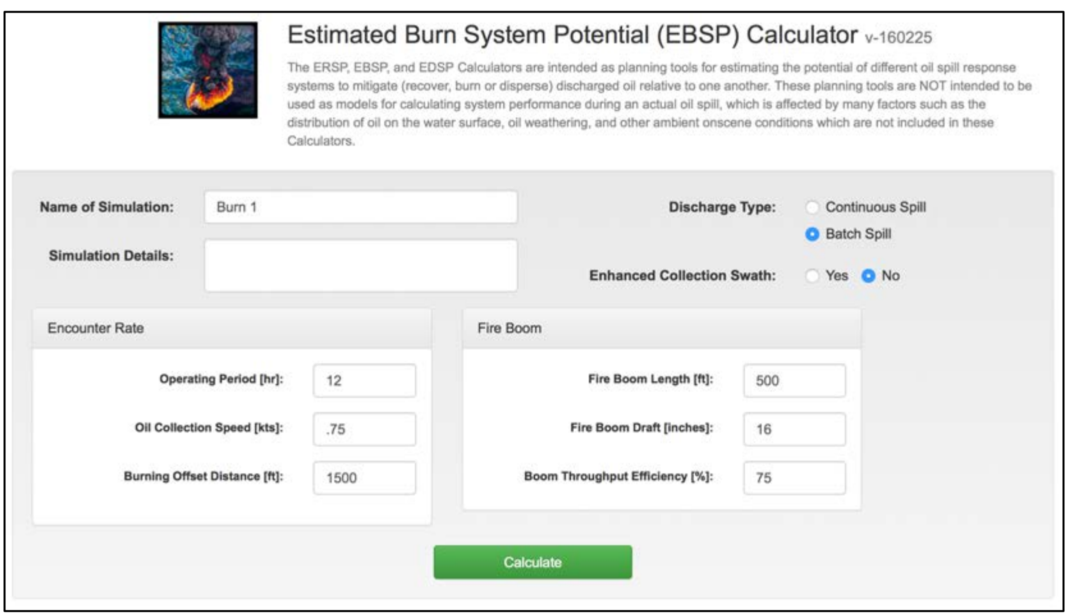

Figure 15. EBSP Input Screen for Burn 1 Batch Spill

Click **Calculate**. The Calculator will provide an estimate for the EBSP of the burn system over the three Operating Periods that occur in the first 72 hours immediately following the discharge.

In the case of a batch spill, the thickness of the oil available for collection is reduced while the emulsification water content increases over the next two Operating Periods. If the burn system configuration and operating parameters remain unchanged during this period, the resulting EBSP values will decrease with each subsequent day as a result. In this example, the calculated EBSP values of 2177 bbls in the first Operating Period, 1633 bbls in the second Operating Period, and 1088 bbls in the third Operating Period (shown below) reflect this reality.

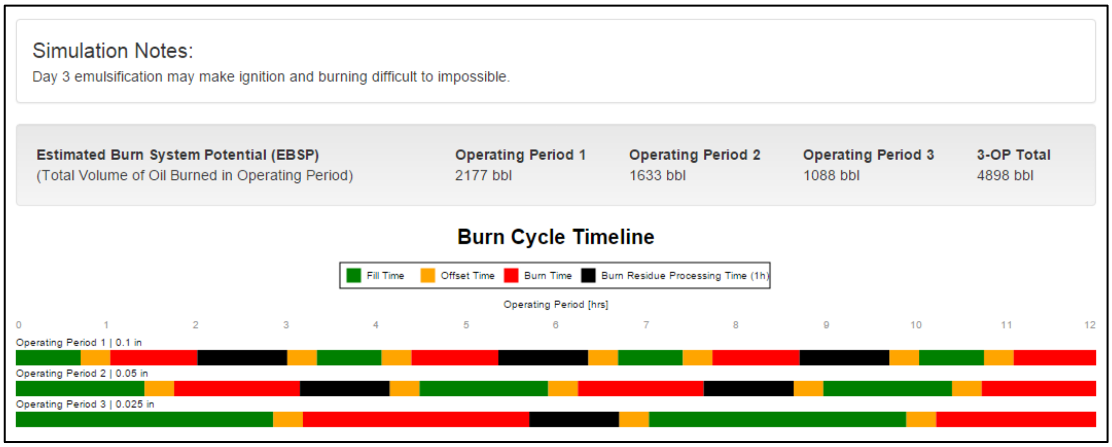

Figure 16. EBSP Graphical Outputs for Burn 1 Batch Spill

Operating Period: **Encountered Product (Oil/Emulsion) Thickness:** **% of Water in Oil/Water Emulsion:**	**Op. Period 1** **0.1** **35**	**Op. Period 2** **0.05** **55**	**Op. Period 3** **0.025** **75**
Swath Calculated from Fire Boom Length	150 ft	150 ft	150 ft
Oil/Emulsion Encounter Rate	710 gpm	355 gpm	178 gpm
Oil/Emulsion Collection Rate	533 gpm	266 gpm	133 gpm
Fire Boom Capacity	544 bbl	544 bbl	544 bbl
Areal Coverage Rate	0.26 acre/min.	0.26 acre/min.	0.26 acre/min.
Time to Fill	0.72 hrs.	1.43 hrs.	2.86 hrs.
Offset Time	19.74 min.	19.74 min.	19.74 min.
Burn Rate	0.09 in/min.	0.06 in/min.	0.04 in/min.
Burn Time	58 min.	83.8 min.	150.9 min.
Number of Burn Cycles in OP	3.59	2.68	1.71
Collection Time in OP	4.1 hrs.	5.9 hrs.	7.8 hrs.
EBSP = Total Volume of Oil Burned in Operating Period	**2177 bbl**	**1633 bbl**	**1088 bbl**

Figure 17. EBSP Tabular Output for Burn 1 Batch Spill.

5c. Calculating EBSP Using Enhanced Collection Techniques

The oil collection swath width can be adjusted using the “Enhanced Collection Swath” radio button in order to examine resultant changes in the burn system’s estimated removal potential. These calculations can be made to compare anticipated burn system potentials for operations the same day using different configurations, or to evaluate the impact of a configuration change over time as the available oil decreases from one operating period to the next.

1. Selecting “**Yes**” for the **“Enhanced Collection Swath”** button will enable you to enter an Enhanced Collection Swath Width that is greater than the computed swath width of the fireboom being towed. For this example, use the same input variables as outlined in Section 5b, but also enter an enhanced collection swath width of 1000 ft. Click calculate.

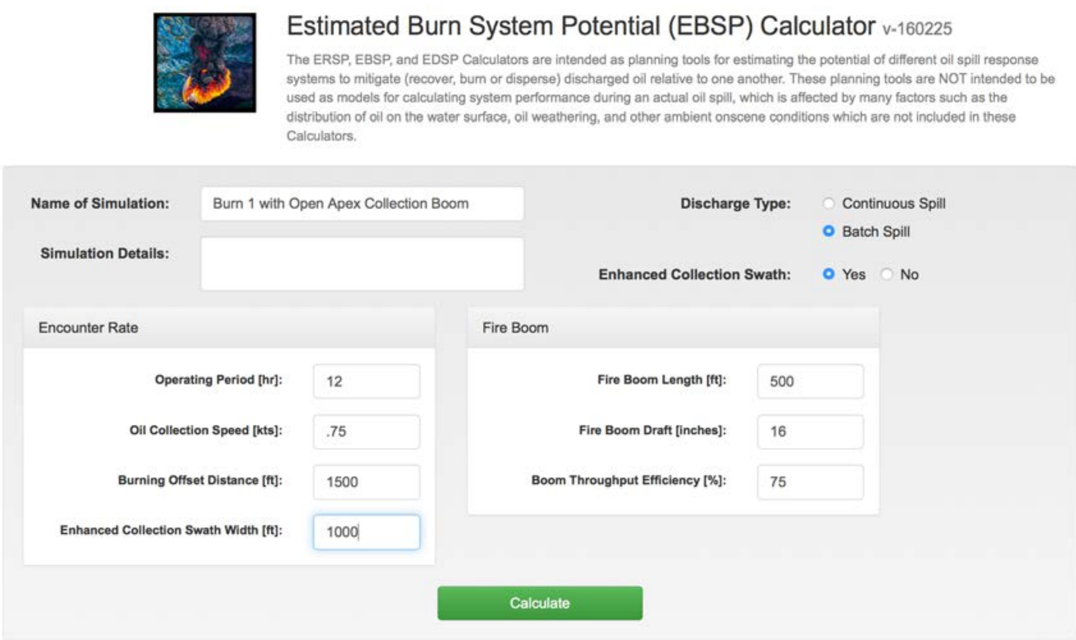

Figure 18. EBSP Calculator for Burn 1 Batch Spill with Enhanced Collection Configuration.

Simulation Notes:
Day 3 emulsification may make ignition and burning difficult to impossible.

Estimated Burn System Potential (EBSP) (Total Volume of Oil Burned in Operating Period)	Operating Period 1	Operating Period 2	Operating Period 3	3-OP Total
	2721 bbl	2177 bbl	1633 bbl	6531 bbl

Burn Cycle Timeline

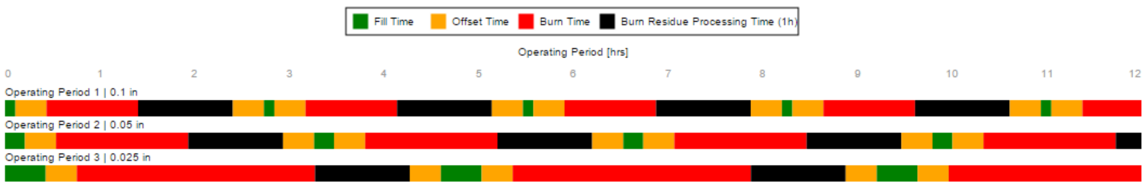

Figure 19. EBSP Graphical Outputs for Burn 1 Batch Spill with Enhanced Collection Configuration.

Operating Period: **Encountered Product (Oil/Emulsion) Thickness:** **% of Water in Oil/Water Emulsion:**	**Op. Period 1** **0.1** **35**	**Op. Period 2** **0.05** **55**	**Op. Period 3** **0.025** **75**
Swath Calculated from Fire Boom Length	150 ft	150 ft	150 ft
Oil/Emulsion Encounter Rate	4735 gpm	2367 gpm	1184 gpm
Oil/Emulsion Collection Rate	3551 gpm	1776 gpm	888 gpm
Fire Boom Capacity	544 bbl	544 bbl	544 bbl
Areal Coverage Rate	1.74 acre/min.	1.74 acre/min.	1.74 acre/min.
Time to Fill	0.11 hrs.	0.21 hrs.	0.43 hrs.
Offset Time	19.74 min.	19.74 min.	19.74 min.
Burn Rate	0.09 in/min.	0.06 in/min.	0.04 in/min.
Burn Time	58 min.	83.8 min.	150.9 min.
Number of Burn Cycles in OP	4.39	3.67	2.61
Collection Time in OP	1.5 hrs.	2.8 hrs.	3.7 hrs.
EBSP = Total Volume of Oil Burned in Operating Period	**2721 bbl**	**2177 bbl**	**1633 bbl**

Figure 20. EBSP Calculator Tabular Outputs for Burn 1 Batch Spill with Enhanced Collection Configuration.

2. Review the Recovery Cycle Timeline. Note how the predicted Times to Fill the fireboom with oil (shown in green) using the enhanced collection configuration have been significantly shortened when compared to the scenario where the fireboom was used as the sole collection arrangement (see Section 5b).
3. Review the values for EBSP in the bottom table row. Using Enhanced Collection on each of the three days, the number of burns conducted has increased due to the shorter fill times; as a result, the EBSP values have also increased for all three Operating Periods.

6. Equations Used in Calculations

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

Equation Variables

OP = Operating Period [hours]

EnR= Oil/Emulsion Encounter Rate [gallons per minute]

CR=Oil/Emulsion Collection Rate [gallons per minute]

OD=Offset Distance [feet]

OT=Offset Time [minutes]

L=Fire Boom Length [feet]

D=Fire Boom Draft [inches]

A=Area of Oil/Emulsion in Fire Boom [square feet] (at holding capacity)

V=Volume of Oil/Emulsion in Fire Boom [barrels] (at holding capacity)

W=Fire Boom Swath Width [feet]

EW=Enhanced Swath Width [feet]

S=System Speed [knots]

T=Oil/Emulsion Thickness [inches]

OP=Oil/Emulsion Percentage [percent]

TE=Throughput Efficiency [percent]

TF=Time to Fill Fire Boom to Capacity [minutes]

BR=Burn Rate [inches per minute]

BT=Burn Time [min]

T1C=Time for One Cycle [minutes]

NC=Number of Cycles in Operating Period

PLC=Partial Last Cycle [minutes]

VLC = Volume of Last Collection [barrels]

LBT=Last Burn Time [minutes]

LCCT=Last Complete Cycle Time [minutes]

RT=Residue Time=60 minutes

Calculator Equations

EnR= Oil/Emulsion Encounter Rate [gallons per minute]

$$EnR = MAX(EW, L * 0.3) * S * T * 63.13$$

CR=Oil/Emulsion Collection Rate [gallons per minute]

$$CR = EnR * \frac{TE}{100}$$

A=Area of Oil/Emulsion in Fire Boom [square feet] (at holding capacity)

$$A = 0.3 * L * 0.1375 * L * \frac{2}{3} = 0.0275 * L^2$$

V=Volume of Oil/Emulsion in Fire Boom [barrels] (at holding capacity)

$$V = \frac{D}{36} * A * 0.178$$

TF=Time to Fill Fire Boom to Capacity [minutes]

$$TF = \frac{V * 42}{CR}$$

OT=Offset Time [minutes]

$$OT = \frac{OD * 0.0099}{S}$$

BR=Burn Rate [inches per minute]

$$BR = 0.14 * (100 - OP/100)$$

BT=Burn Time [min]

$$BT = \frac{D}{3 * BR}$$

T1C=Time for One Cycle [minutes]

$$T1C = TF + (2 * OT) + BT + Residue\ Time[min]$$

NC=Number of Cycles in Operating Period

$$NC = \frac{OP * 60}{T1C}$$

PLC=Partial Last Cycle [minutes]

$$PLC = \left(NC - INT(NC)\right) * T1C$$

VLC = Volume of Last Collection [barrels]

$$VLC = MIN(TF, PLC) * \frac{CR}{42}$$

LBT=Last Burn Time [minutes]

$$LBT = \frac{VLC}{V} * BT$$

LCCT=Last Complete Cycle Time [minutes]

$$LCCT = MIN(PLC, TF) + (2 * OT) + LBT + R$$

$$EBSP\ [bbl] = INT(NC) * V + VLC$$