5.6.2 | Open Storage Devices - Rigid Frame

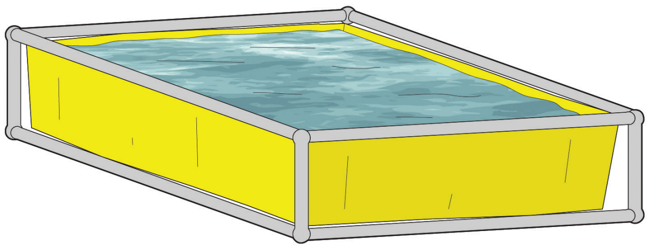


Diagram 5.6.2b Open Storage - Rigid Frame

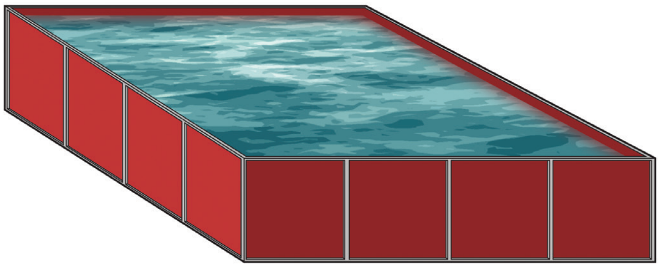


Diagram 5.6.2c Open Storage - Rigid Frame

5.6.3 | Open Storage Devices - Frameless

Typically used for water storage, this self-supporting tank is designed with a floating foam collar, allowing the tank to rise on its own as it is filled. Capacity ranges from 250 gallons / 946 litres on low-side tanks to 20,000 gallons / 75,708 litres for high-side tanks.

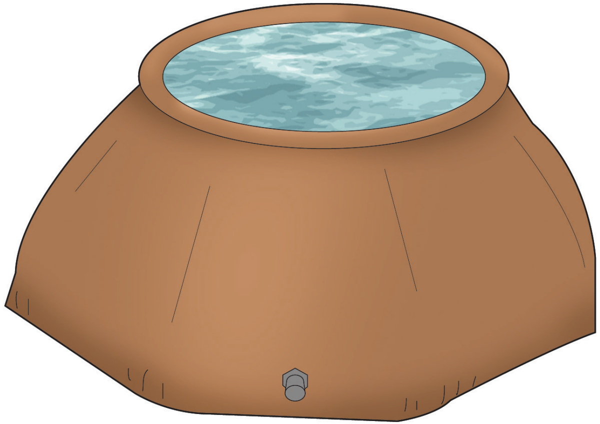


Diagram 5.6.3a Open Storage - Frameless

5.7 | Vacuums

Vacuum units operate on the same principle as an industrial vacuum cleaner. A suction pump pulls large quantities of air through a hose and into a large-volume receptacle. The sudden velocity drop that occurs in the receptacle causes liquids and solids to fall out of the airstream and collect. This process may be aided by internal baffles in the receptacle. Vacuum units may be used in place of pumps to operate weir skimmers or to transfer collected oil from disc or drum skimmers. The open end of the suction hose can also be useful as a simple suction wand or air conveyor during cleanup operations.

Note: The vacuum units in Diagram 5.7.1a and 5.7.2a do not have the large volume receptacles that are key to their usefulness. They are intended to be used with auxiliary tanks (like the one illustrated in 5.7.1b) or drums (not shown).

5.7.1 | Vacuums | Towable Vacuum Unit and Vacuum Tank

An All Terrain Vac is a high-powered vacuum system that is mounted on a towable chassis. When mounted to a vacuum tank it is useful for clean-up operations in remote locations or where smaller quantities of liquids need to be recovered. These units can come with ATV tires or tracks for towing in remote locations and on soft ground.

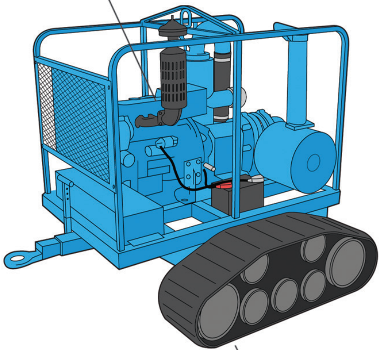


Diagram 5.7.1a Towable Vacuum Unit

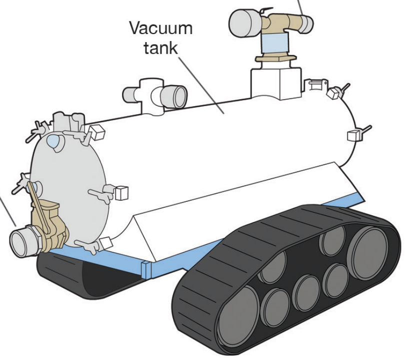


Diagram 5.7.1b Towable Vacuum Tank

5.7.2 | Vacuums | Portable Vacuum Unit

Mounted on a rolling frame, portable units with wheels and tires can be brought to a spill site by hand. A 55-gallon drum is frequently used in the place of a vacuum tank.

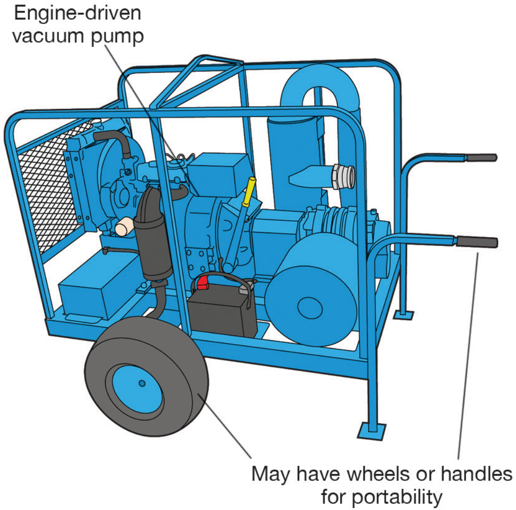


Diagram 5.7.2a Portable Vacuum Unit

5.8 | Boom, Tow Bridles and Other Attachment Devices

5.8.1 | Boom, Tow Bridles and Other Attachment Devices | Containment Boom

The use of floating containment boom is described in detail in Section 3, Inland Spill Control Tactics. Boom comes in many different sizes and configurations, all of which share some common nomenclature.

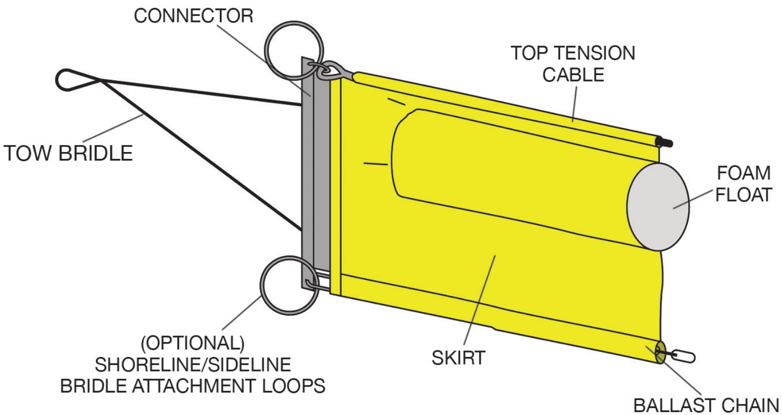


Diagram 5.8.1a Containment Boom

5.8.2 | Boom, Tow Bridles and Other Attachment Devices | Sea Sentry II Boom

Sea Sentry II Inflatable Oil Containment Boom has a tensile strength of over 45,000 lbs. The Sea Sentry II Boom is a proprietary blend of nitrile, adhesives and vinyl impregnated into the fabric. Standard lengths are 110 feet / 33.5 metres. Tactics for Sea Sentry II Oil Containment Boom can be found in Section 3.4.2 of this manual.

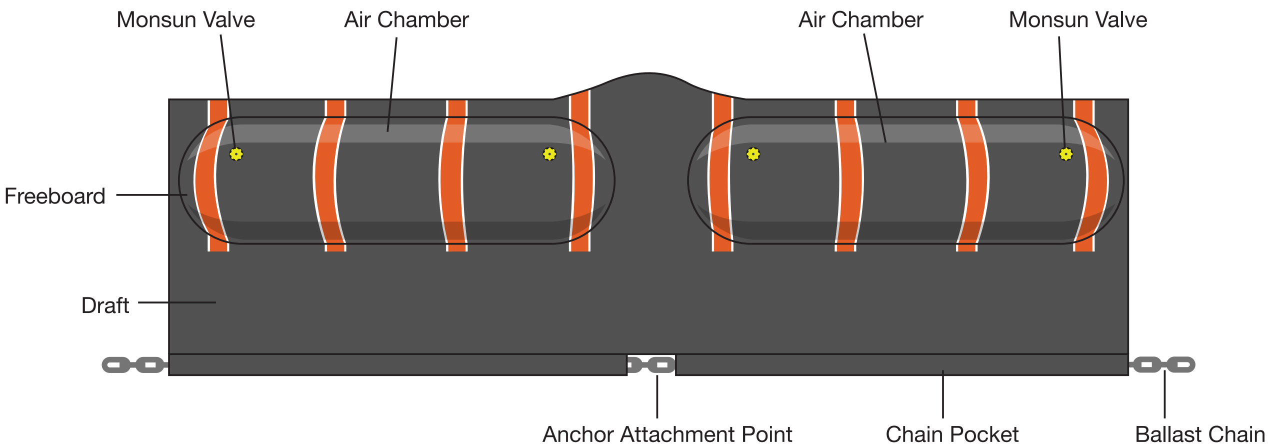


Diagram 5.8.2a Sea Sentry II Boom

5.8.3 | Boom, Tow Bridles and Other Attachment Devices | Boom Connectors

Boom sections are always equipped with end connectors that allow them to be strung together. The end connectors are usually a rigid pipe or extruded shape that may not lend itself to attaching a towline, or securing the free end of a boom to an anchor point.

The ASTM "Z" and the Light Duty Mini Slide are the most common containment boom connectors. Booms with different connectors can attach together as shown in Diagram 5.8.3c.

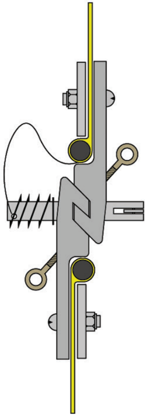


Diagram 5.8.3a
ASTM "Z" Connector

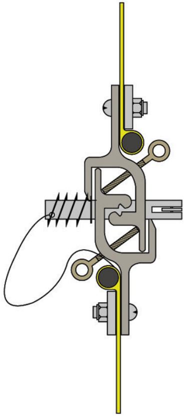


Diagram 5.8.3b
Light Duty Mini Slide Connector

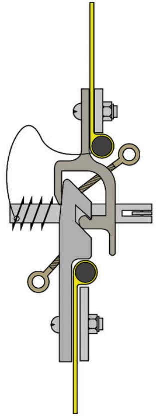


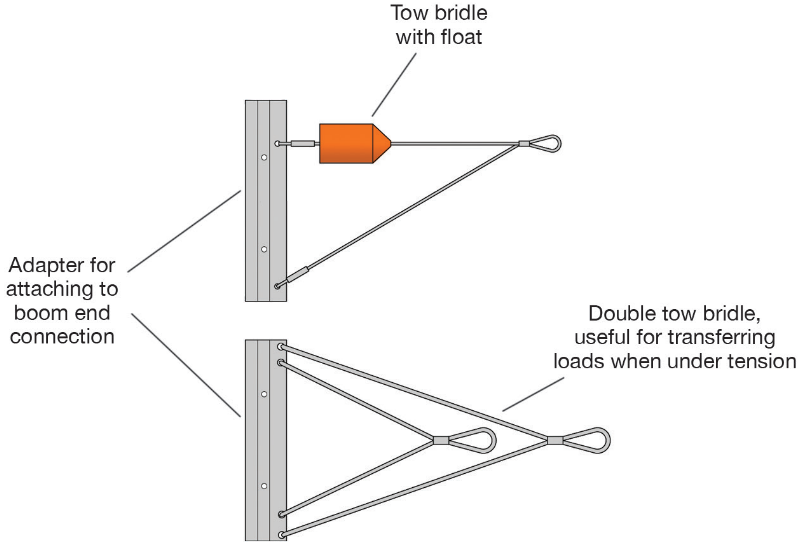
Diagram 5.8.3c
ASTM "Z" Connector with Mini Slide Connector

5.8.4 | Boom, Tow Bridles and Other Attachment Devices | Boom Tow Bridles

Tow bridles are available that will mate with the end connector of a boom, and allow an easy attachment point for a towline or anchor line.

Diagram 5.8.4a Tow Bridle with Bullet Flo

Diagram 5.8.4b Double Bridle



5.8.4 | Boom, Tow Bridles and Other Attachment Devices | Boom Tow Bridles

Diagram 5.8.4c Paravane

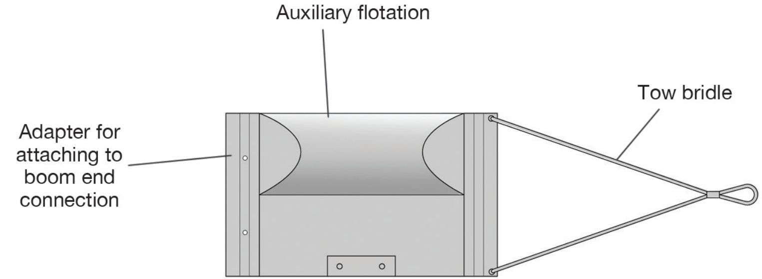


Diagram 5.8.4d Sideline Bridle

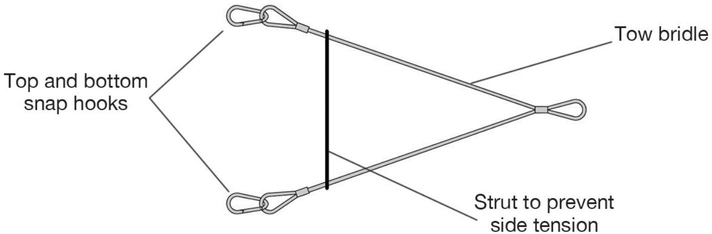


Diagram 5.8.4e Bridge Pier Bridle
100 ft x 1 in / 30 m x 2.5 cm
Center 80 ft / 24 m rubber coated

Line 3 Replacement Project: Addendum to Assessment of Accidental Releases: Technical Report
Attachment 1

Inland Spill Response Tactics Guide

Charts, Tables & Calculators

6

6.1 | Boom Configuration and Length as a Function of Speed Table

Table 6.1a Boom Configuration and Length as a Function of Speed

Angle Degree	Max Allowable River Current			Length of Boom Required per 100 ft (30m) of Span	
	kts	kph	mph	ft	m
90	0.8	1.4	0.9	100	30
75	0.8	1.4	0.9	104	32
60	0.9	1.6	1.0	115	35
45	1.1	2.0	1.2	141	43
30	1.5	2.8	1.7	200	61
15	2.9	5.4	3.3	386	118

6.2 | ASTM Guide for Boom Selection

Table 6.2a ASTM Guide for Boom Selection

Boom Property	**Calm Water***	**Calm Water - Current***
Overall Heigh (range), mm (inches)	150 to 600 (6 to 24)	200 to 800 (8 to 32)
Minimum Gross Buoyancy to Weight Ratio	3:1	4:1
Minimum Total Tensile Strength, N (lbs)	6,800 (1,500)	23,000 (5,000)

* Calm Water = No Waves & No Current. Calm Water - Current = No Waves with Current.

ASTM, F1523 - 94 (Reapproved 2013) *Standard Guide for Selection of Booms in Accordance with Water Body Classifications. West Conshohocken, PA.*

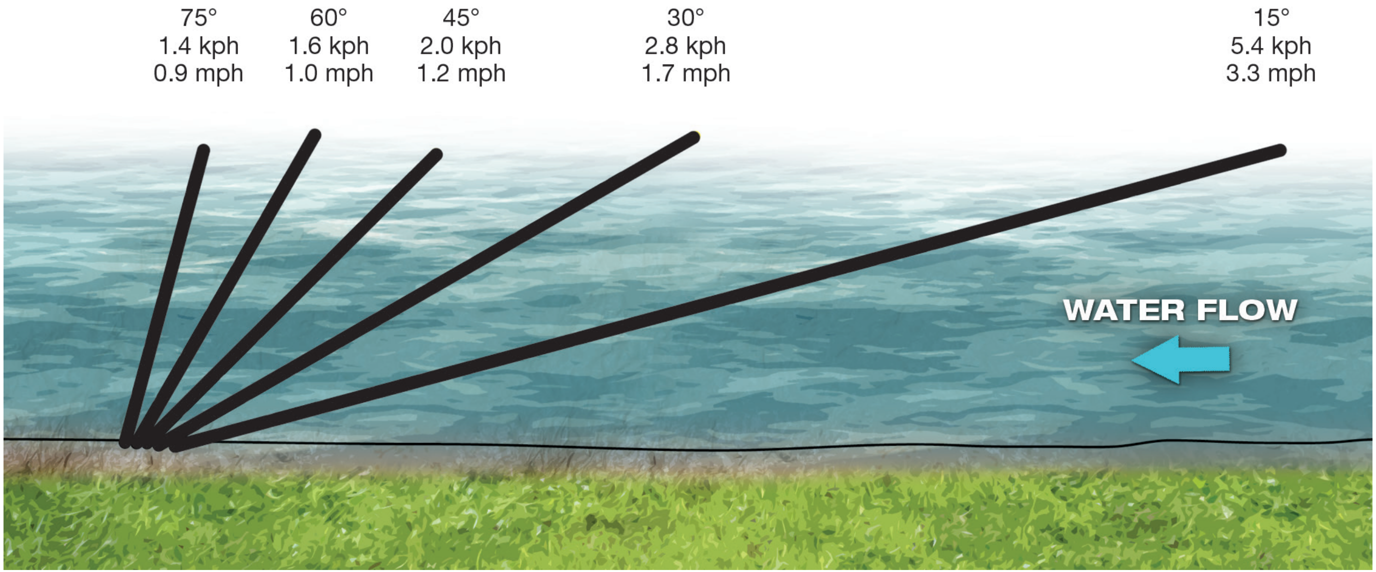
6.3 | Stream Speed Table

Table 6.3a Stream Speed Table

Time for Object to Travel				
30 m (100 ft)				Current
sec	km / hr	m / s	mi / hr	ft / s
216	0.5	0.14	0.3	0.46
108	1.0	0.28	0.6	0.92
72	1.5	0.42	0.9	1.38
54	2.0	0.56	1.2	1.84
43	2.5	0.69	1.5	2.26
36	3.0	0.83	1.9	2.72
31	3.5	0.97	2.1	3.18
27	4.0	1.11	2.5	3.64
24	4.5	1.25	2.8	4.10
22	5.0	1.39	3.1	4.56
18	6.0	1.67	3.7	5.48

When the stream velocity has been determined, use the diagram below and the table in Section 6.1 to estimate the angle that deflection or diversion boom should make with the current and approximate length of boom required to avoid entrainment.

6.4 | Boom Angles



6.5 | Anchor Holding Capacities

Table 6.5a Anchor Holding Capacities Table

Anchor Type	Holding Ground	Holding Efficiency
Danforth	Sand	14.0
	Mud	7.0
Sarca	Sand	20.0
Deadweight	Sand	0.5
	Mud	0.3

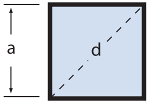
6.6 | Rope & Chain Minimum Breaking Strength

Table 6.6a Rope & Chain Minimum Breaking Strength

Rope Diameter		Nylon		Polypropylene		Wire Rope (6x19, ips, iwrc)		Spectra 12 Strand (Aramid)		Chain Grade 30	
in	**mm**	**lbf**	**kN**	**lbf**	**kN**	**lbf**	**kN**	**lbf**	**kN**	**lbf**	**kN**
3/16	5	880	3.91	904	4.02			3,600	16.00	3,200	14.22
1/4	6	1,486	6.61	1,191	5.29	5,340	23.73	6,000	26.67	5,200	23.11
5/16	8	2,295	10.20	1,940	8.62	8,240	36.62	9,000	40.00	7,600	33.78
3/8	10	3,240	14.40			11,800	52.44	13,900	61.78	10,600	47.11
7/16	11	4,320	19.20			16,00	71.11	14,800	65.78	14,800	65.78
1/2	12	5,670	25.20	4,476	19.89	20,800	92.44	22,500	100.00	18,000	80.00
9/16	14	7,200	32.00			24,200	107.56	27,700	123.11		
5/8	16	8,910	39.60	7,718	34.30	32,300	143.11	36,600	162.67	27,600	122.67
3/4	18	12,780	56.80			46,000	204.44	43,200	192.00	42,400	188.44
7/8	22	17,280	76.90			62,200	276.44	61,000	271.11		
1	24	22,230	98.90	16,758	74.48	80,800	359.11	72,000	320.00	71,600	318.22

6.7 Commonly Used Formulae

Areas are commonly used to describe the extent of a spill's impact. Area can be estimated quickly by selecting a regular geometric shape that most closely resembles the spill and using the formulae given below.

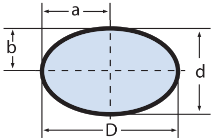


Square

$A = a^2$

$a = \sqrt{A}$

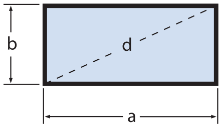
$d = a\sqrt{2}$



Ellipse

$A = \frac{Dd\pi}{4} = ab\pi$

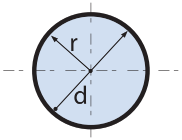
$C = \frac{D+d}{2}\pi$



Rectangle

$A = ab$

$d = \sqrt{a^2 + b^2}$



Circle

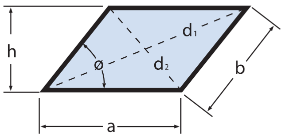
$A = \frac{d^2\pi}{4} = r^2\pi$

$\cong 0.785\ d^2$

$C = 2r\pi = d\pi$

NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

6.7 | Commonly Used Formulae

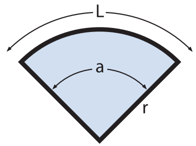


Parallelogram

$A = ah = ab \sin ø$

$d_1 = \sqrt{(a + h \cot ø)^2 + h^2}$

$d_2 = \sqrt{(a - h \cot ø)^2 + h^2}$



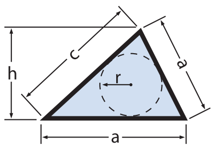
Sector of Circle

$A = \frac{\pi \times r \times r \times a}{360}$

$L \cong 0.01745 \times r \times a$

$a \cong \frac{L}{0.01745 \times r}$

$r \cong \frac{L}{0.01745 \times a}$

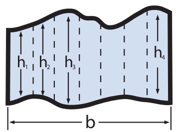


Triangle

$A = \frac{ah}{2} = rs$

$= \sqrt{s(s-a)(s-b)(s-c)}$

$s = \frac{a+b+c}{2}$



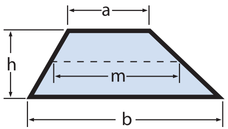
Irregular shape: divide length into parallel strips of equal width.

$A = b \frac{h_1 + h_2 + h_3 + \ldots etc}{n}$

NOTE: A = area C = circumference s = semi-perimeter π = 3.1416

6.7 | Commonly Used Formulae

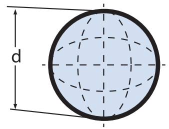
Estimating volume is as important as estimating area. For instance, it may be necessary to estimate the amount of solid waste in a debris pile to know how many roll-off boxes may be required for transport and disposal. As with areas, a quick estimate can be made by selecting a geometric shape most closely resembling the pile.



Trapezoid

$$A=\frac{a+b}{2}h=mh$$

$$m=\frac{a+b}{2}$$

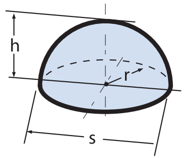


Sphere

$$V=\frac{4}{3}r^3\pi=\frac{1}{6}d^3\pi$$

$$\cong 4.189\,r^3$$

$$A_{\o}=4\pi r^2=\pi d^2$$



Segment of a Sphere

$$V=\frac{\pi h}{6}\left(\frac{3}{4}s^2+h^2\right)$$

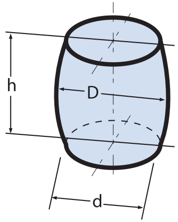
$$=\pi h^2\left(r-\frac{h}{3}\right)$$

$$A_m=2\pi rh=\frac{\pi}{4}\left(s^2+4h^2\right)$$

NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

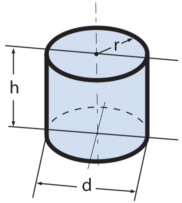
6.7 Commonly Used Formulae

Estimating the surface area of a shape may be necessary. For instance, a pile of oily debris may need to be covered with tarps to minimize secondary contamination. A quick estimate of the surface area will be valuable in estimating how many tarps of a particular size are needed.



Barrel

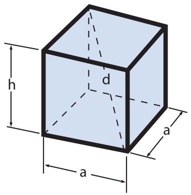
$V = \frac{h\pi}{12}(2D^2 + d^2)$



Cylinder

$V = \pi r^2 h$

$A_o = 2r\pi(r+h)$

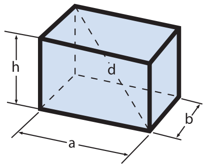


Cube

$V = a^3$

$A_{\varnothing} = 6a^2$

$d = a\sqrt{3}$



Cuboid

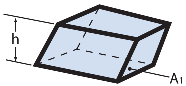
$V = abc$

$A = 2(ab + ac + bc)$

$d = \sqrt{a^2 + b^2 + c^2}$

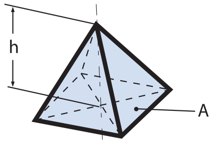
NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

6.7 | Commonly Used Formulae



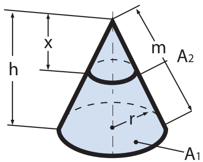
Parallelepiped

$V = A_1 h$



Pyramid

$V = \frac{A\,h}{3}$



Cone

$V = \frac{r^2 \pi\, h}{3}$

$A_m = r\pi m$

$A_o = r\pi(r + m)$

$m = \sqrt{h^2 + r^2}$

$A_2 : A_1 = x^2 : h^2$

NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

6.8 | Weights of Common Gases, Liquids and Solids

Table 6.8a Weights of Common Gases, Liquids and Solids

Substance	Unit Weight (lbs / ft^3)	Unit Weight (kg / m^3)
Air	0.0807	1.29
Aluminum	168	2,690
Asphalt	69 to 94	1,110 to 1,510
Brass	524	8,390
Brick, common	112	1,790
Concrete, plain	145	2,320
Concrete, reinforced	150	2,400
Earth, excavation packed	105	1,680
Earth, loose	80	2,880
Fir, seasoned	30 to 44	480 to 700
Gasoline	41 to 43	660 to 690
Hay Bales, compressed	24	380
Ice	57	910
Kerosene	51	820
Oak, white	46	740
Pine, yellow	44	700
Sand	90 to 100	1,440 to 1,600
Steel	489	7,830
Straw Bales, compressed	19	300
Water, fresh	62.354 (@ 62° F)	998.8
Water, sea	63.976 (@ 62° F)	1,024.8

6.9 | English/Metric Conversions

Table 6.9a English/Metric Conversions

English to Metric	
Length	
1 inch (in)	2.54 centimetres (cm)
1 foot (ft)	0.3048 metres (m)
1 mile (mi)	1.609 kilometres (km)
1 nautical mile (nm)	1.852 kilometres (km)
Area	
1 square foot (ft^2)	929 square centimetres (cm^2)
1 square foot (ft^2)	0.0929 square metres (m^2)
1 acre (ac)	4,047 square metres (m^2)
1 square mile (mi^2)	2.59 square kilometres (km^2)
Volume	
1 US Gallon (US Gal)	3.785 litres (l)
1 Impreial Gallon (Imp Gal)	4.546 litres (l)
1 Barrel (bbl)	159 litres (l)
Velocity	
1 mile per hour (mph)	1.609 kilometres/hr (kph)
1 nautical mile per hour (knot)	1.852 kilometres/hr (kph)
1 foot per second (fps)	0.3048 metre/second (m/sec)
1 foot per second (fps)	1.097 kilometres/hr (kph)

Metric to English	
Length	
1 cm	0.393 in
1 m	3.28 ft
1 km	0.621 mi
1 km	0.540 nm
Area	
1 cm^2	0.0129 ft^2
1 m^2	10.76 ft^2
1,000 m^2	0.247 ac
1 km	0.386 mi^2
Volume	
1 l	0.264 US gal
1 l	0.220 Imp gal
1 l	0.00629 bbl
Velocity	
1 kph	0.621 mph
1 kph	0.54 knot
1 m/sec	3.28 fps
1 kph	0.911 fps

6.9 | English/Metric Conversions

Table 6.9a English/Metric Conversions

English to Metric		Metric to English	
Weight		**Weight**	
1 pound (lb)	0.454 kilograms (kg)	1 kg	2.205 lb
1 short ton (st)	0.907 tonne (mt)	1 mt	1.102 st
1 long ton (lt)	1.016 tonne (mt)	1 mt	0.984 lt
Temperature			
F° = (C° (9) ÷ 5) + 32			
Pressure		**Pressure**	
1 pound per square ince (psi)	0.0689 bar	1 bar	14.504 psi
1 pound per square ince (psi)	6.89 kilopascals (kPa)	1 kPa	0.145 psi
1 pound per square ince (psi)	0.704 metre (water column) (mwc)	1 mwc	1.42 psi
1 inch mercury (in Hg)	25.4 mm mercury (mm Hg)	1 mm Hg	0.0394 in Hg
1 atmosphere (atm)	1.033 kg/cm^2	1 kg/cm^2	0.968 atm
1 atmosphere (atm)	760 mm mercury (mm Hg)	1 mm Hg	0.00132 atm
Flow		**Flow**	
1 gallon per minute (gpm)	0.227 metre^3 per hour (m^3/hr)	1 m^3/hr	4.403 gpm
1 cubic foot per minute (cfm)	1.699 cubic metres per hour (m^3/hr)	1 m^3/hr	0.5886 cfm
1 barrel per day (bpd)	0.1104 litres per minute (lpm)	1 lpm	9.057 bpd
Power		**Power**	
1 horsepower (hp)	0.746 kilowatt (kw)	1 kw	1.341 hp

[redacted]

Inland Spill Response Tactics Guide

Glossary of Terms

7

Absorbent

See “Sorbents”

Adsorption

The process that causes one substance to be attracted to and adhere to the surface of another substance, without actually penetrating its surface

Barrel

A unit of volume equal to 42 U.S. gallons/35 Imperial gallons or 159 litres at 60ºF, often used to measure volume in oil production, transportation and trade

Bell Hole

An excavation or depression in the ground that oil will flow into for containment and recovery by vacuum truck, hose or other similar device

Berm

A constructed wall or barrier of material placed to contain or exclude a spill

Board Weir

A board placed bank-to-bank across a stream or water-filled ditch to block the progress of a floating contaminant in order to retain it for recovery. The board is kept elevated from the bed of the waterway in order to permit the continued flow of unaffected water. It may be raised or lowered as necessary to maintain the balance of flow and containment.

Boom

A manufactured device that extends vertically above and below the water surface in order to contain or exclude a floating contaminant from a particular resource or to consolidate the spill for recovery

Boom Angle

The angle of the boom in relation to the current of the water body

Bridge Pier

Structural support column for a bridge that may be used as a boom anchoring point

Collection Point

A location used for recovery of a spill and frequently referred to as a control point when on a river bank

Containment Capacity

The maximum volume that can be contained within a specified storage device

Control Point

A predetermined location from which spill containment and recovery operations may be conducted with the expectation of a high degree of success

Culvert Block

A board, frequently a plywood sheet, placed across the upstream end of a culvert that permits the halting of the progress of a water surfaceborne contaminant while allowing the water to continue to pass below its lower edge. It is raised or lowered as necessary to maintain the balance of flow and containment.

Current

The velocity or rate of flow

Decontamination

The removal of hazardous substances from personnel and equipment necessary to prevent adverse health effects

Deflection/Diversion Booming

Strategically placing boom in a waterbody to marshal a surface-borne contaminant in a desired direction

Filter Fence

A structure constructed of material such as chicken wire installed across a waterway and used to backstop the spill recovery material on the upstream side of the fence. The recovery material is usually sorbents, hay bales or similar.

Entrainment

The process where tiny droplets of a spill are mixed into and carried with the water flow

Environmental Damage

Any change or disturbance to the environment that is considered detrimental

Exclusion Booming

Strategic placement of boom in water bodies to prevent entry of a spill into a particular area

Ground Tackle

Equipment used in anchoring

Hydrophobic

Having an aversion to water. Hydrophobic substances repel water.

Incident Commander (IC)

Person responsible for all aspects of the response, including developing incident objectives and managing all incident operations. This means the most qualified person, not necessarily the most senior person, on scene.

Incident Command System (ICS)
A standardized on-scene emergency management system specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

In-Situ Burning
A tactic that involves the controlled burning of an oil spill at the location of the spill

Interceptor Trench
Typically a long and narrow excavation created ahead of an advancing spill to halt its progress and facilitate recovery

Leading Edge
The first presence of an advancing spill observed or computed at the farthest distance from its source

Mechanical Containment
Booms or other installed barriers deployed to prevent the advance or spread of a spill

Mechanical Recovery
Recovery of oil by mechanical means such as with skimmers, vacuum trucks and pumps

Oil Spill
Release of oil into the environment

Oleophilic
Having a strong attraction for oil. Oleophilic materials attract oil.

PFD
Personal Flotation Device (life vest, floater coat)

Piling
A vertical post installed in a river or on shore that may be used as an anchor point

Pom-Poms
Design of oleophilic adsorbent in the shape of a pom-pom

PPE
Personal Protective Equipment

Recovery
The process of collecting oil from an inadvertent release

Saw Sleigh
An apparatus used to hold a chain saw vertically and usually employed in the creation of ice slots during a winter response

Sensitive Areas
There are a number of factors that influence whether an area is considered sensitive, and these are frequently determined by local information. These may include areas such as communities, water intakes, beaches, fish-spawning or bird-nesting areas or archaeological sites. The sensitivity of such sites may vary with the season.

Sheen
A very thin layer of oil, less than 0.0003 mm (12 one-millionths of an inch) in thickness, floating on the water surface. Sheen is the commonly observed form of oil during the later stages of a spill. Depending on thickness, sheens range in color from dull brown for the thickest to rainbow, grey, silver and near transparent in the case of the thinnest examples.

Siphon Dam
A pipe or pipes installed at an upward angle through a damming structure enabling the flow of water to drain from deep on the upstream side of the device while any floating contaminant is retained on the water surface. The damming structure may be constructed using a manufactured device, earth or sandbags. A variation on this tactic has the pipe(s) pass through the base of the damming structure. The pipe or hose ends may be raised to control the level of water behind the dam.

Skimmer
A mechanical device for recovering a floating contaminant from the surface of water

Sorbents
Substances that take up and hold liquid. Sorbent materials are designed and produced with different properties such as oleophilic or hydrophobic. Sorbents are mainly supplied in the form of pads, booms and rolls.

Spreading
The action where a spill increases in the surface area it covers, whether on land or water. Rate of spreading is highly variable and determined by a large number of factors such as terrain, soil type, temperature, currents and wind effects.

T-posts
Manufactured metal rods used as posts to anchor temporary fences

Temporary Liquid Storage
Physical containment for liquid that is temporary in nature. Examples are portable tanks, earthen sumps and tank trucks.

Trench
Typically a long and narrow excavation in the ground

Viscosity
Having a resistance to flow; substances that are extremely viscous do not flow easily. Different substances have different viscosities, and temperature and other factors may influence this aspect.

Weathering

Effect of weather on a spill. This may alter the consistency, viscosity, color and other properties of the spilled material.

Weir

An over - or underwater structure that controls the flow of a liquid

Windrows

Streaks of oil of a waterborne spill that have been created by wind, currents and/or natural convergence zones and may be observed in a wide range of colors due to spill weathering and other factors such as particulate in the water.

Inland Spill Response Tactics Guide

Appendix

8

8.1 | References

The following publications are available for information pertaining to oil spill response:

Alaska Clean Seas, *Technical Manual, Volume 1 – Tactics Descriptions*, 2012.

API, NOAA, *Inland Oil Spills: Options for Minimizing Environmental Impacts of Freshwater Spill Response*. Prepared by E.H. Owens (OCC) and J. Michel (RPI) for American Petroleum Institute. Publication N. 4558, Washington, D.C. 1994.

ASTM, F1523 - 94 (Reapproved 2013) *Standard Guide for Selection of Booms in Accordance with Water Body Classifications*. West Conshohocken, PA.

ASTM F1778 - 97 (Reapproved 2008) *Standard Guide for the Selection of Skimmers for Oil-Spill Response*, West Conshohocken, PA.

Alberta Government, 2013. *Best Practice for Building and Working Safely on Ice Covers in Alberta*. Occupational Health and Safety Contact Centre. Publication Number SH010. AB, Canada.

CCG, 1995. *Oil Spill Response Field Guide*. Canadian Coast Guard, Ottawa, ON.

CONCAWE, 1981. *A Field Guide to Coastal Oil Spill Control and Cleanup Techniques*. Oil Spill Cleanup Report No. 9/81, Technology Special Task Force No. 1, Den Haag.

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Dickins, D.F., 2000. *Detection and Tracking of Oil Under Ice*. Submitted to Department of Interior Minerals Management Service, Herndon, VA.

ExxonMobil. 2008. *Oil Spill Response Field Manual*. ExxonMobil Research and Engineering Company.

Hansen, K., and Coe, T.J., 2001. *Oil Spill Response in Fast Currents – A Field Guide*.

Owens, E.H., 1998. *Field Guide for the Protection and Cleanup of Oiled Shorelines*. Environment Canada, Atlantic Region, Environmental Emergencies Section, Dartmouth, NS, 2nd Edition.

USCG, 2003. *Oil Response in Fast Water Currents: A Decision Tool*. U.S. Coast Guard, R&D Center, Groton, CT.

Walker, A.H., Michel, J., Benggio, B., McKetrick, B., Scholz, D., Boyd, J., and Walker, W., 2003. *Selection Guide for Oil Spill Applied Technologies, Volume I: Decision-making*. Prepared for EPA Region III and RRT Region IV.

8.2 | Diagram and Table Index

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Guide

Submerged Oil Management Program

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Appendix A Tables

1.0 Purpose

The purpose of this manual is to provide Enbridge Pipelines Inc., Liquid Pipelines Business Unit (Enbridge) with a consistent approach for managing submerged and/or sunken oil in the event of a release to water.

The manual's primary function is to provide an outline for a timely and coordinated response to effectively manage submerged and/or sunken oil.

2.0 Scope

This document is applicable to Enbridge and provides direction on administration, roles and responsibilities, standards, and management processes for responding to submerged or sunken oil.

The scope of this manual is to:

- Establish the process for activating a submerged/sunken oil response
- Define a clear organizational structure for responding to submerged/sunken oil
- Describe processes for identifying and assessing submerged/sunken oil
- Provide guidance on recovery options and endpoint selection, and
- Assist in establishing a pathway to closure

This document does not address potential response actions for oil that is not submerged.

This document is a guide to responding to submerged/sunken oil. Position titles for staff members executing the Submerged Oil Management Program as presented throughout this document are for illustration purposes only and represent a potential organizational structure for a large, multi-area event. The Submerged Oil Management Program as outlined herein follows the ICS model of flexibility and scalability, whereby position requirements will be determined by site specific requirements at the time of an event. Not all titles or positions may be utilized, and roles and responsibilities may be filled by persons with different or varying titles. Further, response actions in any spill event will be tailored based on the actual circumstances.

3.0 Background

Submerged oil and sunken oil are defined by the American Petroleum Institute (API) (API 2016a) as:

Submerged Oil: *"Spilled oil that is in the water column, below the water surface, including oil that is in temporary suspension due to turbulence and will refloat or sink in the absence of that turbulence."*

Sunken Oil: *"Spilled oil that is on the bottom of the water body."*

Several studies have been completed by API and others (Dettman et al., 2016) to define the conditions under which oil may become submerged or sunken in the environment. Figure A below (API, 2016a) shows the relationship between density, API gravity and salinity, outlining the range of conditions when oil will float or not float in water.

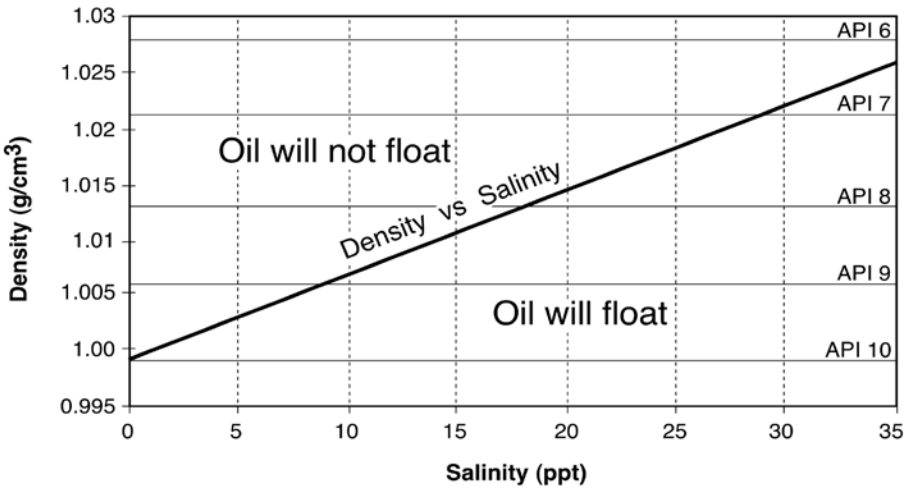


Figure A Relationship between density and API gravity and water salinity (API 2016a)

Further, as depicted in Figure B below (API 2016a), the range of conditions by which oils can sink relative to a number of factors in the receiving environment is shown. Conditions include currents, turbulence and sediment interaction.

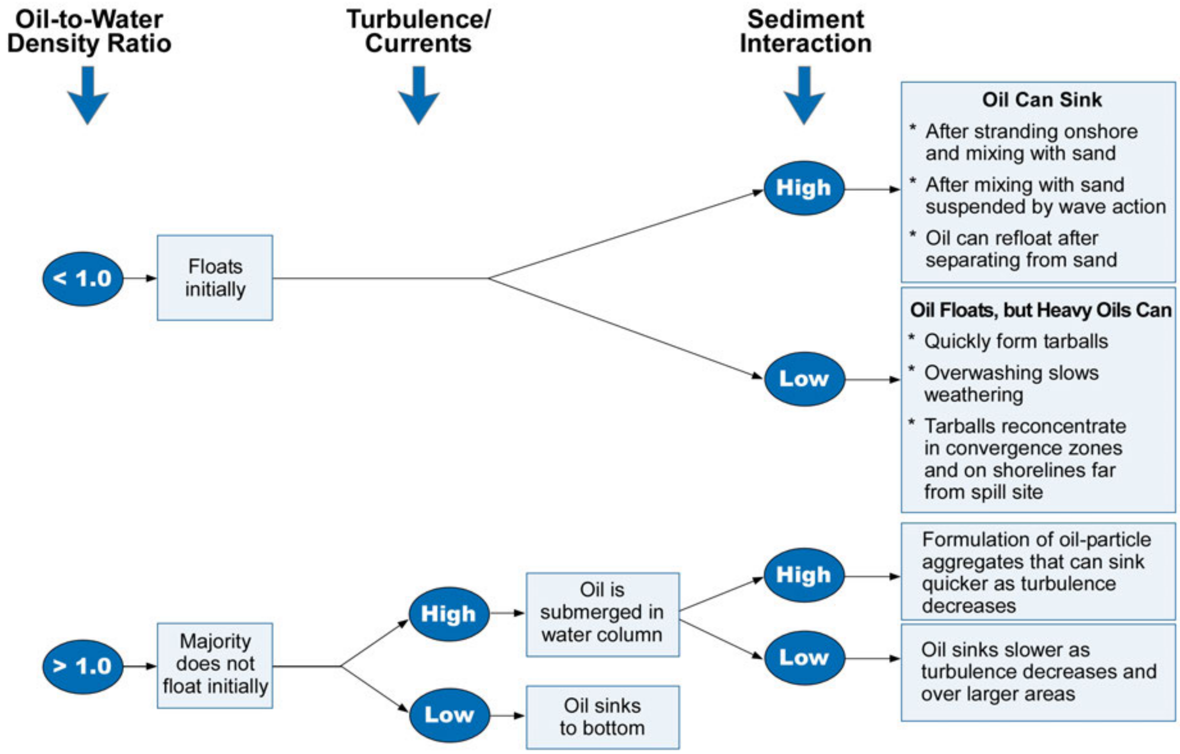


Figure B Conditions by which oils can sink based on the density of the oil relative to the receiving water, turbulence, currents, and sediment interactions (API 2016a)

API (2016a) further defines four factors that control whether oil will float, submerge or sink as:

- The initial density of the oil relative to the receiving water body
- Water turbulence
- Sediment interactions
- Density changes as the oil weathers

The initial density differences could lead to sinking or submerging oil soon after release. However, water turbulence, sediment interactions and density changes due to weathering of oil in the environment affect the character of the released oil over a longer time period which can result in oil submergence/sinking occurring at a delayed time after the initial release.

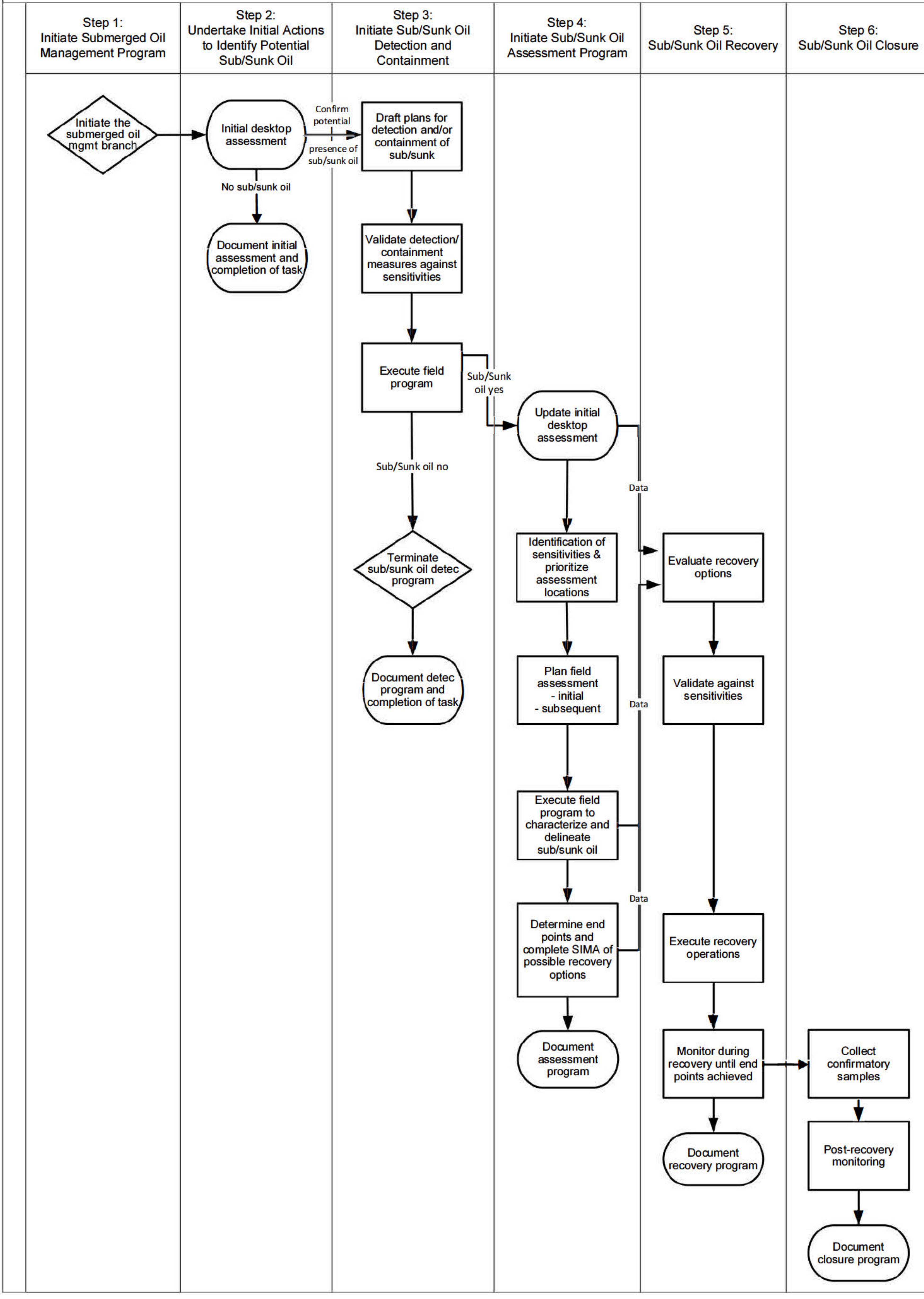
4.0 Step 1 - Initiate the Submerged Oil Management Program

4.1 Incident Command System

The initial actions for identification of potential submerged/sunken oil should involve development of a Submerged Oil Management Branch within the Operations and Planning Sections. Note, these are initial actions related to oil submergence or sinking only; they are not necessarily part of the pro-active emergency response actions related to a release, as oil submergence or sinking can occur after prolonged time in the environment following the initial release. The Submerged Oil Management Program should be initiated by the Operations Section Chief, approved by Incident Command, and follows the structure of the Incident Command System (ICS). The ICS enables a well-managed response and limits the effects of an emergency through the rapid, effective, coordinated response of resources. Additional information on ICS processes is found in Enbridge's Integrated Contingency Plan, Core Section 2.4.

The process flow of information, decisions and outputs for the Submerged Oil Management Program are summarized in Figure C below.

Figure C Submerged Oil Management Program – Flow Chart



Notes:
Tech Specialist = Technical Specialist in EU
Sub/Sunk Oil = Submerged/Sunken Oil
Detec = Detection
Mgmt = Management
SIMA = Spill Impact Mitigation Assessment

The Submerged Oil Management Program exists under the Submerged Oil Management Branch in both Operations and Planning, where submerged/sunken oil identification, detection and assessment, end point development, and closure activities are the responsibility of the Environmental Unit (EU). Submerged/sunken oil containment and recovery are the responsibility of Operations. Refer to Figure D for organization of the Submerged Oil Management Branch under ICS.

Position titles in the Submerged Oil Management Branch, as indicated in Figure D and outlined in Tables A to F, are for illustration purposes only and represent a potential organizational structure of the branch for a large, multi-area event. The Submerged Oil Management Program as outlined herein follows the ICS model of flexibility and scalability, and position requirements will be determined by site specific requirements at the time of an event. Not all titles or positions may be utilized, and roles and responsibilities may be filled by persons with different or varying titles.

Staff is assigned to the Submerged Oil Management Program by the Submerged Oil Management Branch Director. Roles and responsibilities for the members of the Submerged Oil Management Branch are described in the relevant sections below. Note that staff/team members delegated to the Submerged Oil Management Branch will be dedicated to only work for this branch and should not be delegated/assigned to work in any other groups / branches / units / divisions while working for the Submerged Oil Management Branch.

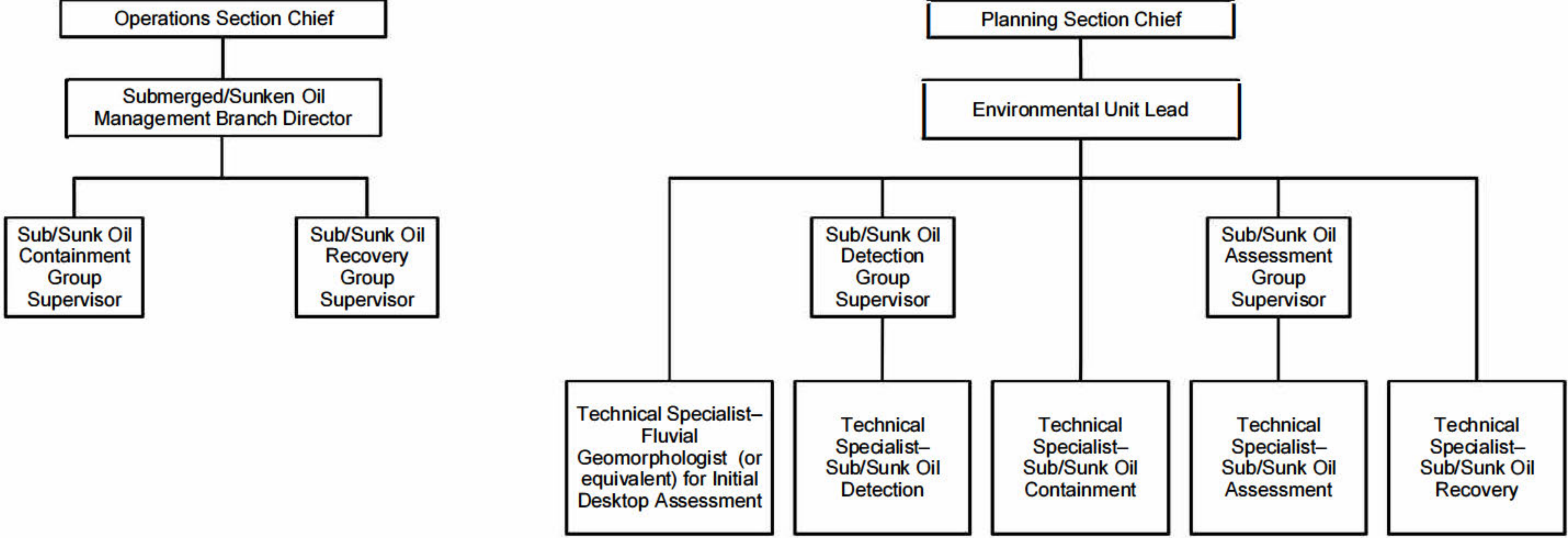


Figure D Submerged Oil Management Program ICS Structure and Staff

4.2 Roles and Responsibilities

The roles and responsibilities of the Operations and Planning staff for Step 1 are presented below in Table A.

Table A Step 1 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Management Branch Director	Appointed by Incident Commander and is responsible for initiating actions to identify potential submerged or sunken oil.
Planning Section	
Environmental Unit Lead (EUL)	Oversees planning aspects to support the Submerged Oil Management Branch. EUL is also responsible to communicate planned submerged oil actions to the Planning Section Chief.

4.3 Health and Safety

Health and Safety plans must reflect Enbridge's safety requirements and site-specific potential hazards (e.g., flowing water, ice and/or extremely cold temperatures) and appropriate mitigations for teams working on the Submerged Oil Management Program.

4.4 Public Notification and Liaison

If the Submerged Oil Management Program actions will impact use of public water ways and/or private property (e.g., private boating docks, private beach/waterfront areas), an approach for consultation/notification for the public should be developed by the Submerged Oil Management Branch Director and team with the Liaison Officer and/or the Public Information Officer and their teams prior to undertaking the steps outlined below.

5.0 Step 2 – Undertake Initial Actions to Identify Potential Submerged/Sunken Oil

MUST:

- Take initial actions to identify the potential for submerged or sunken oil. These require at minimum, an initial desktop assessment to identify potential areas and conditions where oil submergence/sinking could be occurring, and the criteria for determining presence or absence of submerged/sunken oil (e.g., properties of oil released, water body type(s) impacted by released oil, environmental conditions).
- Prior to monitoring for submerged/sunken oil, an experienced fluvial geomorphologist or equivalent subject matter expert/specialist in submerged oil will be retained by the EU to review aerial photography and site-specific information to determine areas where submerged or sunken oil may migrate and potentially deposit.

5.1 Roles and Responsibilities

Roles and responsibilities for the Operations Section staff and Planning Section staff for Step 2 are presented in Table B below.

Table B Step 2 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Management Branch Director	Is responsible for initiating and overseeing actions to identify potential submerged or sunken oil.
Planning Section	
Environmental Unit Lead (EUL)	Oversees planning aspects of the initial submerged oil identification program, including retaining a fluvial geomorphologist or equivalent subject matter expert. EUL is responsible to communicate the results of the initial submerged oil identification program to the Planning Section Chief.
Technical Specialist – Fluvial Geomorphologist/Subject Matter Expert/Specialist	Complete the initial desktop assessment to identify areas where oil submergence/sinking could be occurring. Report the results of the desktop assessment to the EUL.

6.0 Step 3: Initiate Submerged/Sunken Oil Detection and Containment

After initial actions to identify the potential for submerged/sunken oil are complete and the potential or actual presence of submerged/sunken oil is confirmed, detection operations and containment operations (if submerged/sunken oil is detected) for submerged/sunken oil in the identified areas should be planned and executed.

MUST:

- Complete a review of detection and containment methods by the Technical Specialist(s) in the EU to determine the most appropriate and effective detection equipment given site conditions. Refer to Table 1 in Appendix A for an evaluation of matrix and options based on conditions and environment.
- Evaluate detection and containment efforts/methods and implementation in consideration of ecological, cultural/heritage and/or socio-economic sensitivities that may be present at deployment or set-up locations, and may require protection or may exclude certain detection/containment approaches.
- Obtain permits that may be required to deploy certain detection and/or containment methods/approaches as a result of sensitivities and the timing of work in water bodies. Planning within the EU must be undertaken by Technical Specialists to support Operations with containment of submerged or sunken oil, if encountered and if it is practicable. Options for methods of containment including advantages and disadvantages of each approach are presented in Table 2 in Appendix A.

- Where possible and practicable, Planning initiates a program to detect submerged/sunken oil and Operations initiates a program to contain submerged/sunken oil, if detected.
- Planning and Operations should ensure that containment boom placements in the field are set such that the angle of deployment does not encourage the creation of submerged oil by forcing oil under surface containment where it has greater likelihood of oil coming into contact with suspended sediment and increased water turbulence.

6.1 Roles and Responsibilities

Roles and responsibilities for the Operations Section staff and Planning Section staff during Step 3 are presented in Table C below.

Table C Step 3 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Branch Director	Responsible for coordinating efforts on Submerged Oil Management Program with the Operations and Planning Section Chiefs. Overseeing coordinated efforts on submerged/sunken oil detection and containment.
Submerged Oil Containment Group Supervisor	Works with the Planning Section Technical Specialist in EU in submerged oil containment to develop a plan to contain submerged/sunken oil in the water column, in shorelines in overbank areas, etc. Support Operations in executing containment plans and reporting back to Branch Director and Submerged Oil Detection Group Supervisor on progress/challenges/successes of containment program.
Planning Section	
Environmental Unit Lead	Oversees planning aspects of the submerged oil detection and containment program, responsible to communicate planned submerged oil actions to the Planning Section Chief.
Submerged Oil Detection Group Supervisor	Responsible for coordinating efforts as part of the submerged oil detection with the Operations and Planning Sections. Work with submerged oil Technical Specialist in the EU to develop plans for detection, support operations in executing detection plans and reporting back to Submerged Oil Branch Director and Submerged Oil Containment Group Supervisor on detection program findings.
Technical Specialists – Submerged Oil Detection methods and Submerged Oil Containment methods	Work with Planning and Operations Sections to 1) identify appropriate methods for detection based on site conditions and prepare a plan for detection of submerged/sunken oil at the site, 2) work with Resources at Risk (RAR) specialist(s) in the EU to confirm deployment of detection equipment will not adversely impact sensitivities at the site, and obtain permits if required, 3) support operations with deployment of detection devices and reporting of areas assessed and confirmed/refuted for presence of submerged/sunken oil, 4) develop a plan for submerged oil containment with Operations, if encountered, 5) work with RAR specialist(s) to confirm deployment of containment equipment/methods will not adversely impact sensitivities at the site, or exacerbate the formation of submerged oil 6) work with Operations to deploy containment measures and report on the successes/challenges of the deployments.

7.0 Step 4: Initiate Submerged/Sunken Oil Assessment Program

Once submerged/sunken oil has been confirmed by the detection group and containment measures are underway, a Submerged/Sunken Oil Assessment Group must be formed to include delineation and characterization of submerged/sunken oil in the environment as outlined below.

7.1 Update Initial Desktop Assessment

The key objective of the update to the initial desktop assessment would be to further refine the potential/actual locations for occurrence and characteristics of submerged/sunken oil based on field observations from detection and containment activities, as well as complete or update trajectory analysis and oil characterization.

MUST:

- Identify the areas for delineation and rank the areas for deposition potential, using a low/medium/high scale. Any uncertainties or assumptions are to be stated in the ranking.
- Produce output (i.e., figures and tables) that defines the areas where submerged/sunken oil is and may be deposited as response activities/containment recovery operations continue.
- When submerged or sunken oil is encountered, develop criteria for quantifying the amount of oil (e.g., amount of area with visible oil), and the characteristics of the submerged/sunken oil at the locations where assessed (e.g., thickness, chemical composition, etc.).

7.2 Identify the Sensitivities and Prioritize the Assessment Locations

Identify the sensitivities and prioritize the assessment locations once the areas that have submerged/sunken oil have been identified for delineation and characterization work programs.

MUST:

- Identify areas with submerged/sunken oil and prioritize based on the results of the site sensitivity analysis. Delineation and characterization work plans may need to be altered/revised to account for the following:
    - Permits that may be required to execute work in water bodies where there may be sensitive species, etc.
    - Technical Specialists input to validate/confirm presence or absence of nesting animals, habitat, etc. in areas where work may be undertaken. Further planning for potential relocation of habitat or animals may be required.
    - ‘No-go’ areas due to health and safety concerns for access/worker safety or public safety.

7.3 Field Assessment to Delineate and Characterize Submerged or Sunken Oil

Once areas have been prioritized for delineation and characterization, an assessment program must be planned and executed.

MUST:

- Develop plans for sampling and marking/delineating areas with submerged or sunken oil. These plans are site-specific and need to be tailored to site conditions, including field confirmation of suspected depositional areas.
- Where there is likely potential for more than one source of submerged/sunken oil (e.g., from naturally occurring seeps of oil in/adjacent to the water body or from historical releases of oil to the water body), develop plans to assess and characterize different potential sources/types of submerged/sunken oil. Sampling for this type of assessment will likely occur upstream of the spill location and beneath the surface layer of the sediment.
- Further develop the plans to identify the location of submerged/sunken oil and approaches to delineate submerged or sunken oil once encountered.
- Execute the plans in the field to attempt to delineate and characterize submerged/sunken oil including, where applicable, differentiating between submerged/sunken oil from the spill, with that that existed in the water body prior to the spill.
- Develop plans to collect samples as part of an assessment to determine the toxicity of submerged/sunken oil in areas where it has been identified. Plans may include laboratory or in-situ field studies.
- Execute plans in the field to assess the toxicity of sunken oil to ecological and/or human health receptors.

7.3.1 Initial Assessment

API (2016b) summarizes several potential approaches to characterize submerged oil. A summary of methods, logistical considerations, pros and cons of each approach from API's analysis (API, 2016b) are presented in Table 3 in Appendix A. Depending on the scale of the release and the site setting (e.g., stagnant water body vs. flowing water body), the approach to characterize submerged/sunken oil should be tailored for the size of the impacted area and consider the advantages/disadvantages of each technique. Initial assessment should focus on determining general locations of submerged/sunken oil based on preliminary field methods such as visual observations from the air, visual observations from a boat (water surface), visual observations by trained divers, and poling tests (where applicable). The data from the initial assessment should guide subsequent assessments, if required, and provide data to the submerged oil recovery group to determine recovery methods and develop plans for recovery.

7.3.2 *SUBSEQUENT ASSESSMENT*

Follow up assessment should aim to delineate the extents of the submerged/sunken oil at the site, as well as provide relevant operational information for the recovery of the identified submerged/sunken oil.

Follow-up assessments should use the most viable method from the initial assessment phase as well as bottom sampling and sediment sampling to collect samples of submerged/sunken oil to characterize the submerged/sunken oil and refine delineation/update delineation efforts if on moving water. Trajectories should also be updated to reflect data collected in the field for delineation purposes as well as to predict potential additional sites/movements of submerged oil based on field conditions.

Depending on the area identified for submerged or sunken oil presence, additional methods could include sonar, laser fluorescents or sorbents. An evaluation of methods, site setting including weather, access, time of year and sensitivities should be completed prior to selecting additional methods.

7.4 End Point Criteria for Submerged/Sunken Oil

At this stage in the Submerged Oil Management Program, end points and a pathway to closure for the Submerged Oil Management Program need to be determined. Currently there is no available guidance on quantifying or formalizing end points for submerged/sunken oil closure. However, the following section outlines some basic principles and considerations for developing end points for sunken/submerged oil assessment, recovery and closure. End Points examples that could be considered include: 1) sediments that lack of sheen production, 2) sediments that contain concentrations of contaminants that do not present unacceptable risk to aquatic receptors, 3) asymptotic recovery totals, and 4) sediment samples below applicable clean-up criteria/guidelines/standards or risk-based site-specific target levels (SSTL). However, end points are expected to be site-specific, and will be developed on a case-by-case basis. A Spill Impact Mitigation Assessment (as outlined below) will provide context with which site-specific end points can be developed.

MUST:

- Engage a Technical Specialist in submerged/sunken oil recovery for end point planning and recovery of submerged or sunken oil.
- Develop end points based on what is practicable in the field.
- Develop end points/recovery approach that will be agreed to prior to completing the recovery work. These end points will vary between projects and will be site-specific and should be developed with the support of and agreed to in principal by stakeholders (which may include the regulators, affected landowners, local First Nations/Tribes, etc.).

7.4.1 SPILL IMPACT MITIGATION ASSESSMENT (SIMA)

SIMA, which has also been referred to as Net Environmental Benefit Assessment (NEBA), is an approach with the intention of helping responders and responsible parties to make decisions that minimize the impact of spills on humans and the environment.

According to API (2013), these assessments should focus on the core concepts of: initiating a response, implementing response plans, escalating as necessary and finally, adjusting for realities. As summarized by API (2013), the basic concepts of SIMA/NEBA are to evaluate the data, select best options, balance trade-offs and predict outcomes. In the case of sunken or submerged oil, selection of best options for containment, assessment and recovery need to balance the trade-offs of potentially negatively affecting ecological, socio-economic and/or archaeo-cultural sensitivities.

The preferred approach for sunken/submerged oil management is to engage the Technical Specialist in the Planning Section on containment, assessment, and recovery, as well as those who will determine end points (as discussed below) with the Operations Section staff who will be executing the plans, to ensure the above aspects of the response include SIMA for the best possible outcome.

7.5 Roles and Responsibilities

Roles and responsibilities for the Operations Section staff and Planning Section staff during Step 4 are presented in Table D below.

Table D Step 4 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Branch Director	Responsible for coordinating efforts on submerged oil assessment with the Operations and Planning Section Chiefs.
Planning Section	
Environmental Unit Lead	Oversees planning aspects of the submerged oil assessment program, by engaging submerged oil Technical Specialists/Sampling Specialists to prepare plans to delineate submerged and/or sunken oil and collect samples to characterize the oil for recovery efforts. Responsible to communicate planned submerged oil assessment actions to the Submerged Oil Branch Director and Planning Section Chief. Also identify and retain a Technical Specialist in submerged oil recovery in preparation of recovery end points with EU team.
Submerged Oil Assessment Group Supervisor	Works with Detection and Containment Group Supervisors to deliver information and support the Technical Specialist in preparing plans for delineation and characterization of submerged/sunken oil. Works with Operations to execute plans and determine extents and type/properties of submerged/sunken oil in the environment. Communicates results of the assessment program to Submerged Oil Branch Director.

Role	Responsibility
Technical Specialist – Fluvial Geomorphologist/Subject Matter Expert/Specialist	Update initial assessment with trajectory information and with field data collected by Operations/EU to help delineate extents of submerged oil and update predictions based on oil characteristics and site setting. Reports results to Submerged Oil Assessment Group Supervisor.
Technical Specialist – submerged/sunken oil delineation and/or characterization techniques	Technical specialists 1) Identify appropriate methods for assessment and characterization based on site conditions and prepare a plan for assessment of submerged/sunken oil at the site, 2) work with Resources at Risk (RAR) specialist(s) in the EU to confirm deployment of assessment equipment will not adversely impact sensitivities at the site, 3) review permitting requirements and/or any existing permits that might already be in place at the site for assessment activities, 4) support operations (including coordinating with SCAT teams) with deployment of assessment techniques and reporting of areas where submerged or sunken oil has been assessed and/or characterized.
Technical Specialist – submerged/sunken oil recovery	Works with Technical Specialists in delineation and characterization to obtain data relevant to planning recovery operations. Coordinates with Submerged Oil Branch Director to develop a plan for end point determination, consultation and agreement with stakeholders.

8.0 Step 5: Submerged/Sunken Oil Recovery

Submerged oil recovery group activities include the recovery/remediation of submerged/sunken oil in the environment. Methods may include liberation and containment of submerged/sunken oil or other appropriate site-specific recovery methods.

MUST:

- Prioritize sites for recovery operations based on presence, location, and concentration of submerged/sunken oil as well as environmental, socio-economic and cultural sensitivities.
- Evaluate methods to recover submerged oil identified by a Technical Specialist who will work with the Technical Specialists from the Submerged/Sunken Oil Assessment Group and with Operations to determine the most viable approaches to submerged/sunken oil recovery while balancing SIMA in their approach. Table 4 presents a summary from API (2016b) which evaluates methods for recovery of submerged/sunken oil based on site features and conditions, and the properties of the submerged/sunken oil.
- Evaluate recovery efforts/methods and implementation in the context of SIMA, ecological, cultural/heritage and/or socio-economic sensitivities that may be present at deployment or set-up locations, and may require protection or may exclude certain recovery approaches.
- Obtain additional permits if required to deploy certain approaches such as liberation and/or containment methods for recovery as a result of sensitivities and the timing of work in water bodies.

- Select and execute recovery approaches/methods to meet the end points outlined for the Submerged Oil Management Program.
- Develop recovery methods to address all potential streams of impacted media including sediment, soil, and water. Updating the site-specific waste management plan must address waste management procedures for recovered submerged/sunken oil and other impacted media during recovery operations.

8.1 Monitoring During and Recovery of Submerged/Sunken Oil

A monitoring program for sunken/submerged oil recovery must be undertaken to assess if recovery operations have been successful at meeting end points.

MUST:

- Develop a plan based on the results of the recovery program to prioritize and focus areas to be monitored during the recovery program. The plan should outline the scope, extent, frequency and end points of the monitoring program. Clearly establish the monitoring program end points to determine when recovery efforts have met end points and recovery operations can be terminated.
- Collect data during the recovery efforts monitoring program to determine if recovery efforts are effective at liberating and/or containing oil for removal from the water column, sediment, or overbank areas. If monitoring results indicate that recovery methods are not meeting end points, the recovery methodologies must be re-evaluated to determine if additional/revised recovery approaches are required, or if the established end points are/are not achievable.
- Collect data during the recovery efforts to monitor the chemical changes in the sediment from the recovery efforts and the effect recovery efforts have on the toxicity of sediments impacted with submerged/sunken oil. In addition, if additional sources of submerged/sunken oil have been identified at the site (e.g., from natural seeps or historical releases), collect data for analysis to confirm that remaining submerged/sunken oil is not related to the spill.

8.2 Roles and Responsibilities

Roles and responsibilities for the Operations Section staff and Planning Section staff during Step 5 are presented in Table E below.

Table E Step 5 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Branch Director	Responsible for coordinating efforts on submerged/sunken oil recovery with the Operations and Planning Section Chiefs.
Submerged Oil Recovery Group Supervisor	Works with Detection, Containment and Assessment Group Supervisors to deliver information and support the Technical Specialist in preparing plans for recovering submerged/sunken. Works with Operations to execute plans and determine when end points have been practicably achieved with respect to recovery of submerged/sunken oil. Communicates results of the assessment program to Submerged Oil Branch Director.
Planning Section	
Environmental Unit Lead	Oversees planning aspects of the submerged oil recovery program, by engaging submerged oil recovery Technical Specialists to prepare plans to liberate and contain liberated oil as part of the recovery efforts. Responsible to communicate planned submerged oil recovery actions to the Submerged Oil Branch Director and Planning Section Chief.
Technical Specialist – submerged/sunken oil recovery	Works with Technical Specialists from the Submerged/Sunken Oil Assessment and Containment Groups to obtain data relevant to planning recovery operations including liberation of oil and containment of released submerged/sunken oil. Drafts plan/updates for recovery of submerged/sunken oil and meet end points to obtain Submerged Oil Management Program closure.

9.0 Step 6: Submerged/Sunken Oil Closure

The final step in the Submerged Oil Management Program is closure. Closure will be determined through a confirmatory sampling program and post-recovery monitoring.

9.1 Confirmatory Sampling

The confirmatory sampling program should be completed after monitoring indicates that conditions are suitable for achieving recovery and closure end points. This may be to generic standards or guidelines; however, this may also be risk-based depending on how end points were defined during the submerged/sunken oil assessment.

MUST:

- Develop a plan to prioritize and focus on areas of concern (e.g., as identified by stakeholders during consultation, areas with higher risk environmental sensitivities, and areas with higher risk human health sensitivities) to scope the extent, frequency, and criteria for confirmatory sampling program.
- Evaluate the types of samples and methodologies used in the submerged/sunken oil assessment to determine most appropriate methodologies and potential outcomes based on site knowledge and previous sampling programs.

- Outline in the confirmatory sampling program the methods that are most suitable for collecting samples and the types of media to be collected for the program. The sampling could include sampling of sediment or the water column, or visual assessment.
- Evaluate sampling methodologies in the context of ecological, cultural/heritage, socio-economic and/or human health sensitivities that may be present at sampling locations and may require protection or may exclude certain sampling approaches or locations.
- Obtain additional permits if required to complete confirmatory sampling in areas of sensitivities, or as a results of the timing of work in water bodies.
- Evaluate sediment toxicity from confirmatory samples to determine if additional toxicity testing is required to obtain closure.

9.2 Post-Recovery Monitoring

A post- recovery monitoring program should be developed during the confirmatory sampling program. The post-recovery monitoring program must incorporate the following:

MUST:

- Develop a plan based on the results of the confirmatory sampling program to prioritize and focus on areas of concern (e.g., as identified by stakeholders during consultation, with higher risk environmental sensitivities, and with higher risk human health sensitivities) to scope the extent, frequency, and end points for the post-recovery monitoring program.
- Target the post-recovery monitoring program to address events such as floods or in-water construction works (e.g., dredging operations) that could liberate oil.
- Clearly outline when the end points for the post-recovery monitoring have been met and a plan to communicate to stakeholders when the Submerged Oil Management Program has achieved closure.

9.3 Roles and Responsibilities

Roles and responsibilities for the Operations Section staff and Planning Section staff during Step 6 are presented in Table F below.

Table F Step 6 Roles and Responsibilities

Role	Responsibility
Operations Section	
Submerged Oil Branch Director	Responsible for coordinating efforts on submerged closure with the Operations and Planning Section Chiefs. Responsible for communicating to the Section Chiefs when the post-recovery confirmatory sampling and monitoring programs will terminated to close the Submerged Oil Management Program.
Submerged Oil Recovery Group Supervisor	Works with submerged/sunken oil assessment Group Supervisor and Technical Specialist(s) to develop a confirmatory sampling plan and monitoring plan to confirm closure of the recovery operations and the Submerged Oil Management Program to end points. Works with Operations to execute plans for confirmatory sampling and post-recovery monitoring. Communicates results of the confirmatory sampling program and the post-recovery monitoring program to the Submerged Oil Branch Director.
Planning Section	
Environmental Unit Lead	Oversees planning aspects of the submerged/sunken oil closure program, by engaging submerged oil Technical Specialists to prepare plans to outline a confirmatory sampling program and to monitor the recovery of the system in the context of environmental changes such as large precipitation events, floods etc. for liberated oil. Responsible to communicate planned confirmatory sampling and post-recovery monitoring to the Planning Section Chief.
Technical Specialist – submerged/sunken oil delineation and/or characterization techniques	Works with Technical Specialists from recovery group to prepare plans for confirmatory sampling and post-recovery monitoring of the site after recovery efforts to achieve closure.

10.0 Documentation

The procedure for documentation of the plans and results of Steps that are part of the Submerged Oil Management Program is provided below in Table G:

Table G List of Steps and Corresponding Documentation

Step1: Initiate the Submerged Oil Management Program		
Role	**Reporting Requirements**	**Documentation**
No reporting Requirements or Documentation for Step 1		
Step 2: Undertake Initial Actions to Identify Potential Submerged/Sunken Oil		
Role	**Reporting Requirements**	**Documentation**
EU Technical Specialist/Fluvial Geomorphologist/Subject Matter Expert/Specialist	• Drafting plan for desktop assessment and submitting to EU Lead • Reporting for results of desktop assessment, submitted to EU Lead	• ICS 204 and accompanying plan, if required • Document summarizing results of desktop assessment

Step 3: Initiate Submerged/Sunken Oil Detection and Containment		
Role	**Reporting Requirements**	**Documentation**
EU Technical Specialists – Sub/sunk Oil Detection and Containment	• Drafting plan(s) for submerged/sunken oil detection and containment. Selection of detection and containment methods with Operations team and RAR specialist. Submitting plans to Submerged Oil Detection Group Supervisor • Reporting of results of detection and containment program to EU Lead and Submerged/Sunken Oil Detection and Containment Group Supervisors	• ICS 204 and accompanying plan, if required • ICS 213RR – to requisition equipment needed for detection and containment operations • Document summarizing results of detection and containment program
Step 4: Initiate Submerged/Sunken Oil Assessment Program		
Role	**Reporting Requirements**	**Documentation**
EU Technical Specialist/Fluvial Geomorphologist/Subject Matter Expert/Specialist	• Drafting plan to update initial desktop assessment and submitting to EU Lead • Reporting results of updated desktop assessment to EU Lead and Submerged Oil Assessment Group Supervisor	• ICS 204 and accompanying plan, if required • Document summarizing results of update to initial desktop assessment
EU Technical Specialists – Sub/sunk Oil Characterization and Delineation	• Drafting plan(s) for submerged/sunken oil delineation and characterization. Selection of assessment/sampling methods with Operations team and RAR specialist. Submitting plans to Submerged Oil Assessment Group Supervisor • Reporting of results of characterization and delineation program to EU Lead and Submerged/Sunken Oil Detection and Containment Group Supervisors	• ICS 204 and accompany plan, if required • ICS 213RR – to requisition equipment needed for assessment operations • Document summarizing results of assessment program
Technical Specialist – submerged/sunken oil recovery	• Draft plans to develop end points for recovery and closure of Submerged Oil Management Program • Reporting results of end points development (e.g., risk-based analysis, generic guidelines, etc..), as well as consultations with stakeholders and a record of agreement on developed end points	• ICS 204 and accompanying plan, if required • ICS 213RR – to requisition equipment needed for the assessment program • Document summarizing the development of end points, stakeholder engagement/agreement on end points for closure

Step 5: Initiate Submerged Oil Recovery		
Role	**Reporting Requirements**	**Documentation**
EU - Technical Specialist – submerged/sunken oil recovery EU – Technical Specialist – waste management	• Draft plans to recovery submerged and/or sunken oil and to monitor recovery efforts. • Reporting results of recovery and monitoring program to achieve end points. • Update site-specific waste management plan to manage waste streams from submerged/sunken oil recovery efforts.	• ICS 204 and accompanying plan, if required • ICS 213RR – to requisition equipment needed for recovery and monitoring program • Document summarizing recovery and monitoring program results
Step 6: Submerged Oil Closure		
Role	**Reporting Requirements**	**Documentation**
EU - Technical Specialist – submerged/sunken oil delineation and/or characterization techniques	• Draft a plans to collect confirmatory samples to meet end points of Submerged Oil Management Program and to monitor post-recovery. • Reporting results of monitoring program to achieve end points.	• ICS 204 and accompanying plan, if required • ICS 213RR – to requisition equipment confirmatory sampling and post-recovery monitoring program • Document summarizing confirmatory sampling and monitoring program results and termination of Submerged Oil Management Program

11.0 Acronyms and Definitions

API	American Petroleum Institute
EU	Environmental Unit
EUL	Environmental Unit Lead
IC	Incident Commander
ICS	Incident Command System
NEBA	Net Environmental Benefit Analysis
SIMA	Spill Impact Mitigation Assessment
RAR	Resources at Risk

12.0 References

American Petroleum Institute (API), February 2016a. API TECHNICAL REPORT 1154-1 Sunken Oil Detection and Recovery - Operational Guide (First Edition). 2016.

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API, 2013. Net Environmental Benefit Analysis for Effective Oil Spill Preparedness and Response, available at: http://www.api.org/~/media/Files/EHS/Clean_Water/Oil_Spill_Prevention/NEBA/NEBA-Net-Environmental-Benefit-Analysis-July-2013.pdf

Dettman, H., Irvine, G., Farooqi, H., Memarian, R. and LeSergent, L. 2016. Test Tank Studies of the Effect of Oil Viscosity on Oil-Sediment Interactions in Fresh Water, Natural Resources Canada., Artic, Marine Oil Spill Conference Presentation, June 2016.

Enbridge Pipelines Inc., 2015. Inland Spill Response Tactics Guide, Version 1.1, October 1, 2015.

END OF DOCUMENT

APPENDIX A
TABLES 1 TO 4

Table 1 Matrix to evaluate technologies for detection, delineation, and characterization of sunken oil. (amended from API, 2016a)

Red = not likely effective; yellow = may be effective; green = most likely effective

	Sonar Systems	Camera/ Video	Acoustic Camera	Diver Observations	Towed Sorbents	Stationary Sorbents	Visual Observations	Bottom Sampling	Manual Shovel Pits	Laser Fluorosensor	Oil Sorbant "Swab" Poling	Water Column Sampling
Water Depth (ft)[1]	10–000	10–1000	10–1000	5–190	5–100	5–100	0–30	0–1000	0–5	10–100	0–20	5–>1000
Water Visibility												
- > 30 ft	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green
- 5–30 ft	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Red	Yellow	Green	Green
- < 5 ft	Green	Red	Green	Yellow	Green	Green	Red	Green	Green	Red	Green	Yellow
Availability	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow
Substrate Type												
- Sand	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
- Silty sand	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
- Mud	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green
Bottom Obstruction	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green	Green	Green
Oil Patch Size												
- < 0.1 ft^2	Red	Green	Yellow	Green	Yellow	Yellow	Yellow	Red	Yellow	Green	Red	Yellow
- 0.1–1 ft^2	Red	Green	Green	Green	Yellow	Yellow	Green	Red	Yellow	Green	Red	Yellow
- > 1–10 ft^2	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Yellow
- > 10 ft^2	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Yellow
Oil Thickness	Yellow	Yellow	Red	Green	Yellow	Red	Yellow	Green	Green	Red	Green	Red
Buried Oil	Yellow	Red	Red	Yellow	Yellow	Red	Red	Green	Green	Red	Green	Yellow
Sensitive Habitat	Green	Green	Green	Green	Red	Green	Green	Yellow	Yellow	Green	Yellow	Green
False Positives	Yellow	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green
Coverage Rate	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Data Turnaround	Green	Yellow	Yellow	Green	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Yellow

Table 2 – Submerged Oil Containment Options with Advantages and Disadvantages of each approach (API, 2015a)

Advantages	Disadvantages
Filter Fences or Gabion Baskets filled with Sorbents	
- Constructed of readily available materials - Effective at removal of oil droplets in the water column - Can be deployed at and just below the surface or on the bottom, depending on water depth and where the oil is moving in the water column or along the bottom - Closed-loop snare may be more effective	- If currents are less than one foot per second, there can be scouring of the bottom in front of the baskets and less effective oil recovery - Not feasible to deploy in high-flow areas - Can completely fail and be swept downstream if flows suddenly increase - Can only filter the entire water flow in small streams
Sediment Curtains	
- Curtains constructed of hydrophilic materials can sorb oil as well as slow the flow and increase sedimentation - Half-curtains or partial currents can be deployed at angles to the flow in moderate-flow areas to slow currents and increase deposition of oiled sediments	- Full curtains are only effective in low-flow areas, where the curtain can maintain contact with the bottom, where risk of oil mobilization is also low - Requires measurement of current speeds at surface and/or bottom and knowledge of hydraulics for proper design - Can interfere with navigation
Air Curtains	
- Does not interfere with navigation - Could help bring oil in the water column to the surface	- Only effective in very low-flow areas, where risk of oil mobilization is also low
Enhanced Passive Sediment Accumulation	
- Builds on natural processes and uses natural materials that can be left in place - Does not interfere with navigation	- Restricted to areas of natural accumulation, which may be sensitive or high-public use areas such as impoundments - Requires dredging or excavation to remove the accumulated sediment - Need a good understanding of seasonal flow patterns so sudden floods don't flush the oiled sediments out

Table 3 - Techniques for sunken oil detection, delineation, and characterization (amended from API, 2016b)

	Sonar Systems	Still, Video, and Acoustic Cameras	Diver Observations	Towed Sorbents	Stationary Sorbents	Visual Observations by Trained Observers	Grab or Core Sampler	Wading-Depth Manual Shovel Pits	Laser Fluorosensors	Water-Column Sampling	Oil Sorbent "Swab" Poling
Description	Sonar systems can detect and delineate sunken oil on and in the near sub bottom areas.	Visualization devices are utilized to validate the presence of sunken oil.	Professional commercial divers can detect, delineate, and collect field data for oil characterization.	Snares attached to chains are dragged on the bottom at set intervals then pulled up to detect oil presence/amount.	Sorbents are suspended in the water column and/or placed in cages on the bottom and inspected at set intervals to detect oil presence.	Observers visually detect and delineate oil on the bottom as seen from aircraft or boats.	Point locations are surveyed with sediment grabs or cores to detect and characterize the oil on the bottom,	A narrow blade shovel is used to dig shallow pits underwater, bringing the sediments to the surface to determine presence and character.	Laser is used to excite the aromatic compounds in the oil to emit light with a unique pattern, for oil detection.	Underwater unit (fluorometer and/or mass spectrometer [MS]) is towed above the bottom to detect oil dissolved/ dispersed in the water.	Oil sorbent fabric is fixed to the bottom end of a pole. A worker, standing on a boat (or on foot in shallow water), then pushes pole end fixed with fabric into the bottom at set locations. Operator then pulls sorbent material up to detect oil presence/amount.
Availability of Equipment	Available from offshore oil or oceanographic equipment rental companies. The 3D sonar has limited availability in the commercial sector, but the USCG has a supply that could be made available upon request.	Visualization devices are available from offshore oil or oceanographic rental companies or direct from the manufacturer.	Surface-supplied diving systems with diver comms and video are readily available and required to be on-site within 18 hours for salvage operations. Contaminated-water and cold-water diving equipment may require additional time.	Ad hoc systems can be readily constructed. GPS units needed to follow pre-set track lines and record waypoint for intervals.	Ad hoc systems can be readily constructed in most areas, using anchors, floats, snares, and various pots/cages.	Uses readily available equipment	Uses readily available equipment.	Uses readily available equipment.	Only one prototype tested; latest model has not been tested.	Fluorometers are readily available; MSs are not, mostly from academic institutions.	Ad hoc systems can be readily constructed. GPS units needed to georeference assessed areas.
Logistical Needs	Support vessels of sufficient size and sea-keeping capability are required to provide an operational platform for the sonar systems. Different sonar systems have specific platform requirements so care must be taken in platform selection to ensure compatibility.	Visualization systems have definite platform requirements depending on technique selected. Diver-operated video devices have specific diver related logistic requirements as noted for Diver Observations, which must be adhered to.	Diving support vessel/platform; heavy-lift equipment to load compressors, dive control rooms, and other equipment onboard. Emergency transportation to a medical facility with a multi-place decompression chamber. Decompression chamber located on-site as a contingency.	Light tows (1 chain) can be deployed on small boats. Heavy tows (multiple chains with a header bar) require a vessel with a crane or A-frame and pulley to deploy/retrieve the tows.	In shallow water, requires minimal support. In deep water, requires davits or winches to deploy and retrieve them.	Aircraft or boat; GPS units to record locations and geo-reference photos; field computers to record descriptions.	In shallow water, requires minimal support. In deep water, requires a winch, A-frame, etc.	Can require a large team, depending on safety issues and access. Requires safety boat/crew at site, boats for access to sites with no land access.	Unit must be towed close to the bottom; could be deployed on ROV as well.	Units are deployed from boats; navigation system used to record location and measurements in 3D.	Swab poles can be deployed on small, stable boats, or by workers in shallow water wearing waders.
Coverage Rate	Up to 3 square miles/hour using side scan sonar. Other sonar devices have lower coverage rates.	Up to 0.7 square miles/hour in low turbidity water with optics; lower coverage rates in high turbidity.	Low: Due to often limited visibility. Diver rate limited by umbilical length and repositioning of dive platform.	Moderate: Can be towed at up to 5 knots but swath width is 1-8 feet, depending on how many chains are attached.	Low: Only provides point information.	Aerial surveys can cover large areas but in less detail. Boat surveys have low coverage rates.	Low: data are collected from point samples of a very small area.	Low: A team might be able to cover several hundred square yards/hour once in the water, depending on access and spacing of pits.	Low; has a very narrow swath width.	High: Data can be recorded every 5-15 seconds.	Low: A single team might be able to cover several hundred square yards/hour once on location, depending on spacing of poling locations.
Data Turnaround	Most provide usable data in real or near real time for human analysis. Some require minimal post processing; data should be available by end of the survey.	Depending on the device utilized, data are available in real time or near real time.	Immediate turnaround with diver to surface communications and video capabilities.	Moderate: Oiling degree can be reported real time for each interval.	Slow: Data only available when the sorbents are retrieved.	Moderate: Field notes and waypoints have to be entered, raw data converted into oiling categories, and maps generated. Likely 24 hour turnaround.	Moderate: Field notes and waypoints have to be entered, raw data converted into oiling categories, and maps generated. Likely 24 hour turnaround.	Rapid to Moderate: If teams are supporting Operations, they can quickly delineate areas for removal and then re- survey to determine complete removal.	Unknown: Data can be visualized in real time. Uncertain time to process the data to generate geo-referenced maps.	Rapid: Intensity contour maps can be generated quickly in the field.	Moderate: Field notes and waypoints have to be entered, raw data converted into oiling categories, and maps generated. Likely 24-hour turnaround.