

Inland Spill Response Tactics Guide



Contributions in the creation of this tactics guide were made by the staff of:



© 2024 Enbridge Pipelines Inc.

This material is protected by copyright and is the exclusive property of Enbridge Pipelines Inc. and its affiliates. No external distribution or transmission of this material is permitted without the prior written consent of Enbridge Pipelines Inc. Applications for the copyright holder's written permission to reproduce any part of this publication should be addressed to the Law Department of Enbridge Pipelines Inc. at Edmonton Center, 10175 – 101 St, Edmonton, Alberta T5J 0H3. Enbridge Pipelines Inc. assumes no responsibility for errors or omissions in this document or for direct, incidental or consequential losses or damages that may result from the external use or duplication of this material.

Contents

1. Introduction: Purpose and Scope of Guide 1

2. Safety 3

 2.1 Safety Principles 4

 2.2 Responder's Duty 5

 2.3 Initial Discovery/Response Actions 6

 2.4 Decontamination 7

3. Inland Spill Control Tactics 9

 3.1 Land 11

 3.1.1 Berms..... 12

 3.1.2 Interceptor Trench 14

 3.1.3 Trench and Berm 16

 3.2 Small Watercourses 18

 3.2.1 Stream Dams 19

 3.2.2 Board Weir 24

 3.2.3 Culvert Block 26

 3.2.4 Turner Valley Gate 28

 3.2.5 Flexible Hose Siphon Dam 30

 3.2.6 Sorbent Booms 32

Contents

3.3 Larger Watercourses	34
3.3.1 Floating Containment Boom	34
3.3.2 Shore Seal Boom	37
3.3.3 Deflection/Protective Introduction	38
3.3.3.1 Deflection/Protective Booming	39
3.3.3.2 Deflection Booming Cascade System	41
3.3.3.3 Boom Deployment for River Using Instream Anchor	43
3.3.3.4 BoomVane™ Recovery/Deflection Modes	45
3.4 Open Water	47
3.4.1 NOFI Current Buster® 2&4	48
3.4.2 Sea Sentry II Oil Boom	52
3.4.3 Arctic Brush Bucket System	56
4. Cold Weather & Ice Tactics	58
4.1 Ice Tactics	59
4.1.1 Ice Assessment	60
4.1.2 Oil Detection Under Ice	67
4.1.3 Trench on Ice Sheet	69
4.1.4 Diversion Wall to Ice Slot	71

4.1.5 Through Ice-Deflector/Diversion Wall	76
5. Additional Equipment for Containment and Recovery Tactics	78
5.1 Ground Tackle and Anchors	79
5.1.1 Drag Embedment (In-water) Anchors	80
5.1.2 Shoreline Anchors	81
5.1.3 Anchors of Opportunity	83
5.2 BoomVane™	84
5.3 NOFI Current Buster®	86
5.4 Skimmers	88
5.4.1 Selective (Oleophilic) Skimmers	90
5.4.2 Non-selective Skimmers	93
5.5 Power Units	95
5.6 Sorbents	96
5.6.1 Sheets, Pads, Pillows, Rolls	96
5.6.2 Sorbent Booms	96
5.6.3 Sorbent Sweeps	97
5.6.4 Pom-Poms/Snares	97
5.6.5 Sorbent Socks	97
5.7 Temporary Storage Devices	98
5.7.1 Sealed, Vented Storage Devices	98

Contents

5.7.2 Open Storage Devices – Rigid Frame	99
5.7.3 Open Storage Devices – Frameless	101
5.8 Vacuums	102
5.8.1 Towable Vacuum Unit and Vacuum Tank	103
5.8.2 Portable Vacuum Unit	104
5.9 Boom, Tow Bridles and Other Attachment Devices	105
5.9.1 Containment Boom	106
5.9.2 Sea Sentry II Boom	107
5.9.3 Boom Connectors	108
5.9.4 Boom Tow Bridles	109
6. Charts, Tables and Calculators	111
6.1 Boom Configuration and Length as a Function of Speed Table	112
6.2 ASTM Guide for Boom Selection	113
6.3 Stream Speed Table	114
6.4 Rope and Chain Minimum Breaking Strength	115
6.5 Commonly Used Formulae	116
6.6 Weights of Common Gases, Liquids and Solids	121
6.7 English/Metric Conversions	122

7. Glossary of Terms 124

8. Appendix 130

 8.1 Reference 131

 8.2 Diagram and Table Index 132

Inland Spill Response Tactics Guide

Introduction

1

Inland Spill Response Tactics Guide

The Inland Spill Response Tactics Guide is an internal Enbridge document that can be used as a quick reference by Enbridge first-on-scene responders to select and implement containment and recovery tactics with Enbridge-owned oil spill response equipment during the initial stages of a response. It illustrates a collection of inland spill tactics that can be applied using obtainable resources to a liquid products release until additional resources and personnel arrive on site.

This guide is not intended to replace Enbridge's regulated and approved emergency response plans and in every instance, verification with these plans is required. The guide is a reference tool and supplement to company safety standards, prior training, field experience, technical instruction and equipment operation knowledge and is not intended to be used as a guide on the safety practices associated with the tactics herewithin. The guide is not an all-inclusive manual and is a work in progress. Enbridge Pipelines Inc. retains the right to modify the guide as it deems necessary to update tactics and/or equipment improvements.

Enbridge's first responder's primary responsibility is to ensure personal safety and the safety of the public. The safety of our responders is paramount – no response tactic shall be employed if it threatens human health or safety. The company will rely on the training and judgment of its first-on-scene responders to select only those tactics that can be accomplished safely. Enbridge is on a path to zero injuries, incidents and occupational illnesses. On the following pages you will find our Health and Safety Principles, which guide our actions, policies, procedures and culture with regard to safety, as well as our [Lifesaving Rules](#), which are founded on real-life incidents at Enbridge and focus on areas of high risk and high consequence.

Inland Spill Response Tactics Guide

Safety

2

2.1 | Safety Principles

Safety. It's a core value that makes us Enbridge. It's our way of life.

Health and Safety Principles

Enbridge is committed to ensuring everyone returns home safely at the end of each and every day, and that our assets are operated in a safe and reliable manner.

We base our commitment to safety on our care for employees, contractors, the communities in which we operate and the environment.

Our values of Safety, Integrity, Respect, Inclusion, and High Performance guide our decisions, actions and interactions individually and as a company. Our Safety Principles support our values and highlight the fundamental beliefs we share on our path to a zero-incident workplace.



For more information visit [ELink](#) and search 'Safety Principles'

2.2 | Responder's Duty

The first duty of first responders to a spill or suspected spill incident is to ensure the safety of the public and the response personnel. Under no circumstance should personnel place themselves in harm's way or be directed to do so by others when performing response activities.

Source control – Notify the Control Centre, who will isolate the pipeline or give instructions to responders on how to isolate the pipeline.

Control and containment of the released material – Focus on limiting the spread of the released material, especially where watercourses and sensitive areas are vulnerable.

Recovery or alternative removal – Once preparations for controlling the source and the spread are underway, responders can begin to focus on ways to remove the spilled product.

Safety – Responsibility to ensure all operations are conducted in accordance with Enbridge safety standards and procedures.

2.3 | Initial Discovery/Response Actions

Purpose: When exploring a suspected or reported emergency incident, safe work practices will be followed per company guidelines. The order of these actions will depend upon the situation.

Immediate actions are required at the onset of an emergency response to limit the extent of a release, minimize the potential hazard to human health and the environment, and coordinate an effective response. It is also important to act decisively to create a professional working atmosphere among company personnel and stakeholders.

The internal notification procedures are essentially the same for all emergency incidents although the external notifications will vary depending on the type of incident, type and quantity of material released, and the consequences. Notification/Activation procedures along with the Initial Response and First Responder Checklists for each operating Region are located within the Regional Integrated Contingency Plan (ICP) Annex 2 (Notification Procedures).

2.4 | Decontamination

It is critical to ensure that secondary contamination is **NOT** inadvertently introduced into the surrounding area by adhering to strict decontamination procedures for both personnel and tools. Depending on the scope of the emergency incident, a Decontamination Plan may be developed and approved by Incident Command.

All personnel and equipment must go through a decontamination process to ensure released product and contaminated material does not introduce contamination to a larger area than is needed. Establish a decontamination corridor on the established work site as outlined in the Site Safety Plan. As workers exit the hot zone they must go through the decontamination procedures at the stations as they proceed towards the warm and cold zones. A representative corridor for personnel is depicted in **Diagram 2.4a** Representative Decontamination Corridor. For boats, vehicles and heavy equipment, a formal decontamination cell is usually constructed in the warm zone, separate from the personnel decontamination area.

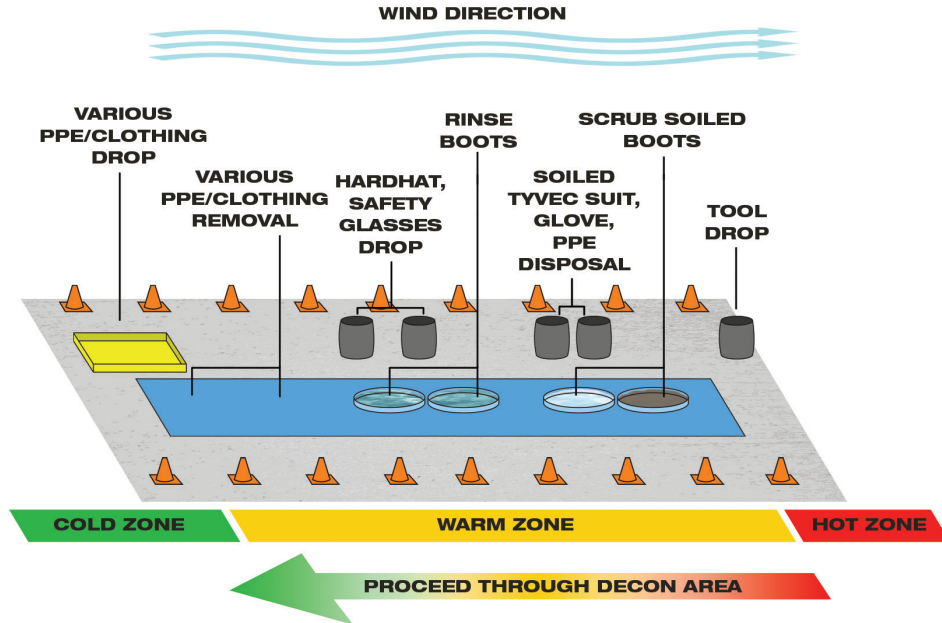


Diagram 2.4a Representative Decontamination Corridor

Inland Spill Response Tactics Guide

Inland Spill Control Tactics

3





Characterize breathing hazards and combustible vapors before starting site mitigation activities. Initial air testing provides information for establishing engineering, administrative and PPE control and establishing protective zones.



Do not enter areas where gas detector readings indicate breathing hazards without appropriate respiratory protection.

Each oil spill is unique, so techniques, strategies and tactics to control, contain and recover spilled oil vary depending on safety, practicality, seasonal and local conditions. Early assessment of some basic parameters—even very rough estimates—can guide decision-making and the selection of strategies and tactics.

Identifying the Extent of the Problem

1. Can the source of the release be found?
2. Can the extent of the impact be estimated?
3. Can it be contained?
4. Does the release threaten a stream or river? If so, how fast is the water flowing? How much time would it take to set up response equipment at some point downstream? Where is the next available control point downstream that can be deployed successfully prior to the estimated arrival of the released substance?
5. Is sufficient temporary liquid storage available or en route?

After isolating the source of spilled oil, preventing or at least influencing how it may spread is a response priority. Preventing the spread of spilled material is called “direct containment”.

If the situation does not lend itself to containment, then tactics and strategies for protection of High Consequence Areas (HCA) can be utilized. Protection tactics seek to exclude or prevent the released substance from entering an area, or to re-direct the substance away from an area.

3.1 | Land

While spills on land may not spread as quickly as those on water, quick response remains important to minimize contamination of soils and vegetation and any impact to wildlife. Oil will move down gradient on top the soil or move vertically down into the soil through gravity. Horizontal movement is based on soil type and volume of material released. This section provides some useful tactics for containing the release using local materials to create barriers. Please note that particular attention is paid to intercepting spills before they reach surface water, where containment becomes even more difficult.

3.1.1 | Land | Berms

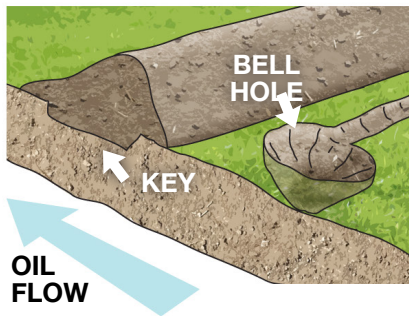


Diagram 3.1.1a

Clay Berm with Key Profile

The key prevents berm movement and ensures the clay berm contacts subsoils to prevent released substances from migrating under the berm. If ground conditions do not permit the berm to be keyed in, the tactic can still be utilized, although it is recommended to key in the berm.

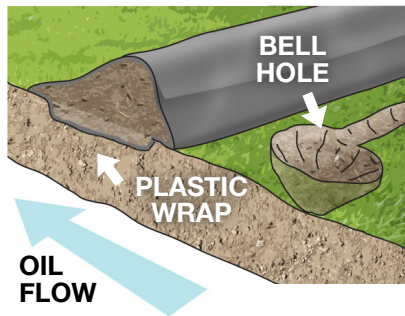


Diagram 3.1.1b

Clay Berm with Key Profile and Plastic Wrap

The plastic wrap ensures an impermeable barrier and reduces contamination of the berm from the released substance. If ground conditions do not permit the berm to be keyed in, the tactic can still be utilized, although it is recommended to key in the berm.

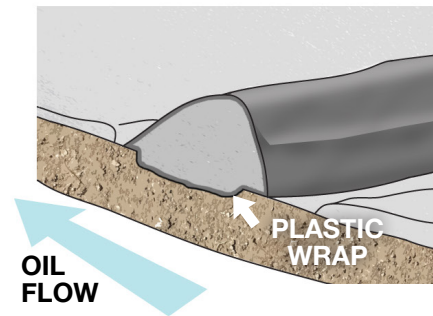


Diagram 3.1.1c

Snow Berm with Key Profile and Plastic Wrap

(or lightly sprayed with water) secure with snow to prevent moving. Ensure to remove snow behind the plastic to monitor for leakage.

Note: Pack snow tightly with shovel or board before spraying with water. If ground conditions permit a snow berm should be keyed into the ground to minimize the potential for released product to migrate underneath the snow berm. If ground conditions do not permit the berm to be keyed in, the tactic can still be utilized, although it is recommended to key in the berm.

3.1.1 | Land | Berms



Watch Your Step



Call Before You Dig



Tip: Hand-dig small bell hole upstream of berm for recovery.

Purpose: Berms act like curbs to halt the advance and allow for recovery of the spill while reducing the potential for environmental damage. Berms may also be used to channel the spill in a particular direction.

Application: Berms can be constructed immediately, with local material. Berms are typically used on flat terrain.

Environmental Considerations: Consider environmental sensitivities such as essential vegetation, rare plants, sensitive soil types or critical habitat before constructing a berm. Where possible, remove topsoil prior to berm construction and avoid constructing berms with topsoil material.

Equipment Required: Shovel(s) or earth-moving equipment, rolls of plastic sheeting

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

For snow berms, water spraying equipment is optional. If snow is to be used for berm without plastic cover and water spray equipment is available, compact the face of the berm with shovels and spray water to form an ice crust on the berm. If ground conditions permit a snow berm can be keyed into the ground to minimize the potential for released product to migrate underneath the snow berm. This will reduce spill penetration.

Operation:

1. Dig a trench perpendicular to the spill path to key in the berm to the ground.
2. Lay down plastic, if available, across expected route of spill travel.
3. Pile soils/snow on downstream side of plastic (away from approaching oil).
4. Flip upstream side of plastic over berm to prevent contamination of berm contents.

3.1.2 | Land | Interceptor Trench

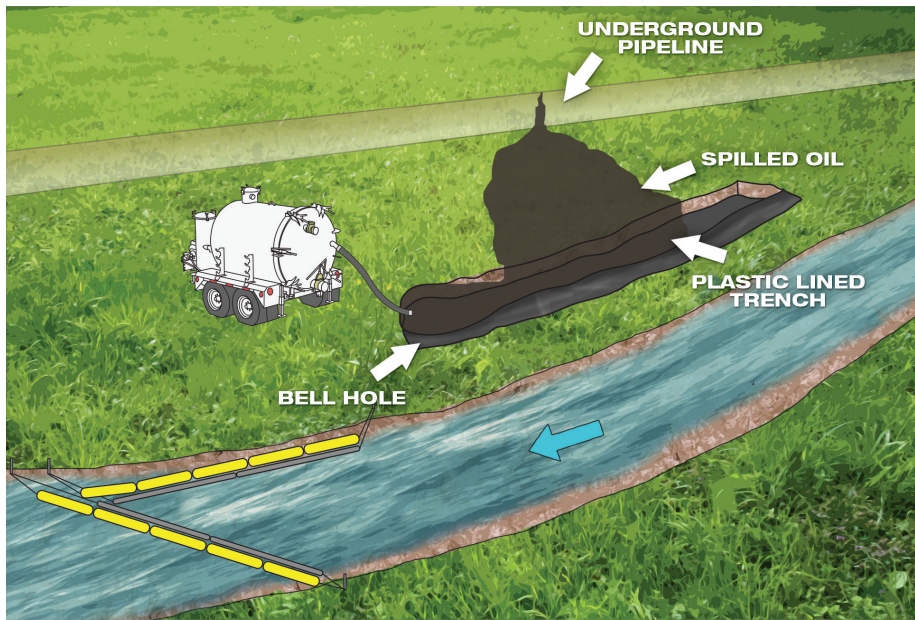


Diagram 3.1.2a Interceptor Trench

3.1.2 | Land | Interceptor Trench

An interceptor trench can be used to prevent a spill from spreading on land. When lined with plastic, it can form a temporary receptacle for oil until the oil can be recovered.



Call Before You Dig



Tip: Installing sorbent boom in the creek serves two purposes: to act as an indicator if the spill is somehow breaching the trench and to collect that seepage.

Purpose: To provide a catchment basin for a spill. The spoil may be used as a berm downstream of the trench to provide further protection.

Application: Where a significant containment capacity is required on a slope.

Environmental Considerations: Consider environmental sensitivities such as essential vegetation, rare plants, sensitive soil types or critical habitat before constructing a berm. Where possible, the maximum trench depth should be above the water table and the trench lined with poly material to prevent groundwater contamination.

Equipment Required: Shovel(s) or earth-moving equipment, rolls of plastic

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

Operation:

1. Dig trench downstream of the anticipated path of the spill. The spoil taken from the trench may be used to construct a berm on the downstream side as secondary containment.
2. Line bottom and downstream side of trench with plastic sheeting to reduce soil contamination.

3.1.3 | Land | Trench and Berm

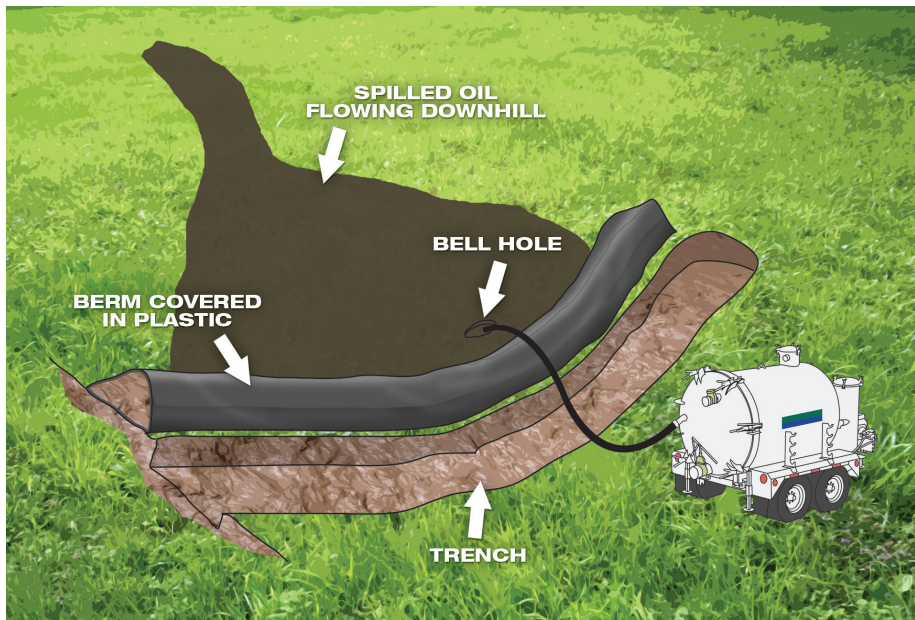


Diagram 3.1.3a Trench and Berm

3.1.3 | Land | Trench and Berm



Call Before You Dig



Tips: - Hand-dig small bell hole upstream of berm for recovery.

- Constructing berm upstream of trench allows berm to be raised in height with clean soil/snow even after spill starts to arrive. It also provides secondary containment (trench) if berm fails.

- This can be used in snow.

Purpose: To halt the advance and allow for recovery of a spill while reducing the potential for environmental damage. This tactic takes the soil from the trench to create the berm and act as a secondary defense mechanism, if necessary.

Application: Where a significant containment capacity is required on a slope.

Environmental Considerations: Consider environmental sensitivities such as essential vegetation, rare plants, sensitive soil types or critical habitat before constructing a berm. Where possible, the maximum trench depth should be above the water table and the trench lined with poly material to prevent groundwater contamination.

Equipment Required: Shovel(s) or earth-moving equipment, rolls of plastic.

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

For snow berms, water spraying equipment is optional. If snow is to be used for berm without plastic cover and water spray equipment is available, compact the face of the berm with shovels and spray water to form an ice crust on the berm. This will reduce spill penetration.

Operation:

1. Lay down plastic, if available, across expected route of spill travel.
2. Dig trench on downstream end of plastic (away from approaching spill). Pile soil/snow on downstream side of plastic (away from approaching oil).
3. When berm is completed, flip the upstream side of plastic over berm to prevent contamination of berm contents while retaining the spill.

3.2 | Small Watercourses

Small watercourses are usually characterized by any combination of shallow depth, narrow width and low current velocity. Watercourses that are less than 10 meters (33 feet) wide, a half meter deep (1.6 feet), flowing at less than a knot are candidates for small watercourse containment response tactics. The tactics that follow rely on man-made fixtures that halt the flow of surface water, or, in the extreme case, halt all flow. Fixtures may be bottom-founded, such as earth dams that are supported by subsoil or stream bed, or rigid structures such as culvert blocks.

3.2.1a | Small Watercourses | Stream Dams | Water Bag

The simplest form of stream dam can be made from a fabric bladder. Filled with water and held in place across a stream or drainage ditch, it can be an effective dam.

Caution: Single-chamber bladders are susceptible to shifting by rolling as water depth (and hydrostatic pressure) increases on the upstream side. The simple pin anchors driven upstream of the dam in Diagram 3.2.1a are used to secure the dam in place. Alternatively, a wedge can be used downstream to act as a brace to prevent rolling.



Tips: - Tactic can cause possible upstream flooding in areas with flat topography.

- Pin anchors driven upstream and underflow pipe installed to pass water beneath. Inflow has to equal outflow or the dam will breach.

- Ensure ground disturbance is completed prior to driving pins and it is recommended to have a valve on the discharge side of the pipe.

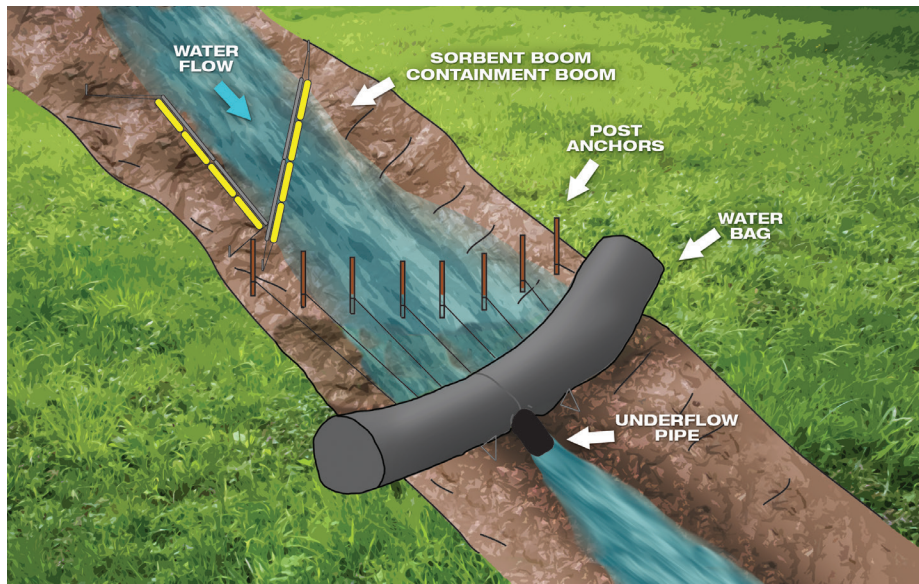


Diagram 3.2.1a Water Bag

3.2.1b | Small Watercourses | Stream Dams | AquaDam™

AquaDams™ are made up of multiple parallel chambers called fill tubes which give it a level of stability against shifting. While slightly more complicated to place and fill than a simple bladder, in many cases it does not require external anchors.

Caution: Even double chamber bladders are susceptible to rolling if the upstream flow can not be regulated. A wedge can be used downstream to act as a brace to prevent rolling.



Tips: - Tactic can cause possible upstream flooding in areas with flat topography.

- Inflow has to equal outflow or the bladder will roll.

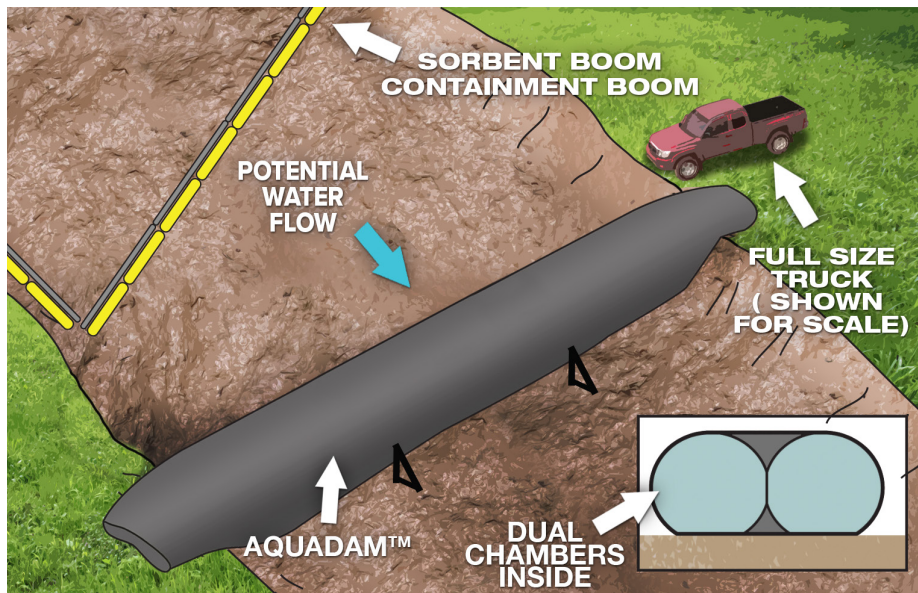


Diagram 3.2.1b AquaDam™

3.2.1c | Small Watercourses | Stream Dams | Tiger Dam®

Similar to the AquaDam™, the Tiger Dam® utilizes multiple water tubes for increased freeboard and resistance to sliding. Unlike the AquaDam™, a Tiger Dam's® tubes may be individual units which are strapped together after placement.



Tips: - Tactic can cause possible upstream flooding in areas with flat topography.

- Multiple water tubes for increased freeboard and dead weight to hold dam in place.

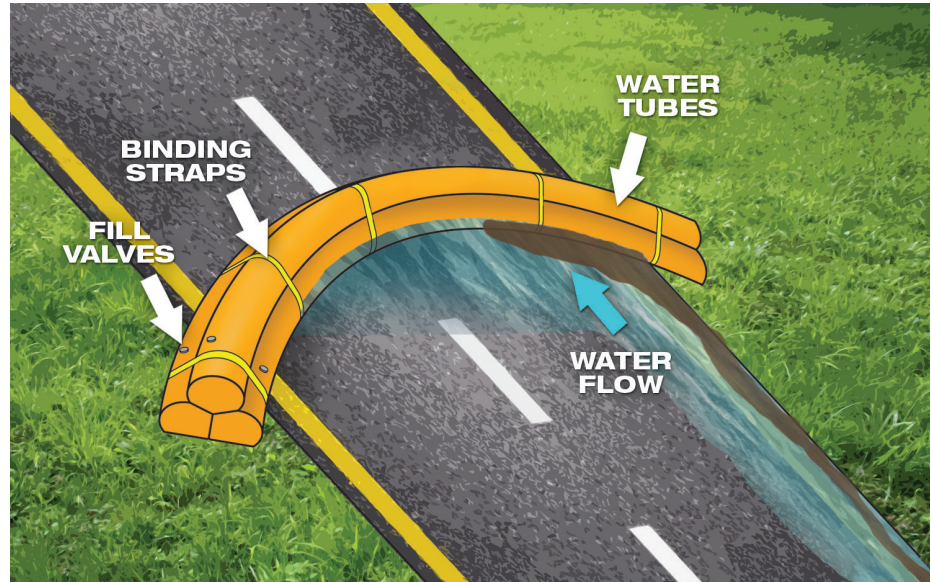


Diagram 3.2.1c Tiger Dam®

3.2.1d | Small Watercourses | Stream Dams | Water-Gate™

The Water-Gate™ dam is an open, self-filling barrier that, when in place, relies on the hydrostatic pressure differential axis to provide a bottom seal and to keep its mouth open. A small version of the Water-Gate weighs less than 30 kg (66 pounds) and can provide a water retention height of 35cm (14 inches) and span up to about 8m (26 feet).



Tips: - Tactic can cause possible upstream flooding in areas with flat topography.

- The boom in the diagram is to protect the dam from contamination.

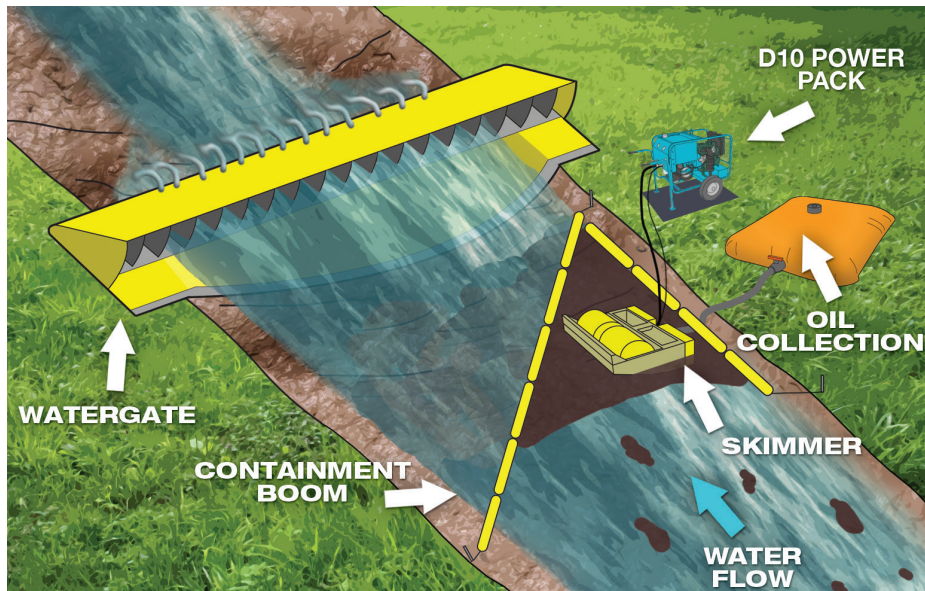


Diagram 3.2.1d Water-Gate

3.2.1 | Small Watercourses | Stream Dams

Water-filled dams and other forms of portable stream dams can be used to control the spread of a spill.



Call Before You Dig



Tip: Stream dams are more effective when used in near-zero current conditions.

Purpose: To contain and facilitate recovery of a water-borne spill from a ditch, creek or stream.

Application: Use in slow-moving shallow watercourses.

Environmental Considerations: Maintain control of damming materials to avoid introducing foreign substances into the watercourse. Handle and dispose of contaminated wastes in an approved manner. Tactic can cause possible upstream flooding in areas with flat topography.

Equipment Required: Water bags or other forms of mechanical stream dam devices, anchoring devices.

If significant amounts of product are expected, ensure recovery equipment is in place or en route.

Waste disposal bags and tags if sorbents are to be used.

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

Waste disposal bags and tags if sorbents are to be used

Operation:

1. Consider ground disturbance requirements before driving stakes/T-posts.

3.2.2 | Small Watercourses | Board Weir

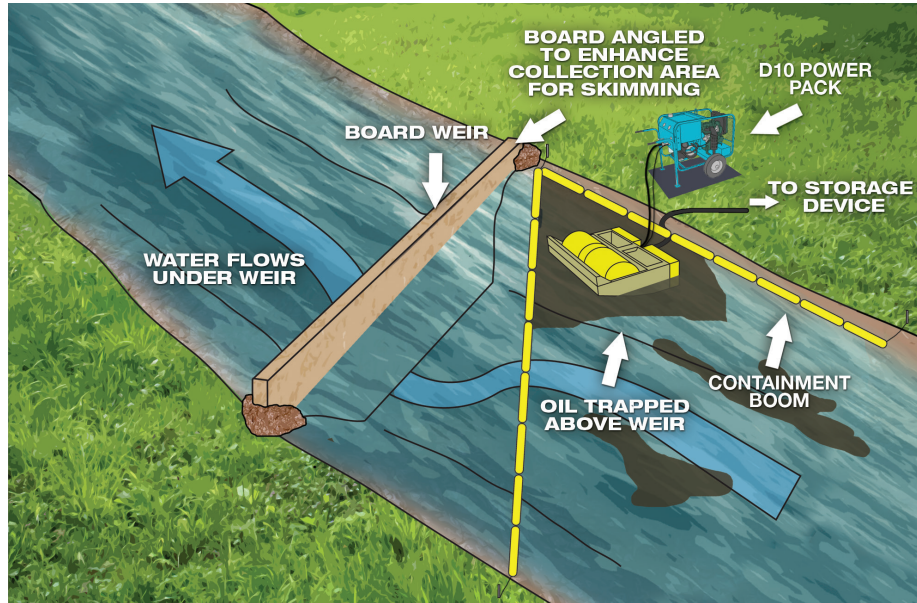


Diagram 3.2.2a Board Weir

3.2.2 | Small Watercourses | Board Weir

A board weir is an example of an underflow dam.



Call Before You Dig



Tips: - Downstream and upstream T-posts can be added for support and adjustment of the weir.

- Angle the board to create a recovery point. Protect the shoreline at the recovery point with boom.

- If sufficient recovery capacity is not in place at the board weir installation, the captured material can thicken and be lost beneath the board due to entrainment.

Purpose: To contain a spill in a water-filled ditch, creek or small stream for recovery.

Application: To stem the advance of oil in a small watercourse.

Environmental Considerations: Increased water velocity below the board may cause local erosion or scouring. Use erosion control measures to prevent excavated soil at edges from entering downstream water.

Equipment Required: Shovel(s), board of sufficient length to cross watercourse.

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

Operation:

1. Place board in the water across the watercourse to prevent the advance of any surface-borne contaminants while leaving a gap below to allow the clean water to continue flowing. Dig the board ends into the banks and seal any gaps at the board ends with sorbents or mud.

3.2.3 | Small Watercourses | Culvert Block



Tip: A pneumatic culvert plug can be used instead of a sheet of plywood.

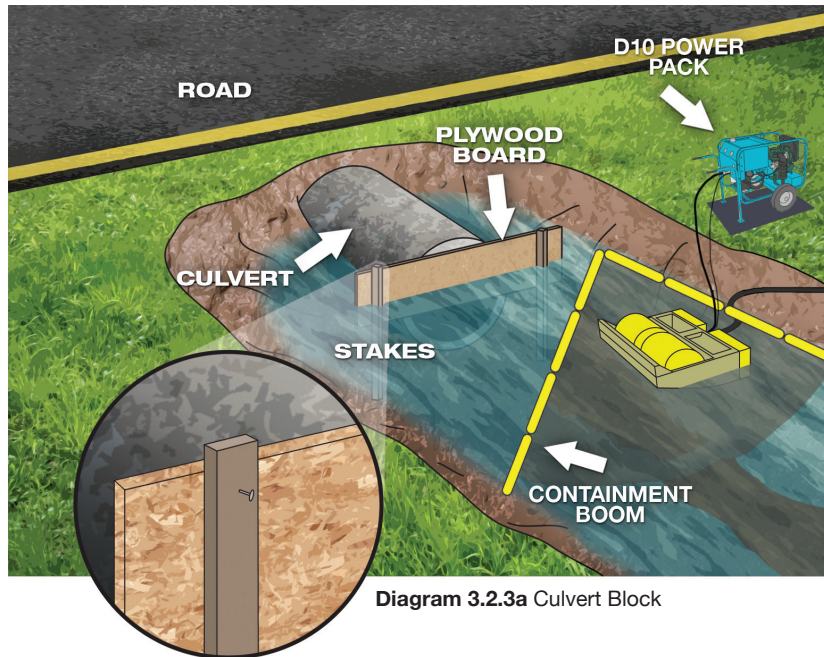


Diagram 3.2.3a Culvert Block

3.2.3 | Small Watercourses | Culvert Block

Culverts and other large diameter conduits that allow a watercourse to pass under or through obstacles present an opportunity for controlling the spread of oil. If water flows are sufficiently low, they can be blocked entirely with boards or plywood to contain oil above the culvert. In higher flow situations, partial culvert blocks can be installed to create underflow dams.



Tip: Board should not be permanently secured but made adjustable to account for water flow. Leave nails protruding to make it easier to adjust board level, if required.

Purpose: To stem the advance of oil in a watercourse.

Application: Where culverts are present.

Environmental Considerations: Manage board level to allow water to pass through culvert, reducing flooding on upstream side and maintaining downstream flow.

Equipment Required: Sheet of plywood, wooden stakes (2), sledge hammer, long nails, claw hammer.

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

Operation:

1. Place plywood sheet on UPSTREAM side of culvert. Secure in place with two stakes driven into bed of ditch, creek or stream.
2. Raise board sufficiently to allow passage of water under the board's lower edge. Secure in place by driving nails through stakes into plywood.
3. Monitor water levels to ensure sufficient flow is being allowed to pass beneath the culvert block. Adjust weir, as appropriate.
4. Sorbents may be required to be placed between rough culvert pipe end and the plywood to ensure a good seal.
5. Install hard containment boom at an angle to the current to direct away from the culvert.

3.2.4 | Small Watercourses | Turner Valley Gate

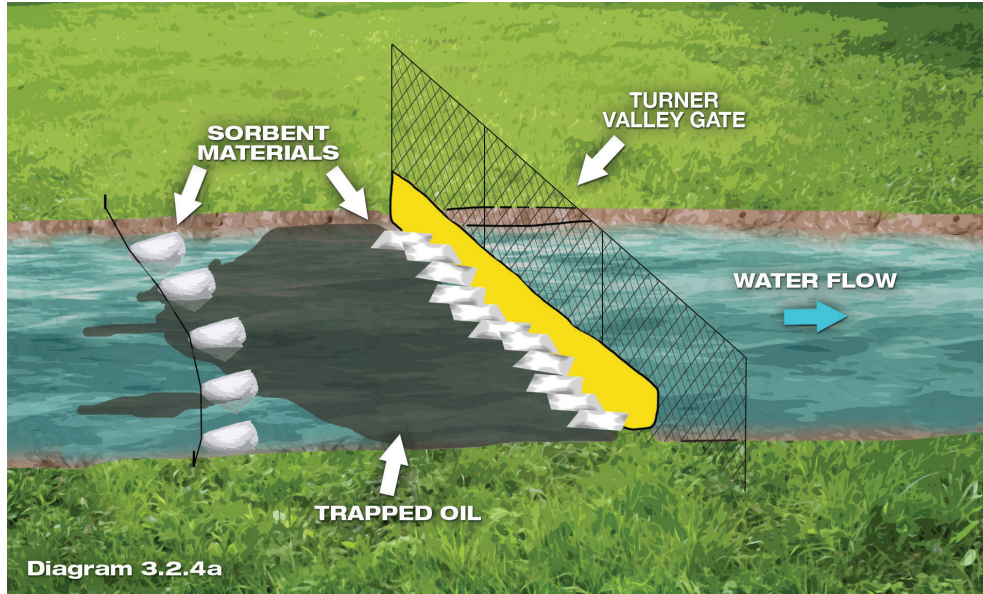


Diagram 3.2.4a Turner Valley Gate

3.2.4 | Small Watercourses | Turner Valley Gate

A filter fence can be used to contain oil in a moving watercourse because it offers a barrier to floating oil while allowing water to pass through.



Consider ground disturbance requirements before driving stakes/t-posts.

Purpose: To contain and recover a water-borne spill from a ditch, creek or stream.

Application: Use in slow-moving shallow watercourses.

Environmental Considerations: Maintain control of damming materials to avoid introducing foreign substances into the watercourse. Monitor setup for possible trapped wildlife. Handle and dispose of contaminated wastes in an approved manner.

Equipment Required: Turner Valley Gate, T-posts

If significant amounts of product are expected, ensure recovery equipment is in place or en route.

Waste disposal bags and tags if sorbents are to be used.

Operation:

1. Place Turner Valley Gates at an angle to direct released product towards the shoreline.
2. Secure Turner Valley Gates with T-Posts on the downstream side to prop the Turner Valley Gates at an angle leaning slightly to the downstream side.
3. Adjust the vinyl on the Turner Valley Gate to the waterline to direct floating product and still allow underflow of water.

3.2.5 | Small Watercourses | Flexible Hose Siphon Dam

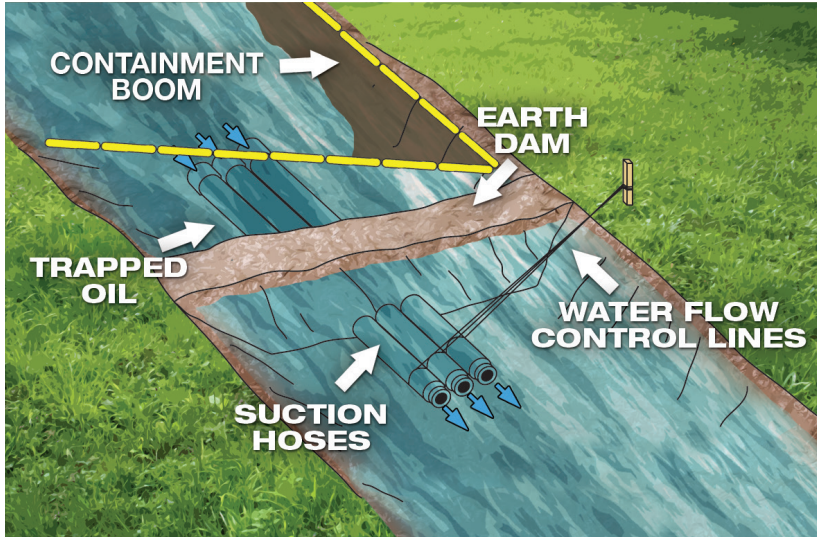


Diagram 3.2.5a Flexible Hose Siphon Dam

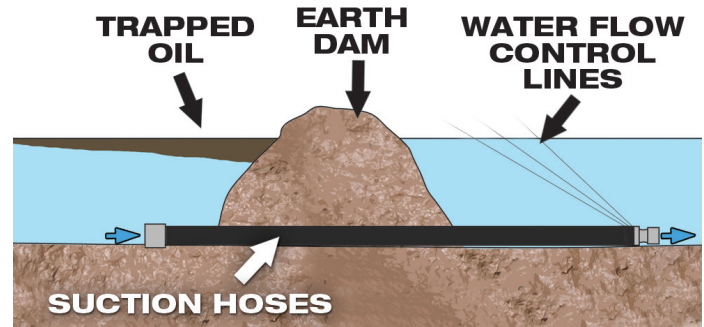


Diagram 3.2.5b Side View of Siphon Dam

3.2.5 | Small Watercourses | Flexible Hose Siphon Dam

A siphon dam or hose siphon dam is an example of an underflow weir. It provides a barrier to a spill moving on the surface, while allowing water to pass, preventing the dam from being over-topped.



Tips: - Siphon dams can also be constructed of soil or sandbag berms with angled hoses to carry water away.

- Install more hoses than necessary, as water may build up very quickly.

- Siphon dams can also be created with rigid pipes set at an angle where the upstream end is lower than the downstream end.

Purpose: To contain a spill in a water-filled ditch, creek or small stream for recovery.

Application: To stem the advance of oil in a small watercourse.

Environmental Considerations: Use appropriate damming materials so as not to cause further damage to the waterway through siltation. Maintain control of damming materials to avoid introducing foreign substances into the watercourse and increase siltation. Downstream water flow may be restricted.

Equipment Required: Shovel(s) or earth-moving equipment, suction hoses, rope and knife.

Recovery Equipment Options: Skimmer, pump, hose with temporary liquid storage capacity and vacuum truck

Waste disposal bags and tags if sorbents are to be used

Caution: Multiple water level adjustments could result in the dam failing as the soil around the hose becomes loose.

Operation:

1. Fasten rope to the downstream end of each of the suction hoses and affix to shore anchor point.
2. Lay the suction hoses in parallel on the bed of the watercourse. Cover hoses with soil/fill sandbags, leaving the exposed downstream portion of the hoses longer than the upstream side.
3. By raising/lowering one or more hoses with the rope, the level of the water being retained by the structure can be effectively controlled.

3.2.6 | Small Watercourses | Sorbent Booms

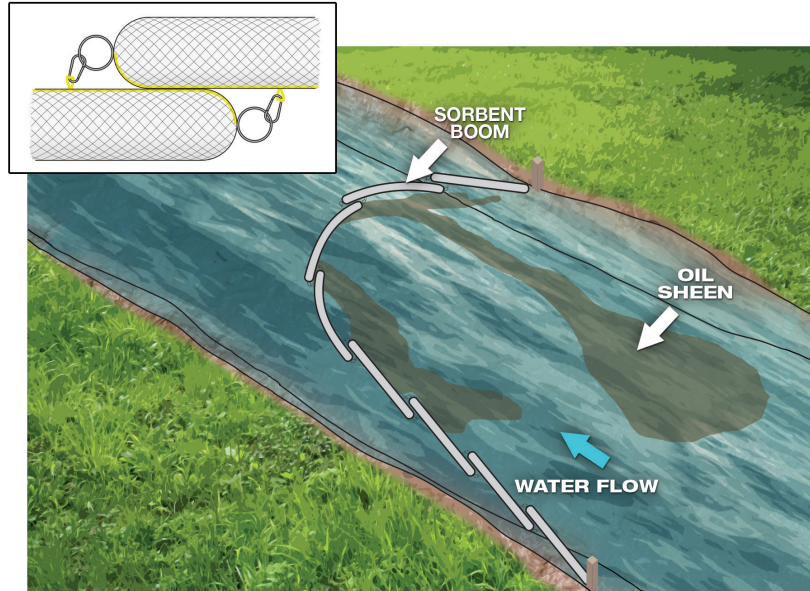


Diagram 3.2.6a Sorbent Booms

3.2.6 | Small Watercourses | Sorbent Booms

Sorbent booms are oleophilic (oil-attracting), lightweight and easily handled, installed and anchored, but are not designed for longterm use or harsh, high-current conditions. They should not be left unattended for long periods.



Tips: - This tactic is less effective in faster flowing water.

- When placing boom at an angle in flowing water, ensure the connection points overlap from upstream to downstream, so product can flow off one onto the other.

Purpose: To contain and recover long periods, and only designed for oil sheen.

Application: Can be used as a containment boom liner, shore-line protection and recover oil sheen from a small watercourse with minimal current or stagnant waterbody.

Environmental Considerations: Handle and dispose of contaminated wastes in an approved manner.

Equipment Required: “Hydrocarbon-only” sorbent boom or booms as appropriate. Stakes/T-posts, shore anchors or shoreline fixtures may be used to secure the boom(s). Rope, knife, waste disposal bags and tags.

Caution: If sorbent boom is not cascaded correctly product will flow between the connection points.

Operation:

1. Clip booms together in overlapping arrangement to achieve the required length. Affix to anchor points with rope.
2. If significant amounts of product are expected, hard containment boom should be used instead of sorbent boom.
3. Monitor and replace the contaminated sorbents as necessary.

3.3.1 | Larger Watercourses | Floating Containment Boom

While materials and configuration may change from one manufacturer to another, floating containment booms share many of the same components and nomenclature. A typical, solid-flotation boom is illustrated in **Diagram 3.3.1a**.

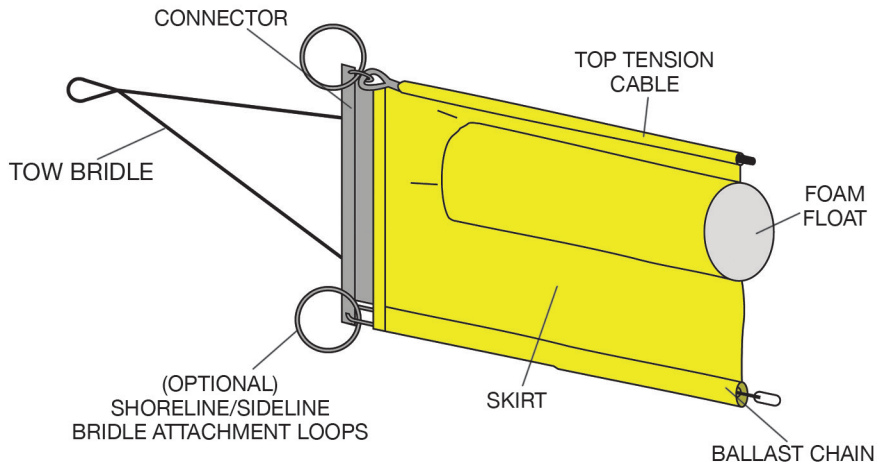


Diagram 3.3.1a Floating Containment Boom

3.3.1 | Larger Watercourses | Floating Containment Boom

Containment boom comes in an assortment of different sizes, identified by the overall height of the boom, or alternatively, by the diameter of the float and the depth of the skirt. ASTM1 elects to classify boom by its overall height, and offers the following guidance for selecting boom that may be useful in inland water spill response:

Table 3.3.1a ASTM Guide for Boom Selection

Boom Property	Calm Water*	Calm Water - Current*
Overall height (range), mm(in)	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)

Shallow skirts are advised for fast moving waters, because their reduced drag makes them easier to deploy and secure. Deeper skirts are advised where waves may be encountered.

* Calm Water = No waves and no current. Calm Water - Current = No waves with current.
1 ASTM, F1523 - 94 (Reapproved 2013) Standard Guide for Selection of Booms in Accordance with Water Body Classifications. West Conshohocken, PA.

3.3.1 | Larger Watercourses | Floating Containment Boom

Boom angle within a watercourse is dependent on the velocity of the current



Tip: It is Enbridge recommended practice, and a general rule of thumb for crews to quickly gauge the speed of the watercourse without a flow meter, by walking parallel to the watercourse. IF the current is faster than walking speed a 10 degree angle should be used, if the current is slower a 30 degree angle should be used.

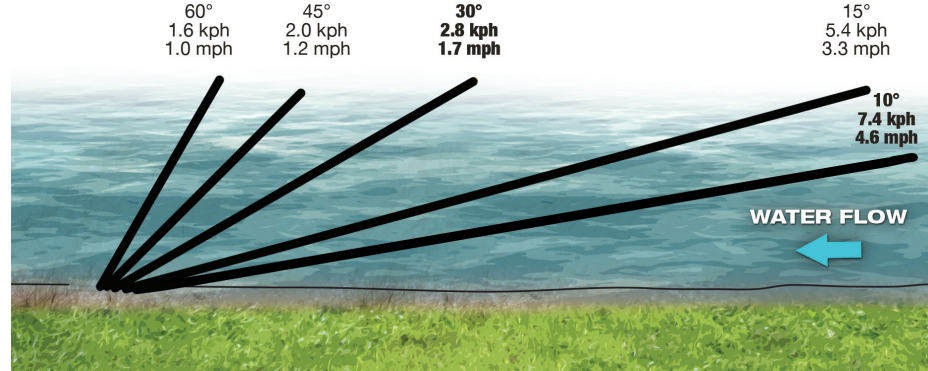


Diagram 3.3.1b Maximum Boom Angles for Various Currents

3.3.2 | Larger Watercourses | Shore Seal Boom

The unique configuration of shore seal boom allows it to provide an effective barrier to control the spread of oil in the critical region where the water meets the shoreline. It is a floating barrier with integral water bags that provide an effective seal when grounded. A smaller tube is fitted into a larger tube. The larger outer tube is filled with water and the smaller inner tube is filled with air. Shore seal boom can adjust to fluctuating water levels and creates a seal between the shoreline and waterlevel.

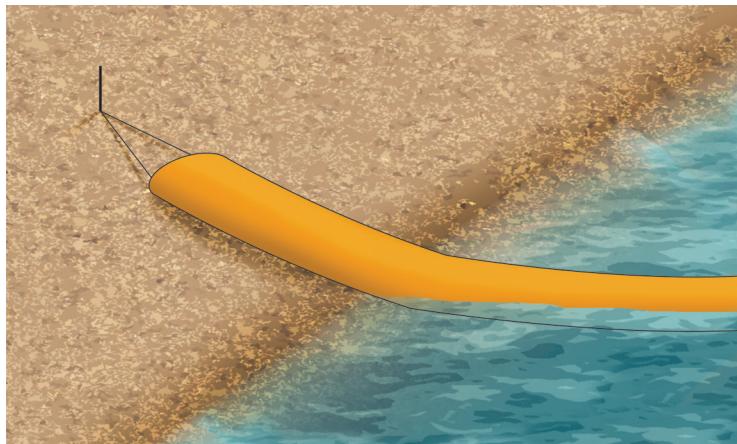


Diagram 3.3.2a Shore Seal Boom

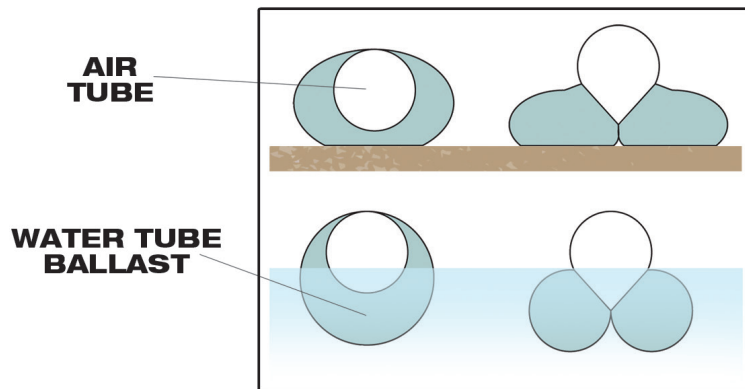


Diagram 3.3.2b Cross-Section of Shore Seal Boom

3.3.3 | Larger Watercourses | Deflection/Protective Booming

Sometimes the spread of a spill simply cannot be contained, particularly if it reaches moving water. This section discusses an alternative tactic for control of spills in moving water, which is to deflect or redirect the flow. This section also discusses the tactic of deflection and protective booming.

The goal of deflection and protective booming is to prevent spilled product from entering particularly sensitive areas, and redirect the product further downstream where there is an area that presents a successful opportunity for containment and collection. The goal of deflection booming is to divert surface oil out of fast-moving surface waters to low-velocity backwaters or eddies where it can be contained and controlled for recovery. Natural, low-energy collection points may already be identified in a river system, but their location can change significantly with the season and fluctuating river flows.

Suitable backwaters for collection points are most easily identified by the presence of high concentrations of floating, stagnant debris. Where backwaters do not exist naturally, it may be necessary to create a similar low current environment by mechanical means, where the spill can be successfully recovered. A circus skimmer or similar device can be the least intrusive means of creating a suitable backwater.

The assumption is made that Control Points have been pre-selected and identified for the affected water body. A Control Point is a predetermined location from which spill containment and recovery operations may be conducted with the expectation of a high degree of success.

The Control Point information sheet may supply guidelines as to the optimum equipment and deployment techniques for that location, considering river flows. For larger releases, it is common for responders to mobilize to more than one Control Point simultaneously.

As with the selection of deflection/exclusion tactics, a critical issue in Control Point selection is the river speed to ensure the correct location is identified that permits adequate time for:

- Personnel and equipment mobilization
- Travel to the location
- Completion of the deployment, ideally in time to capture the leading edge of the spill in the river

While Control Point mapping may provide guidance as to the tactics to be employed at a Control Point, conditions at the time of the response and the available equipment will dictate the one(s) employed.

3.3.3.1 | Larger Watercourses | Deflection/Protective Booming

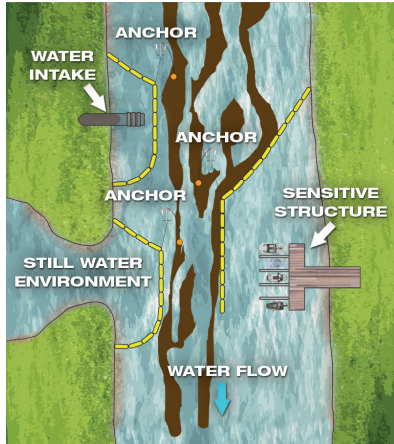


Diagram 3.3.3.1a Protection of Shoreline Resources

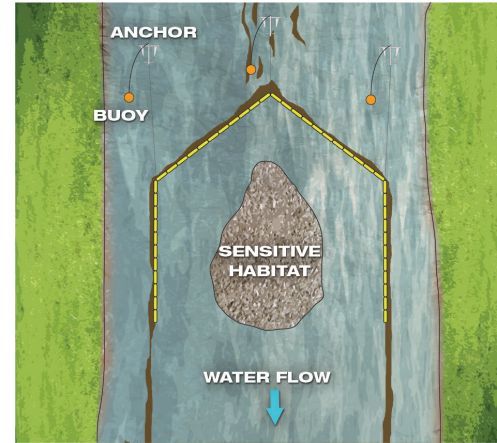


Diagram 3.3.3.1b Deflection of In-Stream Sensitive Resources

Oil is being excluded from the water intake and still water environment on the left side and deflection booms are being used to divert any passing oil around the structure located on the right side of **Diagram 3.3.3.1a**. **Diagram 3.3.3.1b** shows how a mid-stream sensitive resource can be protected using deflection booming techniques. Note the use of anchors in the stream to hold the boom in the desired positions. Anchor deployment is discussed in Section **4.1.2** Anchor Deployment from Boat.

3.3.3.1 | Larger Watercourses | Deflection/Protective Booming



Call Before You Dig



Tip: Stream dams are more effective when used in near-zero current conditions.

Purpose: To prevent a waterborne contaminant from impacting a sensitive shoreline or in-stream resource.

Application: Where containment and recovery is not a viable option.

Environmental Considerations: Anchor deployment may disturb the stream bed ecosystem. Land-based anchor systems may disturb sensitive areas on shore. Avoid unnecessary disturbance.

Equipment Required: Boat, booms, tow bridle(s), ropes, carabiners, anchor assemblies, shoreline anchor pins, sledge hammer/post driver. Consider boom marker lights for night operations.

Recovery Equipment Options: Laser rangefinder, boom marker lights for night operations. Use a postdriver instead of a sledge hammer for safety!

Operation:

1. Identify sensitive area to protect.
2. Place the boom in an arc around the sensitive resource.
3. Affix anchor(s) as necessary to hold boom away from the resource. Anchor lines can be joined to boom at end connectors or at intermediate locations where handbridle loops area available.
4. Other than in areas with significant back eddies, the downstream end of the boom may be allowed to float free.
5. Pick up each “arm” and pull into the desired location. Attach sideline bridle and attach anchor while allowing the downstream portion of the boom to float free. Arms can be anchored at the downstream end, if required.
6. The anchor marker buoys on a line attached to the anchor crown permit it to be reset by dragging along the bottom to the new required location rather than raising it completely and redeploying.

3.3.3.2 | Larger Watercourses | Deflection Booming Cascade System

Deflection booming can be used to assist oil collection for recovery in high-current environments. If the current in the middle of the river is high, a boom stretched across the river will not contain the oil because the oil will **ENTRAIN** and pass beneath it. However, if booms are placed at an angle to the current, entrainment is reduced and the oil is deflected out of the heaviest current to low-velocity zones.

The illustration shows multiple short sections of boom being used in a **CASCADE** arrangement to move oil away from the lower bank to the collection area installed on the opposing bank. The illustration shows multiple short sections, because it is frequently easier to install than one long one.



Tip: If boom vanes are available they can be more efficient than in-stream anchors for cascade boom sets.

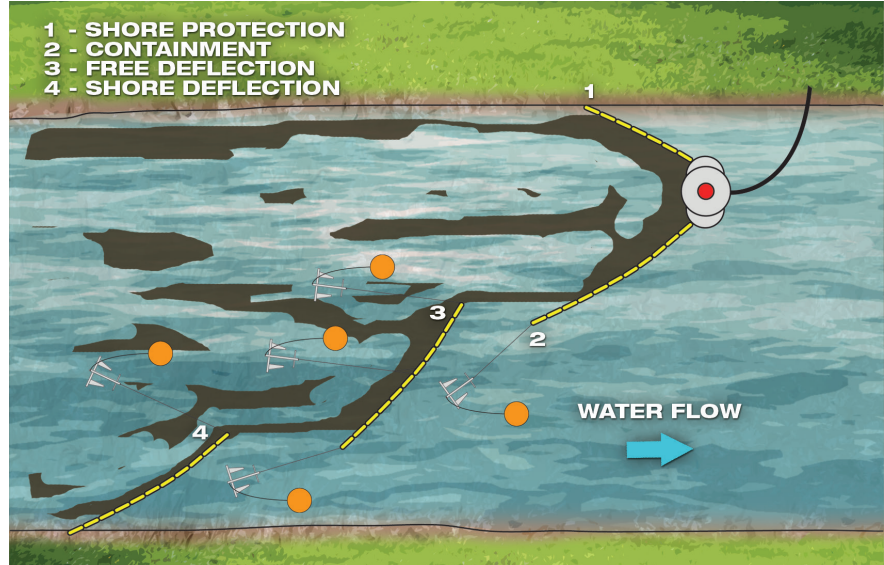


Diagram 3.3.3.2a Deflection Booming Cascade System

3.3.3.2 | Larger Watercourses | Deflection Booming Cascade System



Observe “No Anchor” Zones



Tips: - A three-way manifold will permit options for the distribution of recovered liquids coming from the skimmer without interrupting skimmer operations: direct to temporary storage tank, direct to vacuum or tank truck, or from temporary storage tank to vacuum or tank truck.

- The anchor marker buoy on a line attached to the anchor crown plate permits it to be reset by dragging it along the river bottom to the new required location, rather than raising the assembly completely and redeploying. It is also easier and safer retrieving an anchor, especially a Danforth or Davistype with movable flukes, by pulling it up by the buoy rope and lifting it into the boat by the stock.

Purpose: To deflect a spill across part or all of the water flow to a collection/recovery point.

Application: In wider and faster moving watercourses with shoreline access for recovery.

Environmental Considerations: Anchor deployment may disturb the stream bed. Avoid unnecessary disturbance.

Equipment Required: Workboat, boom, tow bridles, sideline bridles. If intermediate anchoring is required: ropes, anchor assemblies, shoreline anchor pin(s), if required.

Optional But Recommended: Laser rangefinder, three-way manifold, boom marker lights for night operations.

Recovery Equipment Options: Skimmer, pump, hoses, temporary liquid storage and/or vacuum/tank truck, and BoomVane™.

Operation:

1. Install the skimmer and booms (Booms 1 and 2) first and then work upstream.
2. Install deflection booms (Boom 3 followed by Boom 4, and so on).
3. Connect anchor assemblies to the boom by attaching the rhode line to the tow bridle at each end. Intermediate anchors can be attached using handline bridles.
4. Deploy upstream end anchor assembly first; move downstream and deploy river bed anchor and marker buoy for the downstream end. Attempt to place the boom so that it forms a straight line overlapping the downstream boom set, maintain the correct boom angle for water speed.

3.3.3.3 | Larger Watercourses | Boom Deployment for River Using Instream Anchor

Installation of boom sets in rivers using instream anchors are completed in stages. Components required are typically laid out on shore to ensure all components are available. Handline bridles connect to the boom and the handlines are pulled tight to hold the boom more linear.

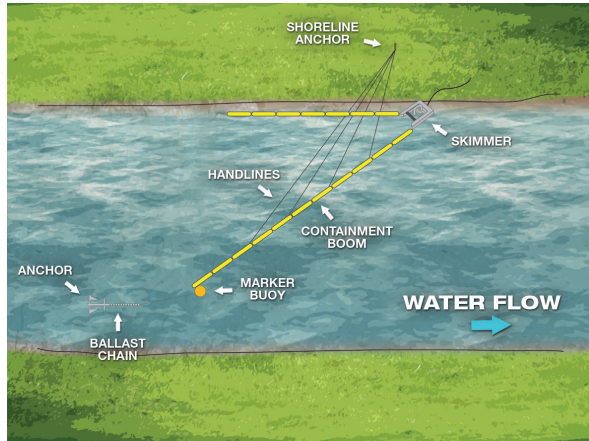


Diagram 3.3.3.3a Boom Deployment for River: Single Anchor

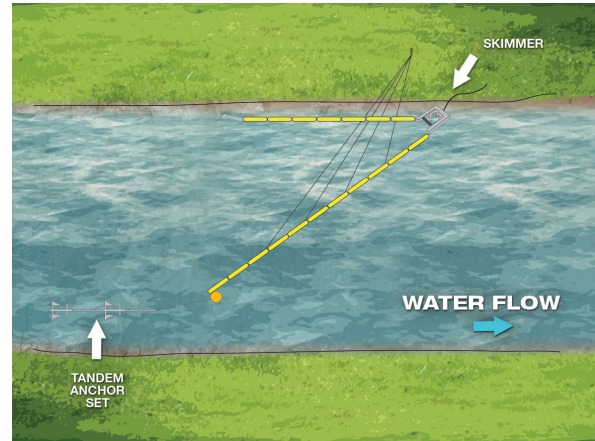


Diagram 3.3.3.3b Boom Deployment for River: Tandem Anchor

3.3.3.3 | Larger Watercourses | Boom Deployment for River Using Instream Anchor



Watch Your Step



Call Before You Dig



Observe “No Anchor” Zones

Purpose: To install a spill containment and recovery deployment at a river bank location using river bed anchored boom and a skimmer.

Application: To install a collection and recovery system in a moving watercourse.

Environmental Considerations: Anchor deployment may disturb the stream bed. Avoid unnecessary disturbance. Ensure minimal disturbance of shoreline.

Equipment Required: Boats (workboat and safety boat), anchor assemblies, booms, ropes, carabiners, tow bridles (single and double designs, if available), sideline bridles, shore anchor pins, sledge hammers/post drivers, skimmers, pumps, hoses, temporary liquid storage devices.

Optional But Recommended: Laser rangefinder, three-way manifold to permit easy changing from delivering to or from temporary liquid storage tank to vacuum truck or tank truck.

Operation: Compute or determine stream speed, boom angle and calculate the length required for the containment boom.

Note: A safety boat, deployed downstream of the work area, is advisable when available and should remain on station throughout the activities that are on, in or near the water. If boat is unavailable, position personnel downstream with throwbags.

Anchor Deployment and General Equipment Assembly Note that there are potentially many pieces to a midstream diversion/collection system. Whenever possible, the installation of individual components overlapping one another will be easier than placing a single, integrated unit.

3.3.3.4 | Larger Watercourses | BoomVane™ Recovery/Deflection Modes

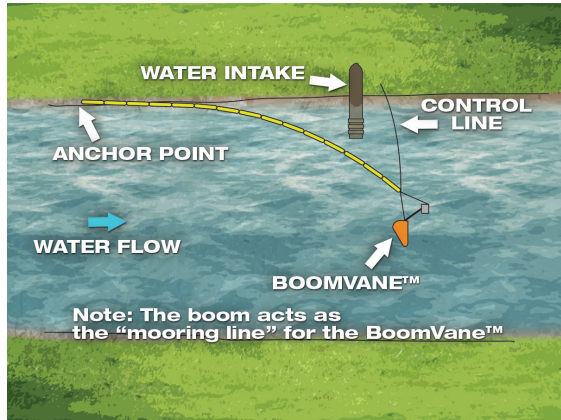


Diagram 3.3.3.4a BoomVane™ Deflection Mode

Example 1: BoomVane™ is used to tend the downstream end of a boom intended to divert oil away from the shoreline.

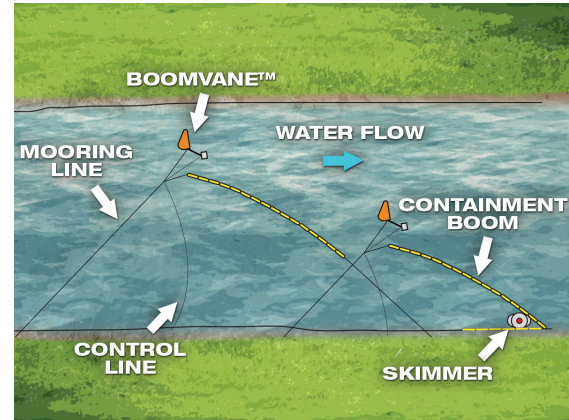


Diagram 3.3.3.4b BoomVane™ Recovery Mode

Example 2: BoomVanes™ are used to tend the upstream ends of booms being used to divert oil out of the main stream to a recovery area. A cascade system is shown.

3.3.3.4 | Larger Watercourses | BoomVane™ Recovery/Deflection Modes

BoomVanes™ can be used in place of ground tackle when deploying deflection and diversion booms.

More comprehensive information may be found in the BoomVane™ Operation & Service Manual and the BoomVane™ Shore-based Deployment Geometry and Quick Reference Tables.



Tips: - A BoomVane™ can be “walked” into deep water more easily if rolled on its side, with the float facing away from the person deploying it.

- Secure mooring points and proper mooring line lengths are critical to the deployment and use of BoomVanes™. Tables found in BoomVane™ manuals will aid in locating anchors and determining proper line lengths. **Diagrams 3.3.3.4a** and **b** highlight some techniques that can utilize the capability of the BoomVane™.

Purpose: To deploy boom quickly in a river to contain/recover/deflect a spill.

Application: Used in place of midstream anchors when there is sufficient current; useful when boats are not available to set anchors or when there is limited access

Environmental Considerations: If using a tree as an anchor, protect the tree bark from chafing by employing a piling bridle or sorbent boom as a liner.

Equipment Required: Boom, BoomVane(s), control line, mooring line, short line to connect BoomVane’s bridle to connector plate (optional), downstream boom/shore anchor line, tow bridles (2), shore anchor pins, if required

Sledge hammer/post driver, if applicable, skimmer, pump, hoses, temporary liquid storage device (bladder, tank, vacuum truck)

3.4 | Open Water

Oil containment and recovery systems in Open Water environments and large river systems require dedicated vessels with deep draft, high volume skimmers, storage barges, and heavier containment boom. In rivers, oil usually travels downstream. However, oil can travel upstream, such as at the mouth of a river, where an incoming tide can reverse its flow. Wind speeds, currents, ice, and ambient temperature may also have an effect on the direction and character of oil in Open Water situations. Containment and recovery tactics such as special oil storage boom, equipment for recovering oil in ice, and high volume pump skimmers for very large and deeper water bodies are addressed in this section.

3.4.1 | Open Water | NOFI Current Buster® 2 & NOFI Current Buster® 4



Hazard Management

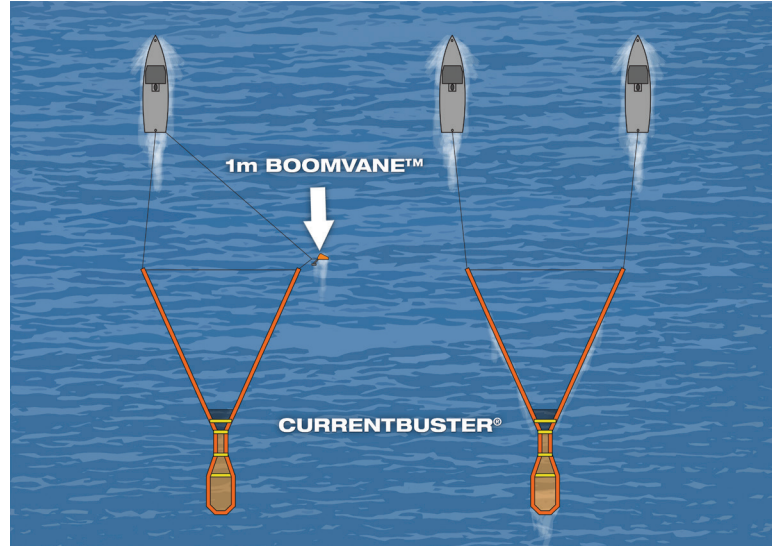


Diagram 3.4.1a NOFI Current Buster® Technology Shown with a Single Vessel Configuration with BoomVane™(Left) and NOFI Current Buster® Technology Shown with a Double Vessel Configuration (Right).

3.4.1 | Open Water | Containment | NOFI Current Buster

Purpose: To contain and collect oil at speeds ranging from 0.5 up to 3 knots in reasonable weather conditions.

Application: Both the NOFI Current Buster® 2 and 4 are capable of open and inland shallow water recovery and containment of oil. The NOFI Current Buster® 2 is also useful for inland river and stream applications in both a standard towing configuration and a stagnant/fixed application to shore or a structure such as a bridge or pier.

Environmental Considerations: Consider environmental sensitivities such as vegetation, rare plant and animal species, sensitive soils and shorelines, critical habitat, and fisheries regulations before deploying the equipment.

Equipment Required: QT Environmental Containerized system with contents consisting of: NOFI Current Buster® 2 or 4, hydraulic reel, hydraulic power pack with regenerative blower for inflation, two vessels equipped for towing (150 hp minimum recommendation).

Optional Equipment: Backpack blower equipped with Monsun inflation adaptor, QT Environmental Inland River Anchor System, NOFI Integrated Pump System, NOFI Light System for night operations, Elastec BoomVane™

Operation:

1. Deploy with guide booms first and retrieve with separator to allow water to flow freely out of the system without forming water pockets.
2. The integrated Front Sweep net is weighted and will therefore sink. When deploying in shallow water the net may snag on the bottom. In such unfavorable conditions a rope may be tied around the sweep arms and the netting to prevent the net from sinking. NOTE: This rope must be cut prior to operation.

3.4.1 | Open Water | Containment | NOFI Current Buster® 2 & 4

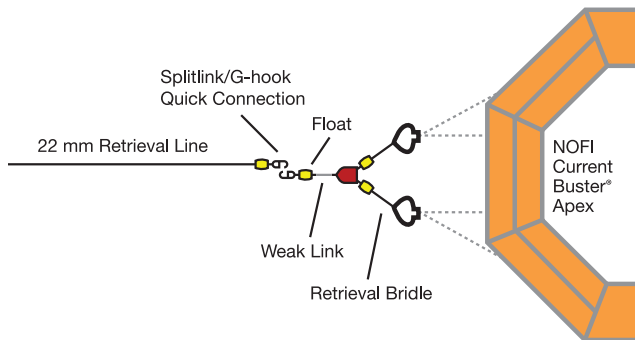


Diagram 3.4.1b NOFI Current Buster® Retrieval

Operation/Retrieval:

- The retrieval line is connected to the retrieval bridle by a G-Hook (split-link) connection.
- Retrieving may be done with any accessible equipment e.g. forklift, crane, winch, a car's towing hook, etc.
- If the system is retrieved to a boom reel, it must be wound up firmly. A vessel or a vehicle may assist in maintaining tension in the system while it is being retrieved. When winding up the towlines, make sure that the towlines do not get stuck in between the boom reel's sidewalls and the boom system itself, due to risk of jamming the towlines.

Application:

- When towing begins, the separator fills slowly with water. An initial speed of 2 to 3 knots is recommended in order to fill up the separator. During this filling process the separator bottom may appear unstable but the system will still collect oil.
- If the towing stops, the ballast in the separator will impede the separator bottom from floating up. Some water will escape, and when the towing begins again, it will take a few minutes to reach the normal filling level.
- Even if the speed through the water and oil type varies, no adjustments of the system are required.

3.4.1 | Open Water | Containment | NOFI Current Buster® 2 & 4

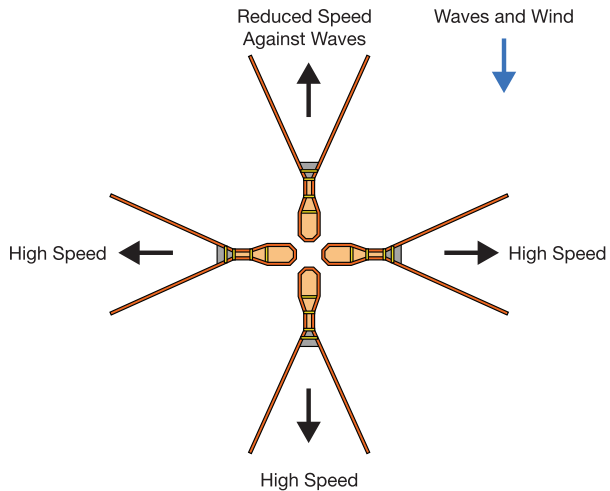


Diagram 3.4.1c NOFI Current Buster® Towing Speed

Operation/Towing Speed:

- The maximum towing speed is determined in two ways:
 1. The maximum oil collecting speed is 3 knots through water because significant loss of oil occurs. Operation at higher speed is not recommended. Note that in current exposed areas, a GPS reading will give wrong speed-reading against water.
 2. When towing directly against short-period waves, the speed should be limited to 1 to 2 knots to avoid splash-over in the stern.
- Normally higher speeds may be used when towing with the waves or at 90 degrees to the wave direction, compared to directly into the waves.

3.4.2 | Open Water | Containment | Sea Sentry II Oil Boom



Hazard Management



Isolation of Energized Systems

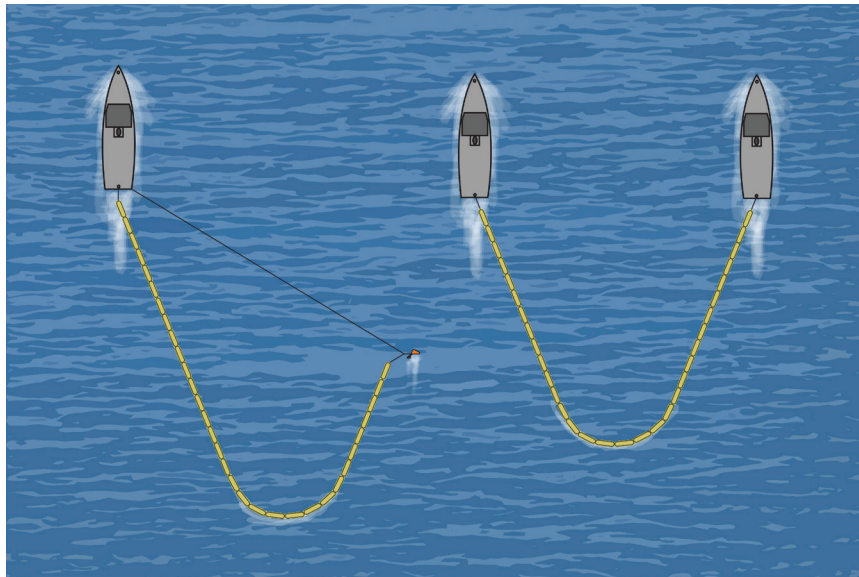


Diagram 3.4.2a Sea Sentry II Boom with Single Vessel / 1m BoomVane™
Configuration (Left) Sea Sentry II Boom with Two Vessel Configuration

3.4.2 | Open Water | Containment | Sea Sentry II Oil Boom or Lake Boom (Inflatable or Foam)

Purpose: To contain and collect oil at speeds up to 0.75 knots in reasonable weather conditions and in high demanding environments.

Application: Heavy duty offshore application. Can be used for active towing and as protection boom for islands, sensitive areas such as hatcheries, etc.

Environmental Considerations: Consider environmental sensitivities such as vegetation, rare plant and animal species, sensitive soils and shorelines, critical habitat, and fisheries regulations before deploying the equipment.

Equipment Required: IFoam Lake Boom, Inflatable Lake boom and blowers to fill or QT Environmental Containerized System with contents consisting of: 550' of Sea Sentry II Oil Containment Boom, hydraulic reel, hydraulic power pack with regenerative blower for inflation, two vessels equipped for towing (300 hp minimum recommendation).

3.4.2 | Open Water | Containment | Sea Sentry II Oil Boom

Operation/Inflation:

1. During towing operation, be cognizant of the temperature of the boom. During colder morning operation, if the boom is inflated to 1.5 psig, as the boom warms the air may expand increasing the psig and exceeding the 1.5 psig maximum causing severe damage.
2. Monsun valves have an open and closed position. When the valve seat (plate) is pressed down and turned to the right, the valve is locked in open position (as is done during retrieval). When turned to the left, the valve is closed. Inflation is still possible with the valve in closed position.
3. All air chambers have two valves. Prior to inflation, make sure the opposite valve is closed. The boom is designed to be inflated to a maximum of 1.5 psig. Once inflated, be sure to seal the Monsun valve with the outer cap.

Operation/Retrieval:

1. A rope or tag line may be used to connect to the tow bridle to recover the 550 feet /168 meters of boom. Be sure to open both Monsun valves and recover onto the boom reel being sure to avoid over pressure and severe damage.
2. If the system is retrieved to a boom reel, it must be wound up firmly. A vessel or a vehicle may assist in maintaining tension in the system while it is being retrieved.

Operation/Towing Configuration:

1. When towing begins, constant communication between the vessel operators/captains should be maintained. This will aid in a successful collection of oil as they match speed and achieve maximum efficiency.
2. It is worth noting that at towing speeds exceeding 0.75 knots entrainment is encountered and conventional booms may start to fail.
3. Even if the speed through the water and oil type varies, no adjustments of the system are required.

3.4.2 | Open Water | Containment | Sea Sentry II Oil Boom



Tip: When starting operation, tow boom slowly, and be sure to communicate between vessels.

Operation/Towing Speed:

- The maximum towing speed is determined in two ways
 1. The maximum oil collecting speed is 0.75 knots through water because significant loss of oil occurs. Operation at higher speed is not recommended. Note that in current exposed areas, a GPS reading will give wrong speed-reading against water.
 2. When towing directly against short period waves, the speed should be limited to slower towing speeds to avoid splash-over in the stern.
- Normally higher speeds may be used when towing with the waves or at 90 degrees to the wave direction, compared to directly into the waves.

3.4.3 | Open Water | Recovery | Arctic Brush Bucket System



Watch Your Step



Monitor Your Surroundings

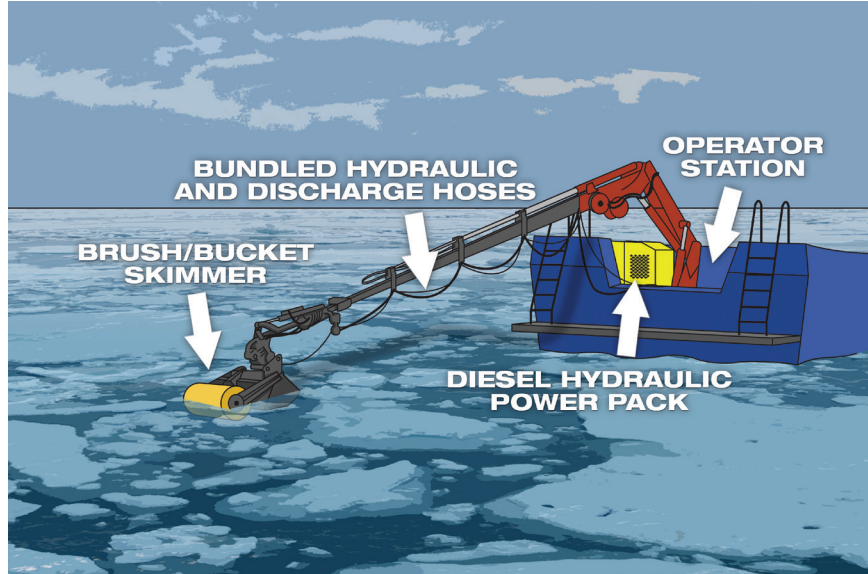


Diagram 3.4.3a Arctic Brush Bucket System Tactical Illustration

3.4.3 | Open Water | Recovery | Arctic Brush Bucket System



Tips: - Note that during recovery operations one responder with a radio should be positioned with a full view of the skimmer and the ice edge or containment boom. Constant communication with the wheelhouse should be maintained for optimal maneuvering and positioning for oil recovery.

- Check for the proper operation of the of the operating components of the system including the crane, brush/drum skimmer, feed screw, bucket locking pins, hydraulic tilt cylinder and pump prior to deployment.

- The skimmer should be deployed in the thickest oil (black oil), trapped against the ice edge or contained in a boom.

Purpose: To recover medium to heavy oil on water or land in all seasons, but specifically designed for cold climate conditions where broken ice is present.

Application: To recover oil that is released in a watercourse where ice is present.

Environmental Considerations: Consider environmental sensitivities such as vegetation, rare plant and animal species, sensitive soils and shorelines, critical habitat before deploying the equipment.

Equipment Required: For water recovery, a vessel with a platform or tank barge; for land, a flat-bed truck; water source, hot water generator for injection pump, and 5/8 inch / 15.9 mm hose for deck tank water source or by drawing suction from lake.

Operation: After mobilizing, positioning, and mounting the skimmer on the receiving vessel, lock the securing pins and wire in place. Conduct power pack prestart checks. Check crane functions. Transfer the skimmer storage cradle and connect it to the crane arm and pin into place. Connect hot water generator (if used) to the water supply and connect to the skimmer. Test all skimmer and pump functions. If oil is thick, the skimmer can be used in a weir configuration. For most recovery operations, the brush wheel skimmer will be adequate.

Inland Spill Response Tactics Guide

Cold Weather & Ice Tactics

4

4.1 | Ice Tactics

Responding to a product release in winter conditions requires a different approach than traditional inland spill response tactics. Seasonal safety concerns such as cold weather and slipping hazards on ice must be considered. The tactics used in response scenarios that deal with ice also require a variety of specialized equipment.

Unlike a non-ice covered watercourse, releases under the ice require responders to conduct an ice assessment to ensure that the weight bearing capacity of the ice will support operations. Detecting and tracking a product release under the ice may also require responders to break through the ice to determine the product's trajectory.

Multiple methods of containment and recovery are available to responders based on the weight bearing capacity of the ice cover and available equipment.

4.1.1 | Ice Tactics | Ice Assessment



Use appropriate life safety measures when working on ice. Refer to company PPE standards, FLHAs and JHAs prior to starting work.

Before beginning any recovery and containment work on ice, an ice assessment must be completed to ensure the work can be performed safely.

A quick estimate of ice bearing capacity can be calculated as follows:

$$L = 40 \times (t)^2$$

Where

L is the bearing capacity of the ice in pounds per square inch.

t is the thickness of the ice in inches.

A more comprehensive means of estimating ice bearing capacity follows.

4.1.1 | Ice Tactics | Ice Assessment



Tips: - Calculate the weight bearing capacity in multiple areas, as the ice thickness may change significantly throughout the work area.

- Do not complete ice evaluation directly within the containment and recovery area as this will reduce the integrity of the ice where you are trying make safe.

If safe to do so, one responder attached to safety line will proceed out onto ice while other responders remain on shore manning safety line.

Choose a location where recovery and containment work will be completed and use ice auger to drill a hole through ice. Use an ice depth measuring device to determine ice thickness.

Test multiple locations on ice to determine a safe working zone for recovery and containment.

Calculations:

$$\text{Total effective ice thickness} = (\text{Clear} + \frac{1}{2} \text{ White}) \times \text{Temp} \times \text{Crack}$$

Where:

Clear = clear ice thickness

White = white ice thickness

Temp = safety multiplier for temperature effects (Table 3.4.1a)

Crack = safety multiplier for cracks in the ice (Table 3.4.1b)

If water lies between layers of ice, use the thickness of the top layer of ice only.

4.1.1 | Ice Tactics | Ice Assessment

Table 4.1.1a Safety Multiplier for Temperature Effects

Sudden Temp. Drop	Temp. Safety Multiplier
None	1.0
41°F / 5°C or less	0.7
41°F / 5°C to 50°F / 10°C	0.5
50°F / 10°C or more	0.4
OR	
If the air temperature has exceeded 0°C in 6 of the preceding 24 hours	0.8
If the air temperature has stayed above 32°F / 0°C for 24 hours or more	0.5 conditions can change rapidly conduct frequent ice assessments to determine safety.

Table 4.1.1b Safety Multiplier for Cracks in Ice

Type of Crack	Crack Safety Multiplier
None	1.0
Dry cracks less than 2cm (3/4") wide	1.0
Refrozen cracks	1.0
Non-intersecting dry cracks wider than 2cm (3/4")	0.8
Intersecting dry cracks wider than 2cm (3/4")	0.58
Non-intersecting wet cracks	0.7
Intersecting wet cracks	0.5

4.1.1 | Ice Tactics | Ice Assessment



Tip: Use local knowledge, including known danger areas and historical data.

Purpose: To calculate ice thickness to determine the maximum weight allowance of responders and equipment on ice.

Application: Completed when product is released on or below ice on a watercourse.

Environmental Considerations: Avoid disturbing the stream bed with auger. Do not refuel mechanical equipment on ice unless secondary containment has been established. Minimize tracking of soil onto ice surface..

Equipment Required: Ice auger, ice depth measuring device.

Operation:

Observe ice conditions before stepping onto watercourse (extent of ice conditions, abnormal surfaces, large breaks or cracks, flowing water at edges of watercourse).

Color of ice is an important indicator of ice strength:

- Clear Blue Ice = Strongest
- White Opaque Ice = Half as strong as blue ice
- Grey Ice = Indicates presence of water and is unsafe

4.1.1 | Ice Tactics | Ice Assessment

Examples of Total Effective Ice Thickness

1. The location has 60 inches / 1.53 meters of clear, blue ice and 10 inches / 0.25 meters of white ice. There are no cracks of significance and the temperature has been consistent and below freezing.

Total Effective Ice Thickness = $(60 + 10/2) \times 1.0 \times 1.0 = 65$ inches / 1.65 meters

2. The location has 40 inches / 1.02 meters of clear, blue ice and 20 inches / 0.51 meters of white ice. The temperature has peaked above 32°F / 0°C a few times in the past day.

Non-intersecting wet cracks are present.

Total Effective Ice Thickness = $(40 + 20/2) \times 0.8 \times 0.7 = 28$ inches / 0.71 meters

4.1.1 | Ice Tactics | Ice Assessment

Table 4.1.1c Weight Bearing Capacity for Continuous Travel

Total Effective Ice Thickness (in / cm)		Permissible Load
Lake	River	
2.0 / 5.1	2.4 / 6.1	One person on foot (not recommended)
3.1 / 7.9	3.5 / 8.9	Group, in single file (not recommended)
7.1 / 18.0	8.3 / 21.1	Passenger car 4,400 lbs / 2,000 kg
7.9 / 20.1	9.1 / 23.1	Light Truck 5,500 lbs / 2,500 kg
10.2 / 25.9	11.8 / 29.9	Medium Truck 7,700 lbs / 3,500 kg
13.8 / 35.1	16.1 / 40.9	Heavy Truck 15,000 - 17,5000 lbs / 6,800 – 8,000 kg
15.0 / 38.1	17.3 / 43.9	20,000 lbs / 9,000 kg
24.8 / 62.9	28.7 / 72.9	50,700 lbs / 23,000 kg
31.5 / 80.0	36.2 / 91.9	99,200 lbs / 45,000 kg
39.4 / 100.1	45.3 / 115.1	150,000 lbs / 68,000 kg
49.2 / 124.9	56.7 / 144.0	240,350 lbs / 109,000 kg

4.1.1 | Ice Tactics | Ice Assessment

Table 4.1.1d Weight Bearing Capacity for Stationary Loads and Working on Ice

Total Effective Ice Thickness (in / cm)		Permissible Load
Lake	River	
7.9 / 20.1	9.1 / 23.1	2,200 lbs / 1,000 kg
11.8 / 29.9	13.8 / 35.1	4,400 lbs / 2,000 kg
17.7 / 44.9	20.5 / 52.1	8,800 lbs / 4,000 kg
23.6 / 59.9	27.2 / 69.1	17,650 lbs / 8,000 kg
43.3 / 109.9	50.0 / 127.0	50,700 lbs / 23,000 kg
59.1 / 150.1	68.1 / 172.9	99,200 lbs / 45,000 kg
70.9 / 180.1	81.5 / 207.0	150,000 lbs / 68,000 kg
90.6 / 230.1	104.3 / 264.9	240,350 lbs / 109,000 kg

Note: When multiple stationary loads are on the ice, separate them 200 times the minimum total effective ice thickness required for the larger of the two loads

4.1.2 | Ice Tactics | Oil Detection Under Ice

Detecting the location of the oil beneath ice is a challenge. This section offers guidance on ways to detect the location and expected spread of oil that is trapped beneath the ice, so that proper planning for collection and recovery can proceed.

Detecting oil under ice is essential to determining where diversionary boards and ice slots need to be cut. The lack of wind under ice reduces water current and is beneficial to recovery, as oil will travel slower on a watercourse. Technologies such as infrared, ultraviolet, laser-fluorosensors and satellite remote sensing exist, though they may not be readily available to responders. The following tactics use equipment readily accessible to responders.

When auguring holes to delineate oil impacts always work from the outside edges inwards. Stop delineation once outer edge of oil is detected; then reposition to determine the outer extents from a different direction.



Use appropriate life safety measures when working on ice. Refer to company PPE standards, FLHAs and JHAs prior to starting work.

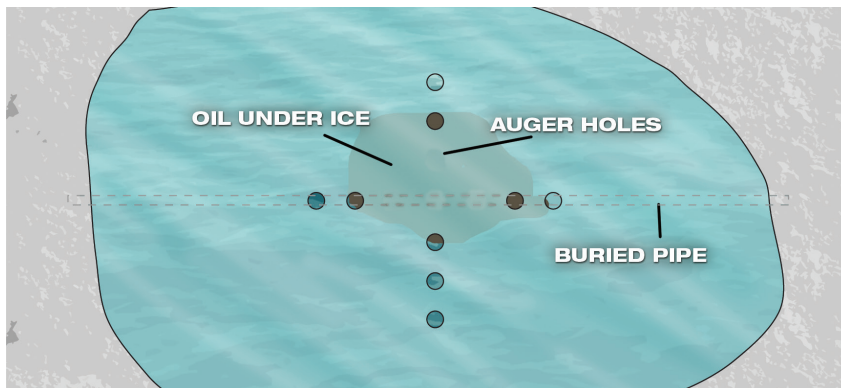


Diagram 4.1.2a Oil Detection Under Ice

4.1.2 | Ice Tactics | Oil Detection Under Ice



Tips: - Ice retards the movement of oil in a current. Oil trapped under the ice will be relatively immobile until the current reaches approximately 0.2–0.4 meters/ second (about 3/4 of a knot).

- Even if the current is moving oil, the uneven surface of the base of ice will trap oil in ridges and pockets. Locating and recovering these pockets of oil must be considered for continuing recovery operations.

- Knowing the location of the release will improve chances of detecting oil. Use pipeline markers to identify line location.

- Limit the number of auger holes used during detection. Too many holes can weaken the ice and potentially increase the spread of oil. An airboat can be used as a safe platform for completing ice evaluations. On smaller water bodies a punt boat can be used as a safe working platform with the use of a trolley line.

Purpose: To determine location and trajectory of oil to contain and recover product.

Application: When oil is under ice and its trajectory must be determined.

Environmental Considerations: Avoid disturbing the stream bed with auger. Do not refuel mechanical equipment on ice unless secondary containment has been established. Minimize tracking of soil onto ice surface.

Equipment Required: Ice auger, ice depth measuring device, current/flow meter, shovels, underwater flashlight.

Operation:

1. Ensure an ice assessment has been performed before beginning any operations.
2. Remove snow from surface of ice.
3. On a lake begin augering holes from the outside of the project plume and move towards the suspected release location.
4. Determine the Point of entry and calculate the current speed and time of release to determine how far down stream you will need to be to get ahead of the advancing plume. Begin augering holes from the shoreline working across the ice to the other side if safe to do so.
5. An underwater flashlight can be inserted into auger holes to provide greater visibility.
6. Using a current meter (rated for cold-water use), determine if current is capable of moving oil.
7. If current is moving oil downstream, determine a viable recovery location downstream.
8. If current is not strong enough to move oil, consider using the ice slotting tactic. Shown in 4.1.4.
9. When oil is detected, the outline should be marked with spray paint or flagging.

4.1.3 | Ice Tactics | Trench on Ice Sheet



Tip: Ensure that the V Trench does not cut through the entire column of ice.

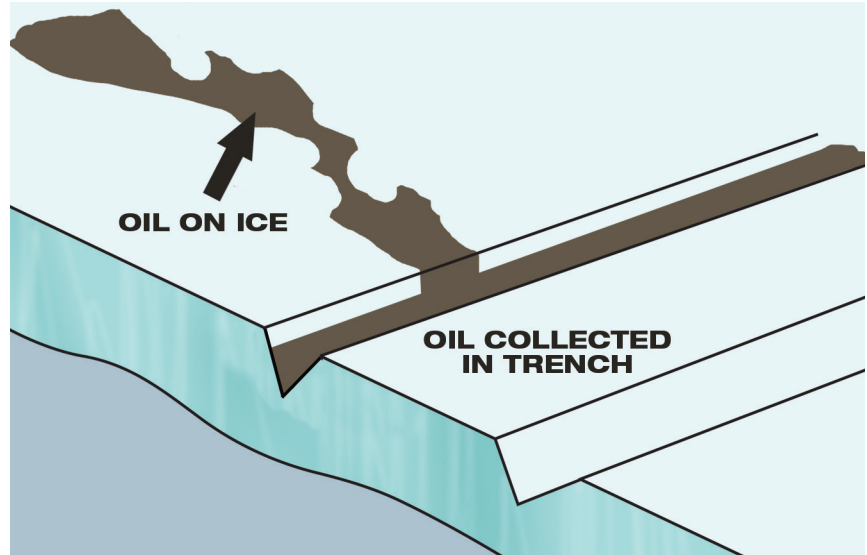


Diagram 4.1.3a Trench on Ice Sheet

4.1.3 | Ice Tactics | Trench on Ice Sheet



Ensure ice assessment has been completed.



Tips: - An ice auger may be used to create a bell hole for product recovery.

- Sorbent material will freeze to the surface of the ice, recommended not to use.

Purpose: To limit the spread of oil and collect oil that is loose on an ice sheet surface.

Application: When oil is on top of ice, ice thickness is suitable and an ice berm is not sufficient.

Environmental Considerations: Ice must not be breached entirely to prevent oil from entering surface water. Ensure mechanical equipment is free of petroleum lubricants. Do not refuel mechanical equipment on ice unless secondary containment has been provided.

Equipment Required: Ice cutting chainsaws, Ice augers, squeegees and brushes.

Optional Equipment: Ice cutting chainsaw, commercial ice resurfacer.

Recovery Equipment Options: Leaf blowers, pump, hoses, hose strainer, temporary liquid storage capacity, vacuum truck.

Caution: Ensure not to cut through the ice sheet when making the V slot.

Operation:

1. Ensure an ice assessment has been performed before accessing the ice sheet.
2. When using mechanical equipment, do not break through or fracture the ice.
3. Use squeegees and ice scrapers to direct oil into trench.

4.1.4 | Ice Tactics | Diversion Wall to Ice Slot

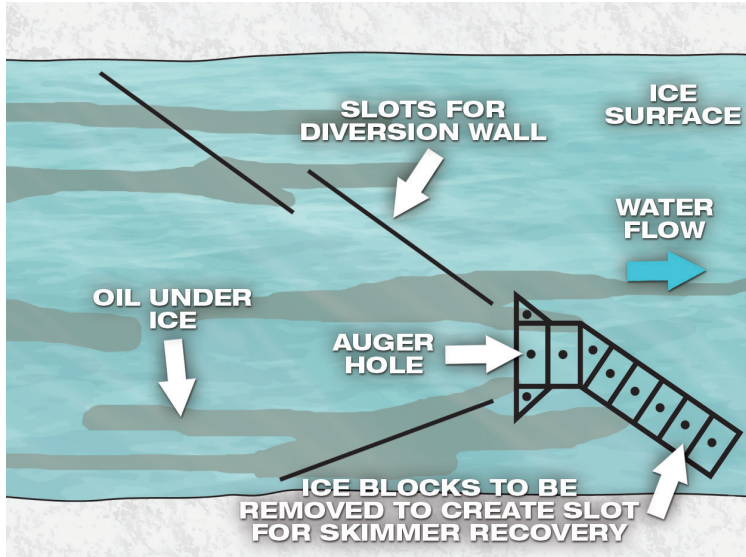


Diagram 4.1.4a Ice Slotting on Rivers

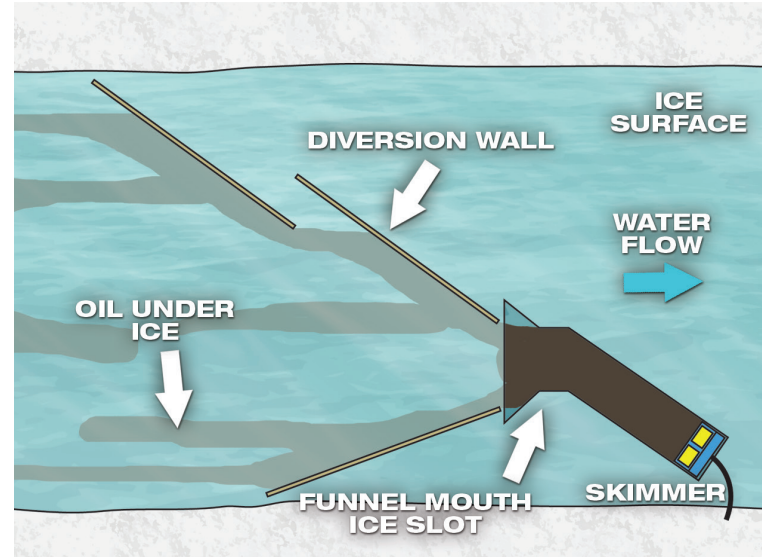


Diagram 4.1.4b Ice Slotting on Rivers

4.1.4 | Ice Tactics | Directing Oil Under Ice



Tips: - If ice slotting on still water, a current can be created to move oil toward recovery area.

- A suction hose with foot valve and screen, pump, discharge hose and reducer will be required. Ensure fish intake screen is present on pump intake.

Caution: - Ensure all ignition sources are within the cold zone.

- These processes could erode the ice sheet if use for a prolonged period of time.

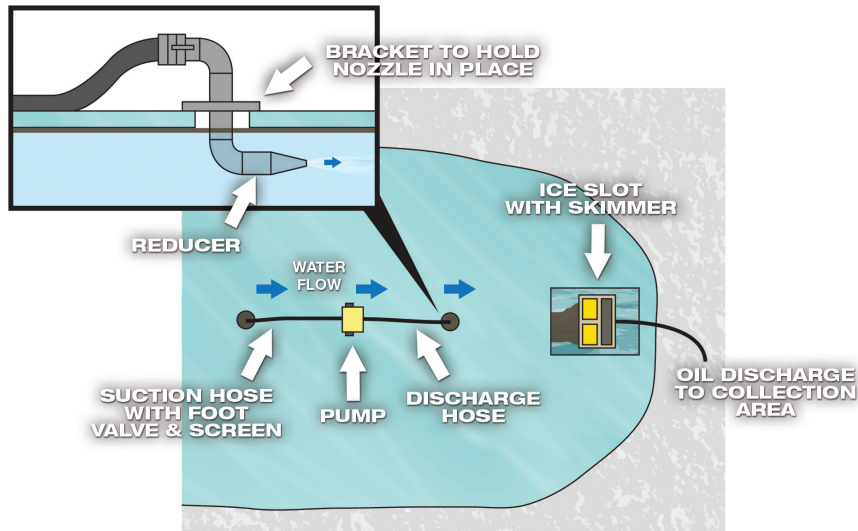


Diagram 4.1.4c Directing Oil Under Ice

4.1.4 | Ice Tactics | Ice Slotting

When spilled during winter freezeover, oil may be carried by currents beneath the ice. Sections of ice must be removed in order for the product to rise to the surface, allowing for containment and recovery.



Ensure ice assessment has been completed.



Refer to company PPE standards for operating free-hand chain saws.



Mark open holes with pylons, wire flags or other safety markers.

Purpose: To free trapped product for recovery in an ice-covered watercourse and to prevent its further spread

Application: When product needs to be contained and recovered on an ice-covered watercourse.

Environmental Considerations: Ensure mechanical equipment is free of petroleum lubricants. Do not refuel mechanical equipment on ice unless secondary containment has been provided.

Equipment Required: Chain saws, chain saw slotting guides, ice auger, Ditch Witch, backhoe, pry bars/tamper bars (approximately 5 feet / 1.5 meter), rope, chalkline, crane, ice hooks, A-frame hoist, T-bar, shovels, mechanical snow removal equipment (for site snow clearing once site has been approved for operations), snow fence and stakes, chalk line, aerosol paints (not white), wire flags (not white), chain block lifter(s) with tripping line, ladle, slot cleaning basket (for ice debris) (optional), plywood sheets, propane torch with propane bottle(s), toboggan or sled for equipment transport or snowmobile with towed sled (optional), tent for recovery area.

Recovery Equipment Options: Skimmer, pump, hoses, temporary liquid storage capacity and vacuum truck.

4.1.4 | Ice Tactics | Ice Slotting



Tips: - Cut blocks at a slight angle they will be easier to remove than if cut vertically.

- A wider slot at the upstream end will aid oil collection.

- When using a crane or excavator to remove blocks, they may shift unexpectedly on the extraction chain. Ensure that personnel stand a safe distance from this operation. An ice hook can be attached to slide the block away.

- When manually extracting blocks with pry bars or tamper bars, place at least two responders on either side of the block and force bar underneath the block, which will allow it to rise out of water. An ice hook or ice anchor can be attached to slide block away.

Operation:

- Ensure an ice assessment has been performed before beginning any operations.
- Mark out the area where the Ice Slot will be cut, this helps to guide the worker making the cuts.
- Auger holes can be drilled in the center of each block prior to cutting through ice to allow a T-bar to grasp the block from underneath, allowing an A-frame hoist or crane to lift blocks out. Alternatively, an ice anchor can be used instead of drilling and auger hole.
- Free-hand chain saws or chain saws mounted inside slotting guides can be used to cut blocks of ice.
- A skimmer or vacuum truck hose can be placed at the base of the J-slot to recover product.

4.1.4 | Ice Tactics | Ice Slotting

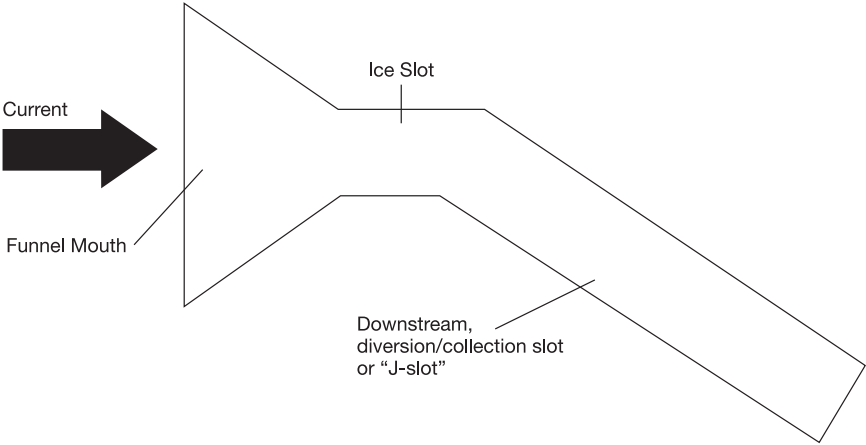


Diagram 4.1.4d J-Slot Template

4.1.5 | Ice Tactics | Through Ice-Deflector/Diversion Wall



Tips: - A saw sleigh or slotting guide should be used, as manually-sawed lines are unlikely to be straight and vertical.

- Overlapping auger holes or trenching tools can be used to create the slot.

- It is usually impossible to recover the plywood sheet post-response. Therefore, it is normally acceptable to cut it off at the ice sheet surface to prevent it being a hazard to winter river users.

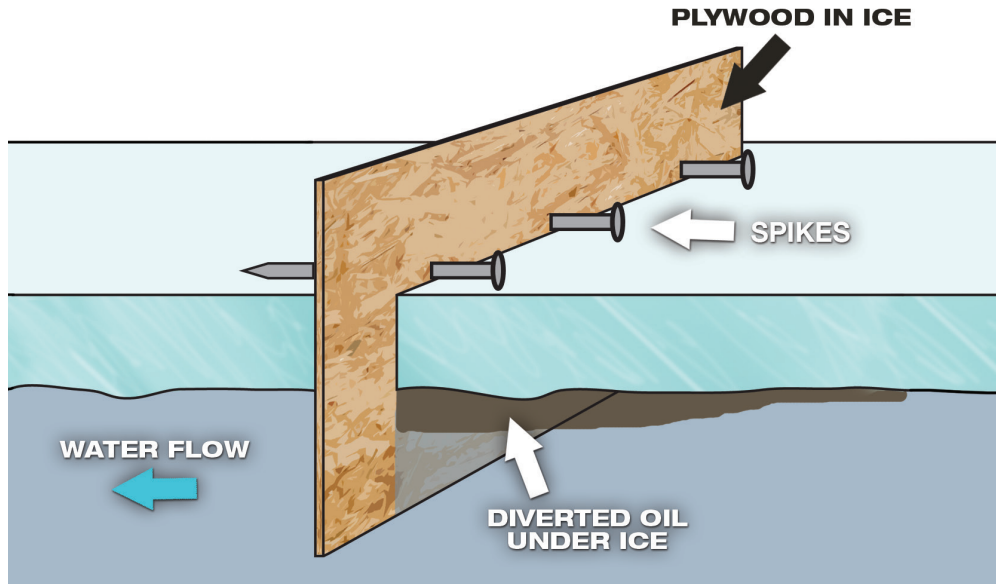


Diagram 4.1.5a Through Ice-deflector/Diversion Wall

4.1.5 | Ice Tactics | Through Ice-Deflector/Diversion Wall

The deflection walls are made by installing a barrier (plywood or puck boards) vertically through the ice.

Purpose: To deflect or divert an under-ice spill towards a desired direction such as into an ice slot for recovery.

Application: In wider, faster watercourse under ice or where the weight bearing capacity does not support heavier pieces of equipment.

Environmental Considerations: Avoid disturbing the stream bed with ice auger or diversion wall, or by pushing ice blocks under the ice sheet.

Equipment Required: 4 x 8 feet / 1.2 x 2.4 meters 1/2 or 3/4 inch / 12.7 or 19 mm thick plywood sheet(s), spikes, chain saw with chain/bar of sufficient length to cut completely through the ice sheet; saw sleigh that holds the saw vertically while cutting.

Optional but Recommended: Spikes, wooden wedges and hammer to hold the plywood in place.

Operation:

- Ensure an ice assessment has been performed before accessing the ice sheet.
- Determine position and angle for deflector wall(s). Mark outline on the ice. Two parallel saw cuts, approximately 3/4 inch / 19 mm apart, will make it easier to drive the plywood sheet down into the ice.
- Place the plywood sheet into the cut ice. Place a wood block on the top edge to reduce damage to the plywood sheet itself. Sledge hammer the plywood sheet vertically downward until it reaches the required depth beneath the ice sheet. Approximately 8 - 12 inches / 20 - 30 cm is normally sufficient, depending on the expected volume of oil and the water depth beneath the ice. If ice thickness is greater than about 36 - 40 inches / 91 - 101cm, the plywood will need to be installed vertically to reach sufficiently far below the ice sheet base. Do not rest the plywood base against the river bed, as this can seriously affect the water flow/direction in smaller rivers. The displaced ice will normally break off and be carried downstream by the water flow.
- Secure the plywood sheet in place with spikes or wooden wedge(s) between it and the ice cut on the ice surface, if necessary. Install re-bar to support and adjust barrier in ice.

Inland Spill Response Tactics Guide

Additional Equipment for Containment and Recovery Tactics

5

5.1 | Ground Tackle and Anchors

Released oil will be recovered to the greatest extent possible. Recovery will involve use of equipment and temporary storage as determined by plans and the scope of the incident.

Oil spill response operations can generate large volumes of waste in a short period of time. Plans for characterization, treatment, handling, disposal and temporary storage of wastes during initial stages of an oil spill response are important considerations and should be discussed with Environment Department personnel who will coordinate with the appropriate regulatory agencies. As with containment and recovery equipment, there are many temporary storage options that can be made to meet operational requirements.

5.1.1 | Ground Tackle and Anchors | Drag Embedment (In-water) Anchors

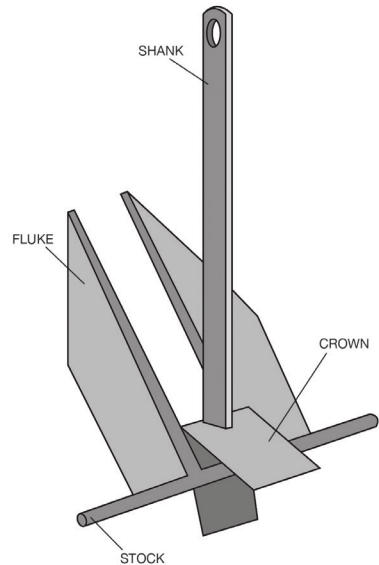


Diagram 5.1.1a Danforth Anchor

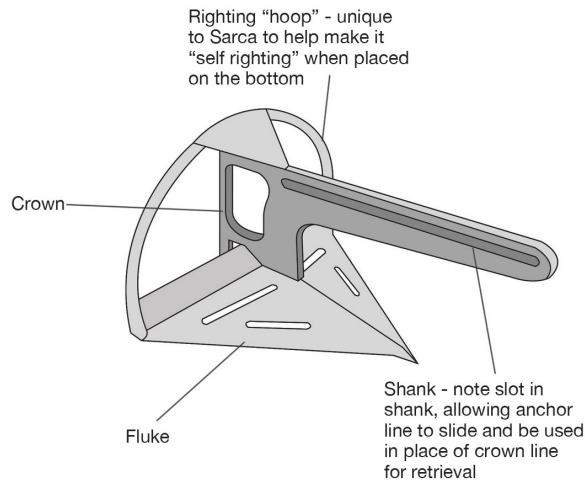


Diagram 5.1.1b Sarca Anchor

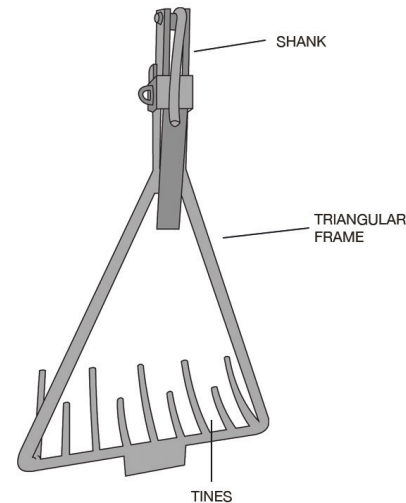


Diagram 5.1.1c Rake Anchor

5.1.2 | Ground Tackle and Anchors | Shoreline Anchors

Anchor points can also be established on the shoreline. Trees, for instance, when properly protected from chafing damage, can be used as anchors. Any tree with a caliper (trunk diameter) of greater than 6 inches / 15 cm is a candidate for use as a tie-off or anchor point.

Spade, Rake and T-Post anchors are examples of shallow water or shoreline anchors that can be installed by response personnel without boats. They are generally pushed or pounded into the bottom sediment.

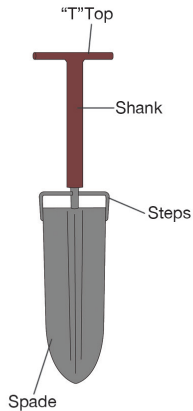


Diagram 5.1.2a Spade Anchor

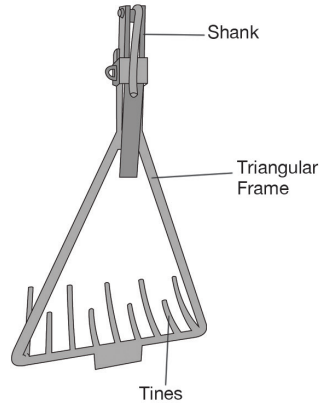


Diagram 5.1.2b Rake Anchor



Diagram 5.1.2c Screw Anchor

5.1.2 | Ground Tackle and Anchors | Shoreline Anchors

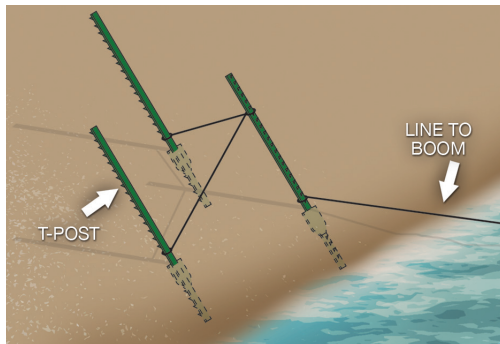


Diagram 5.1.2d T-Post Anchor

T-Post Anchor

Some points of interest for the T-post anchor set:

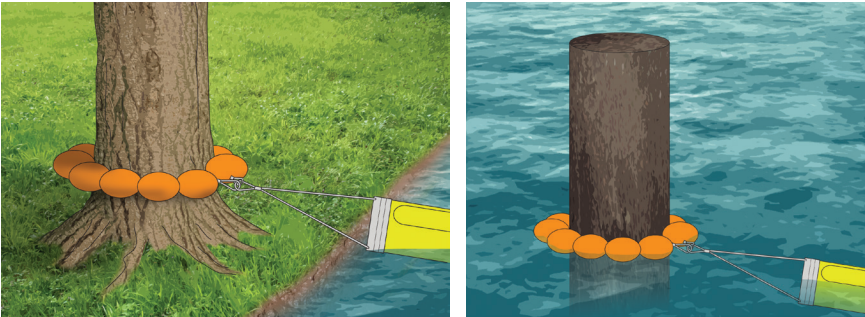
- Tie rope from front top to rear bottom.
- Face T-post nubs forward (toward the boom) on the front post and backward (away from the boom) on the rear posts.
- Overlap rope wraps on the rear post before tying to help prevent them from sliding up the post.
- Pound T-posts in, angled away from the boom pull direction using a post pounder.
- To reinforce this anchor in sand or in loose dirt, use another set of T-posts and a top-to-bottom rope behind the rear posts.



Caution: Ensure ground disturbance has been completed prior to installation

5.1.3 | Ground Tackle and Anchors | Anchors of Opportunity

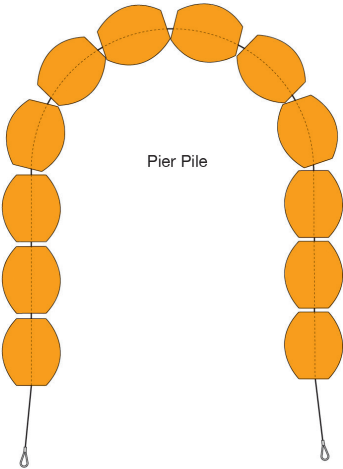
If there are man-made structures such as road bridges or piers in the vicinity, pilings that support these structures can sometimes be used as midstream anchoring points. Piling bridles depicted below will prevent damage to pilings and allow the bridle to adjust to changes in water level.



Tip: - Piling bridles can be used to protect trees.



Solid core floats compress under pressure.



5.2 | BoomVane™

A BoomVane™ offers an alternative to ground tackle for deploying boom in moving water and holding it in place by harnessing the power of the current. There are five sizes of BoomVane™ in regular use in inland waters, the 0.3m, 0.5m, 1m, 1.5m and 2m. The BoomVane™ is designed for both shore-based and vessel operations with containment boom.

BoomVane™ is constructed as a cascade of vertical wings mounted in a rectangular frame. Powered by the current, BoomVane™ is held by a single mooring line, and then swings out toward the opposite shore with the oil boom in tow. Its operation is based upon the science of sailing with the art of flying a kite, in the water.

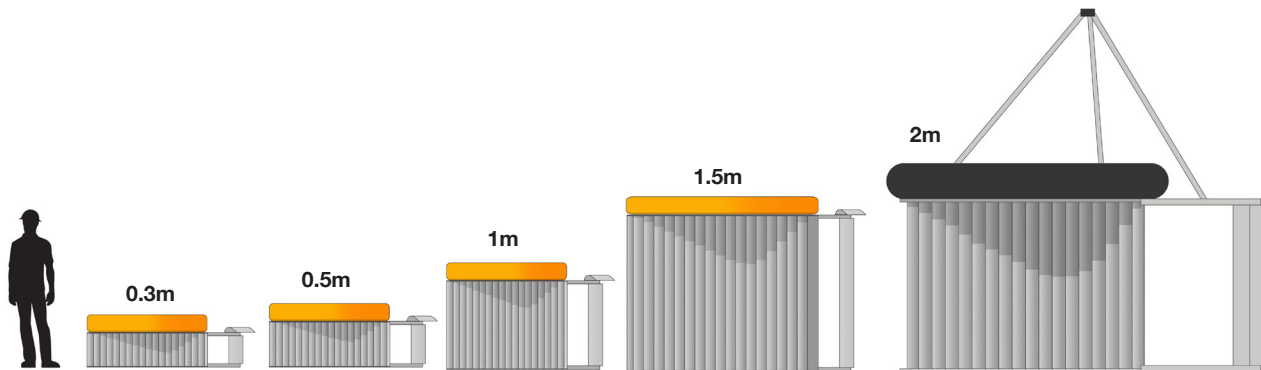


Diagram 5.2a BoomVanes™

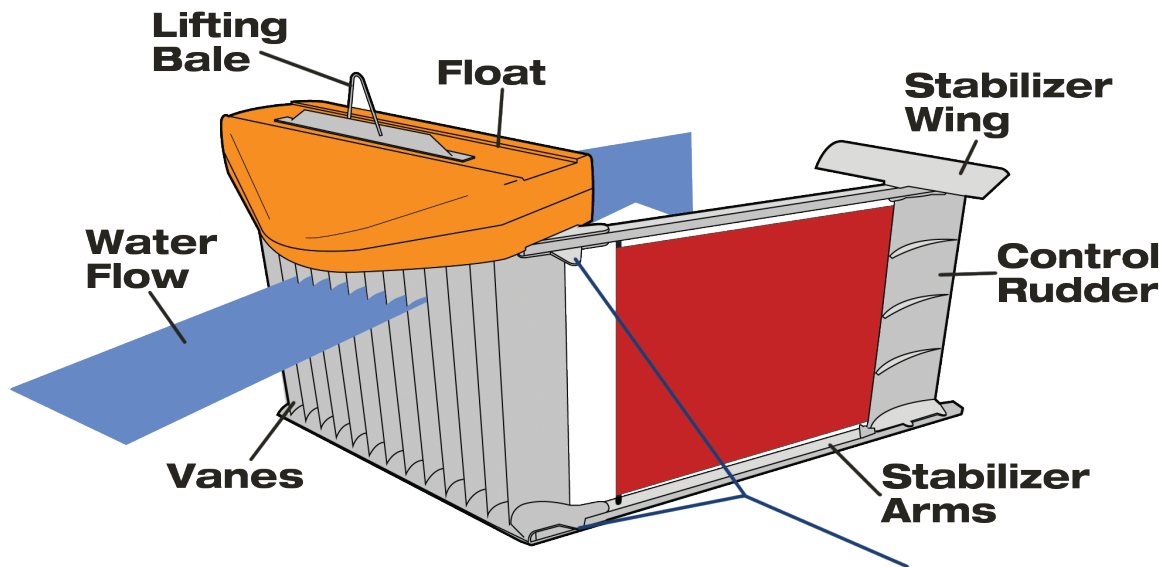


Diagram 5.2b 1.0 Meter Standard BoomVane™

5.3 | NOFI Current Buster®

The NOFI Current Buster® technology contains and controls oil spill with minimum loss at up to 5 knots towing speed. It incorporates a separator combined with a temporary storage unit. The thick layer of oil in the separator provides excellent recovery rates. It is suitable for most types of oil. It can be operated as a single vessel sweep system in combination with BoomVane™ systems and are available in four different sizes depending on application. Tactics for the NOFI Current Buster® 2 and NOFI Current Buster® 4 can be found in section **3.4.1** of this manual.

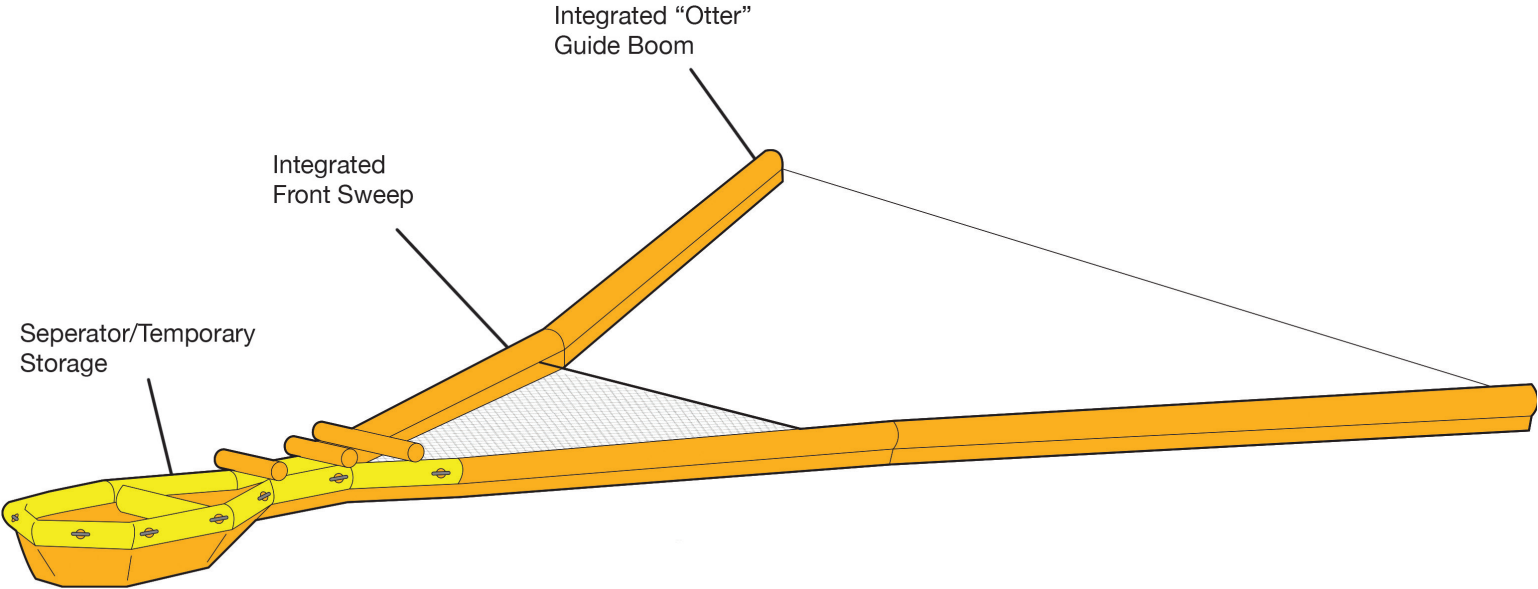


Diagram 5.3a NOFI Current Buster®

5.4 | Skimmers

Selective skimmers rely on oleophilic (oil-attracting) material that can be passed through the oil-water interface. Selective skimmers collect a higher concentration of oil in the recovered fluid stream than non-selective skimmers. Non-selective skimmers are usually weir or suction devices that recover fluid indiscriminately.

The table below is a guide developed by the American Society for Testing and Materials (ASTM) for the selection of oil skimmers relative to incident criteria.

Table 5.4a ASTM Skimmer Selection Guide

Skimmer Type	Oil Type	Mode	Debris Tolerance	Wave Tolerance	Currents
Drum	Wide range of oil viscosities	Stationary	Debris must be managed to allow flow of oil to skimmer	Low sensitivity to waves with height less than diameter of drum	Not generally used in currents
Disc	Low to medium viscosity	Stationary	Debris must be managed to allow flow of oil to skimmer	Low sensitivity to waves with height less than diameter of disc	Not generally used in currents
Brush	Medium to high viscosity	May be operated in stationary mode if current is present	Effective in most forms of small debris	Low sensitivity to waves	May be operated in stationary mode if current is present
Belt	Medium to high viscosity	Stationary or advancing	Relatively insensitive to most types of debris	Low sensitivity to waves	Some units can work in currents greater than one knot
Rope Mop	Wide range of oil viscosities	Stationary	Generally not affected by debris	Good wave-following characteristics in nonbreaking waves	Typically operated in low current environments

5.4.1 | Skimmers | Selective (Oleophilic) Skimmers

5.4.1a | Drum Skimmer

Drum skimmers (smooth and grooved) use an oleophilic drum rotating at low rpm to separate oil from water. Scraper blades remove the recovered oil from the rotating drum and direct it to a trough, from where it can be pumped or sucked into a temporary storage device. Some of the lightest units can easily be carried by one or two people. Drum skimmers are stationary skimmers. They function most effectively in near-zero relative current velocities.

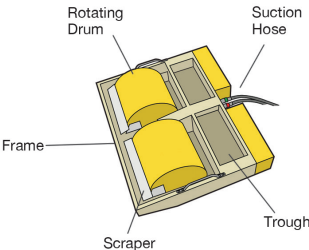


Diagram 5.4.1a Drum Skimmer

5.4.1b | Disc Skimmer

Disc skimmers are similar to drums, except that the oleophilic component of the separation device is a disc or series of discs mounted in parallel. They can be single or multiple banks of discs. Historically, disc skimmers have used smooth or brushed surfaces on the individual discs, and offer only stationary recovery. However, recent design improvements have incorporated grooved discs and unique housings that allow recovery in both stationary and advancing modes at speeds up to 3 knots. Grooved discs have proven to have higher recovery rates than smooth discs.

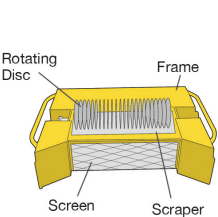


Diagram 5.4.1b Disc Skimmer

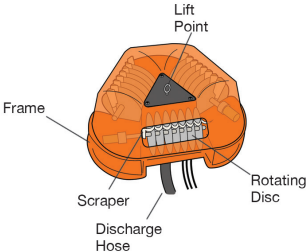


Diagram 5.4.1b Multi-Sided Skimmer

5.4.1 | Skimmers | Selective (Oleophilic) Skimmers

5.4.1c | Brush Skimmer

Brush skimmers use chains or drums equipped with oleophilic bristles to separate oil from water. They are more effective on thicker or more viscous oils. Some brush skimmers rely on currents or forward motion to introduce oil and water to the brushes. Oil is removed from the bristles by combs and scrapers.

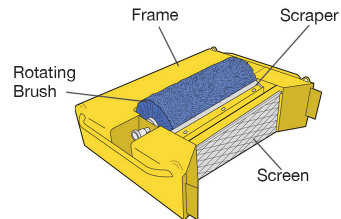


Diagram 5.4.1c Brush Skimmer

5.4.1d | Belt Skimmer

Oleophilic belt skimmers can either be upwardly or downwardly moving belts. For lifting belts, the belts themselves are oleophilic. Oil is removed from the belt by scrapers and squeeze rollers, similar to the wringer rollers found on old washing machines. On submerging belt skimmers, or dynamic inclined planes, oil adheres to the belt and is forced downward. Oil is then separated from the belt using a scraper, and allowed to float up into a collection well that is open at the bottom. Capable of stationary and advancing skimming, belt skimmers are effective in a wide range of viscosities.

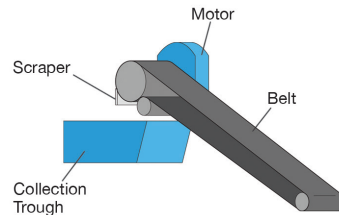


Diagram 5.4.1d Belt Skimmer

5.4.1 | Skimmers | Selective (Oleophilic) Skimmers

5.4.1e | Rope Mop

A rope mop uses a continuous loop of oleophilic filaments attached to a central tension member, laid down on the surface and drawn through the oil. The oiled rope mop is pulled upwards out of the fluid and passed through squeeze rollers to remove the oil. Rope mops are traditionally stationary skimmers.

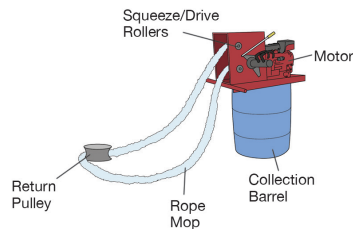


Diagram 5.4.1e Rope Mop

5.4.1f | Arctic Bucket Brush

The arctic bucket brush is an active skimmer ideally suited for the recovery of contained oil in ice conditions. The arctic brush bucket skimmer is fitted to a dedicated crane and can be used either with the oleophilic (oil attracting) brush wheel skimmer that rotates through the oil/water interface or the integral bucket in a weir skimming mode. The bucket can also be used to scoop solid heavy oil sludge or remove other materials such as ice. The skimmer is controlled by a single operator, can be used in a stationary or sweeping mode and is unaffected by ice or debris.

Some skimmers offer floating skimmer heads with interchangeable skimming mechanisms. This allows users to select the skimming technology that best fits the requirements of spill recovery. (Not shown.)

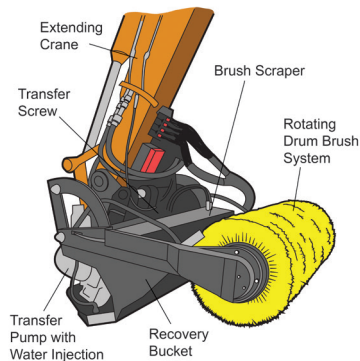


Diagram 5.4.1f Arctic Bucket Brush

5.4.2 | Skimmers | Non-Selective Skimmers

5.4.2a | Weir Skimmer

Weir skimmers encourage fluid to flow over a shallow lip or weir by continuously pumping from behind the weir. The surface current created by the pumping draws water and oil to the unit. These units are very lightweight and easy to operate, and are suitable for lighter, less viscous oils. However, they are not efficient separators of oil from water. They recover large quantities of water with the oil.

5.4.2b | Circus Skimmer

Oleophilic belt skimmers can either be upwardly or downwardly moving belts. For lifting belts, the belts themselves are oleophilic. Oil is removed from the belt by scrapers and squeeze rollers, similar to the wringer rollers found on old washing machines. On submerging belt skimmers, or dynamic inclined planes, oil adheres to the belt and is forced downward. Oil is then separated from the belt using a scraper, and allowed to float up into a collection well that is open at the bottom. Capable of stationary and advancing skimming, belt skimmers are effective in a wide range of viscosities.

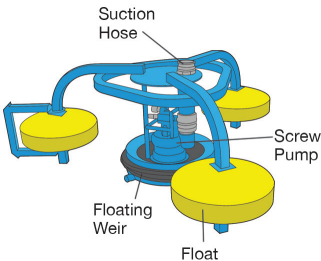


Diagram 5.4.2a SeaSkater Weir Skimmer

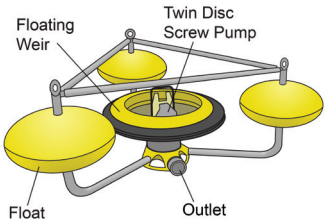


Diagram 5.4.2a Foilex Weir Skimmer

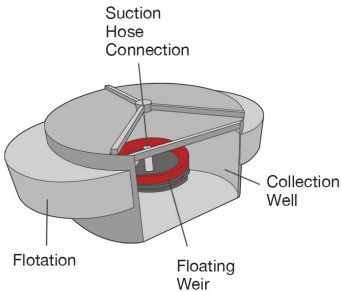


Diagram 5.4.2b Circus Skimmer

5.4.2 | Skimmers | Non-Selective Skimmers

5.4.2c | Broad Suction Skimmer

Broad suction skimmers are another example of non-selective skimmers. Powered by a vacuum or pump, and designed for still water applications, these collectors allow an operator to “sweep” an area of the water surface to remove floating oil. The broad suction collectors can be attached directly to a vacuum tanker.

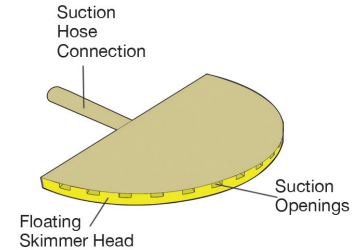


Diagram 5.4.2c Broad Suction Skimmer

5.4.2d | Adjustable, Half-Barrel Weir-Type Skimmer

This half-barrel, weir-type skimmer pivots on a central crossbar, enabling it to be adjusted to capture the approaching waterborne spill while reducing the amount of water intake. The two most common models are the .6 meter wide with one spill recovery pipe and the 1.2 meter wide with two spill recovery pipes. In both cases the pipes are camlocked for hose attachment. It is essential that this device be manned during operation in order to limit the quantity of water recovered with the oil. Unmanned, this skimmer has been known to recover over 99 percent water, thus should be continuously monitored while in operation. Some units have been equipped with adjusters that will lock the half barrel in a particular position for this purpose. The skimmer works best for recovery of very deep liquid product.

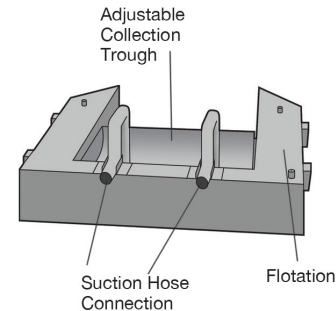


Diagram 5.4.2d Adjustable, Half-Barrel Weir-Type Skimmer

5.5 | Power Units

5.5.1a | Pneumatic Unit

A pneumatic unit operates utilize compressed air to generate motion for recovery. Can be paired with many different skimmers to pump product into recovery tanks.

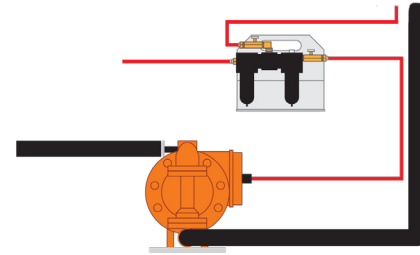


Diagram 5.5.1a Pneumatic Unit

5.5.1b | Hydraulic Unit

A compact and portable diesel driven hydraulic power unit for operating a range of equipment. A control panel with valves to control flow of the two hydraulic circuits, skimmer and pump.

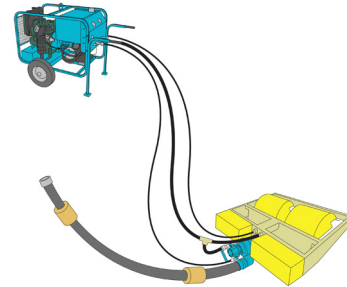


Diagram 5.5.1b Hydraulic Unit

5.6 | Sorbents

Sorbents (both absorbents and adsorbents) are a family of disposable textile or granular products manufactured from oleophilic materials. Hydrocarbon-only sorbents are preferentially wetted by oil and mostly repel water. They are predominately single-use products. When allowed to come in contact with oil on water, they will absorb or adsorb the oil over time. In general, they come in the following forms.

5.6.1 | Sheets, Pads, Pillows, Rolls

Generally smaller in size. Useful for spot cleaning by hand.

5.6.2 | Sorbent Booms

Sorbent booms are easily deployed in low current environments. Usually sausage-shaped, with a few inches of freeboard (height above water) when floating.



Tip: If sorbents are placed into plastic bags ensure that they are double bagged prior to placing within a labeled secondary containment.

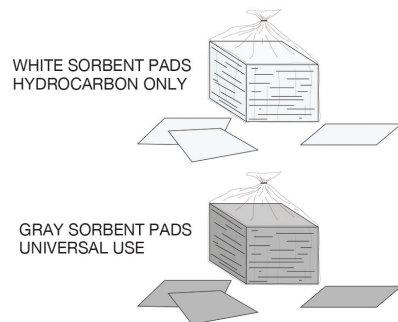


Diagram 5.6.1a Sheets, Pads, Pillows, Rolls

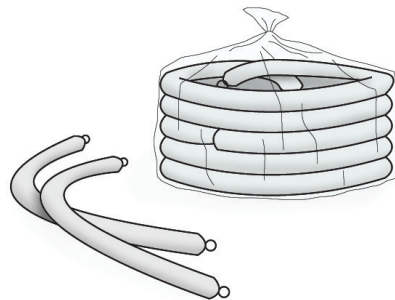


Diagram 5.6.2a Sorbent Booms

5.6.3 | Sorbent Sweeps

Long, narrow sheets of sorbent material with an integral tension member, sorbent sweeps can be used in place of sorbent booms for managing and recovering sheens.

5.6.4 | Pom-Poms/Snares

Oleophilic filaments, both individual and attached to ropes. Particularly useful with more viscous oils. Can be used to wipe down rocks or vegetation or anchored in place to catch oil. Several individual snares may be attached along a length of rope to form viscous oil sweeps or “snare boom”.

5.6.5 | Sorbent Socks

A smaller, more compact version of sorbent booms. Useful for building small containment walls around storm drains, sumps, bilges or sewer entries.

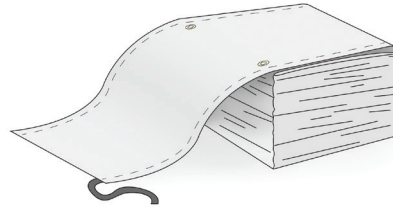


Diagram 5.6.3a Sorbent Sweeps

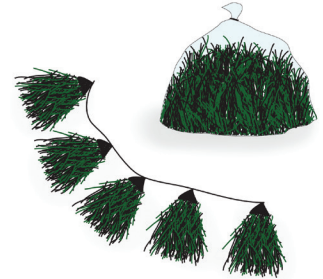


Diagram 5.6.4a Pom-Poms/Snares

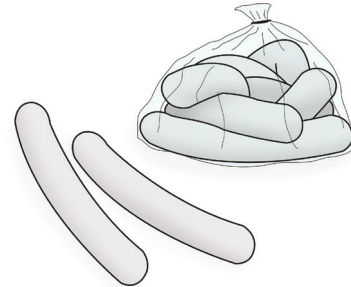


Diagram 5.6.5a Sorbent Socks

5.7 | Temporary Storage Devices

Temporary storage of recovered oil can be critical to the success of a spill response. Temporary storage tanks are usually fabric, for storage and portability. Depending on the type, they may or may not have a rigid frame. Note that open storage devices do not have positive vapor control. Hence, they may not be suitable for storage of highly volatile products.

5.7.1 | Sealed, Vented Storage Devices

A pillow tank is a collapsible storage container that provides temporary as well as long-term liquid storage. Pillow tanks can be used for potable (drinking) water, fruit juices, wastewater, chemicals, oils and more. They are made of urethane, rubber or vinyl fabrics, depending on the usage intended. Capacity ranges from 200 to 5,000 gallons (750 to 19,000 liters).



Tip: Ensure to place on level ground as slope will allow the bladder to roll.

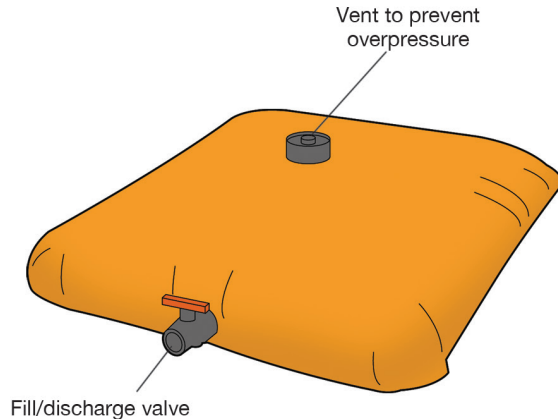


Diagram 5.7.1a Pillow Tank

5.7.2 | Open Storage Devices - Rigid Frames

Rigid frame, fabric storage devices are easy to assemble and can be taken apart and re-sited quickly. Some of them can accommodate uneven ground. Capacities range from 240 gallons / 909 liters to 20,000 gallons / 75,708 liters. The next three diagrams are examples.



Tip: Only fill to 3/4 capacity to reduce spillage from either slope or splash.

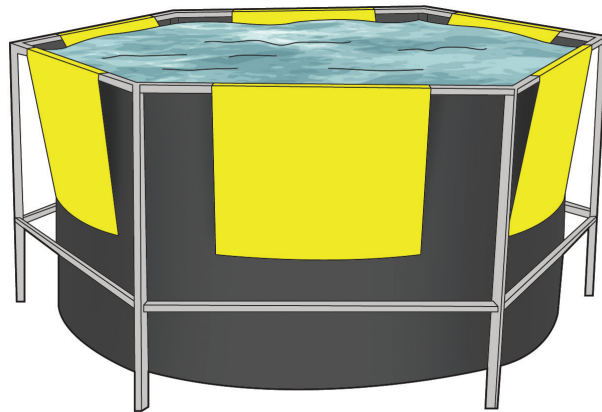


Diagram 5.7.2a Open Storage - Rigid Frame

5.7.2 | Open Storage Devices - Rigid Frame

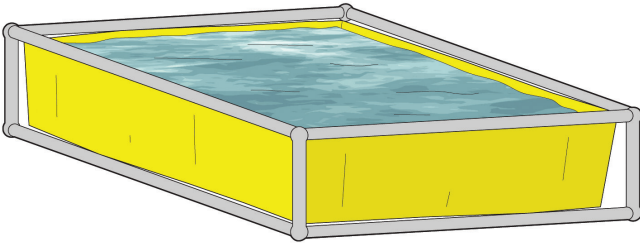


Diagram 5.7.2b Open Storage - Rigid Frame

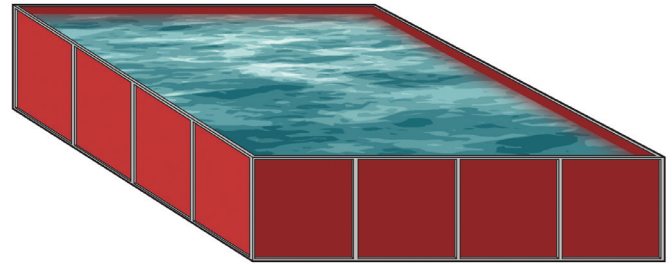


Diagram 5.7.2c Open Storage - Rigid Frame

5.7.3 | 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 liters on low-side tanks to 20,000 gallons / 75,708 liters for high-side tanks.

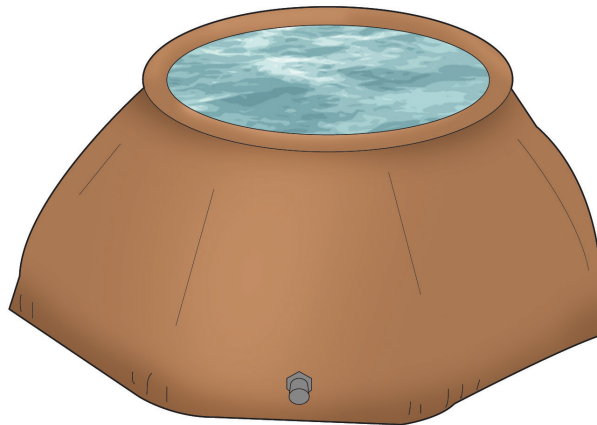


Diagram 5.7.3a Open Storage - Frameless

5.8 | 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 5.8.1a** and **5.8.2a** 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 **5.8.1b**) or drums (not shown).

5.8.1 | 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.

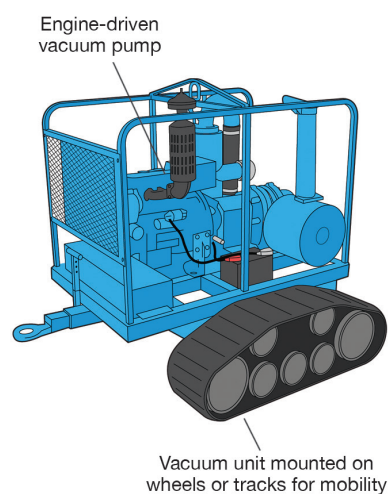


Diagram 5.8.1a Towable Vacuum Unit

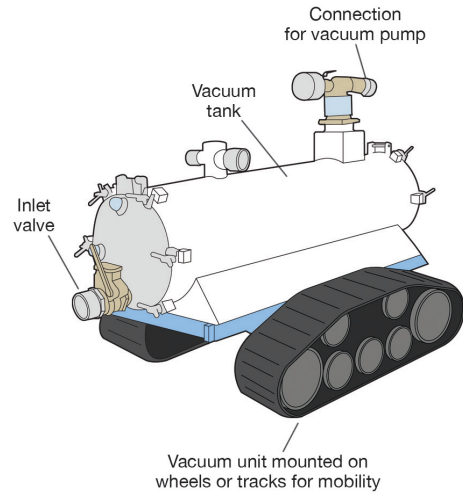


Diagram 5.8.1b Towable Vacuum Tank

5.8.2 | 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.

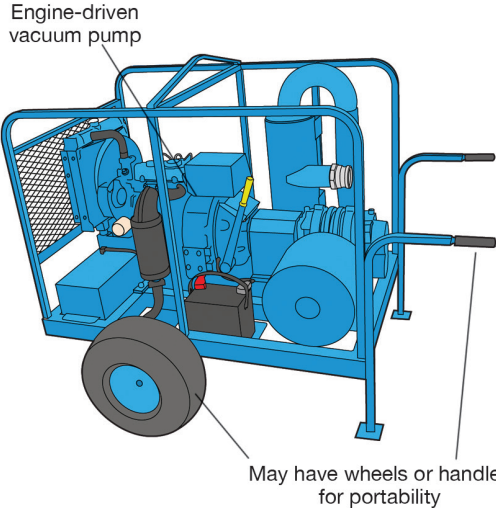


Diagram 5.8.2a Portable Vacuum Unit

5.9 | Boom, Tow Bridles and Other Attachment Devices

5.9.1 | 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.

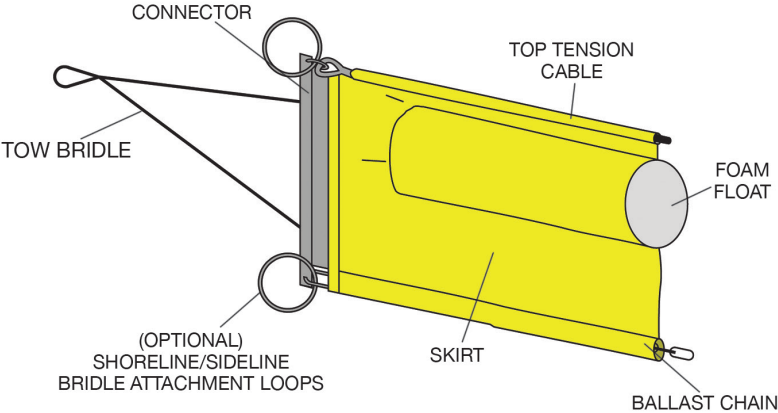


Diagram 5.9.1a Containment Boom

5.9.2 | 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 meters. Tactics for Sea Sentry II Oil Containment Boom can be found in Section 3.4.2 of this manual.

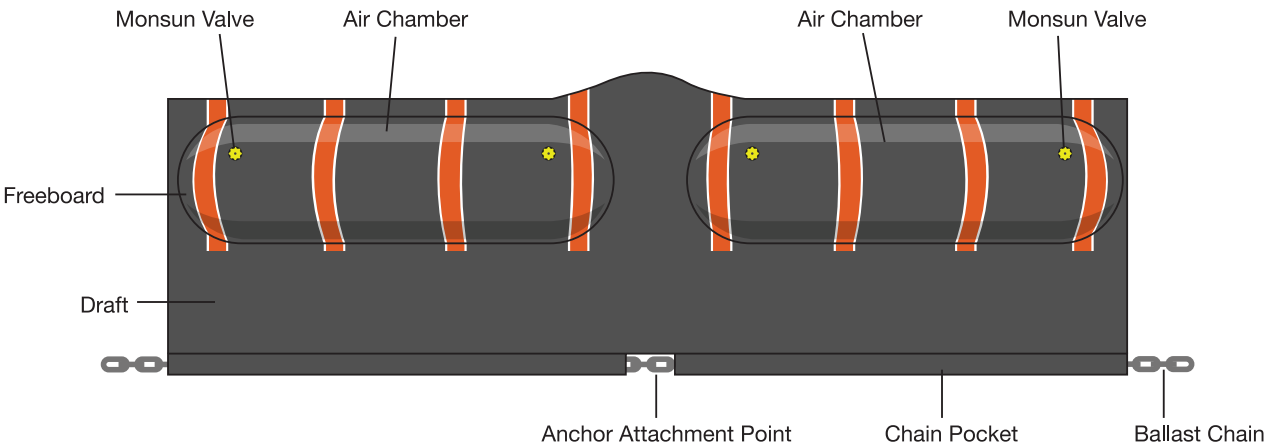


Diagram 5.9.2a Sea Sentry II Boom

5.9.3 | 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 5.9.3c**.

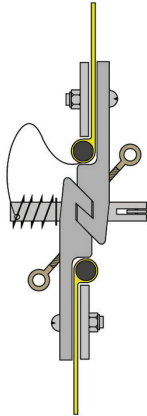


Diagram 5.9.3a
ASTM “Z” Connector

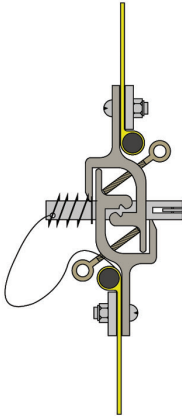


Diagram 5.9.3b
Light Duty Mini Slide Connector

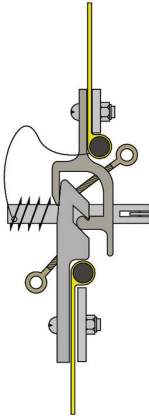


Diagram 5.9.3c
ASTM “Z” Connector with Mini Slide Connector

5.9.4 | 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.

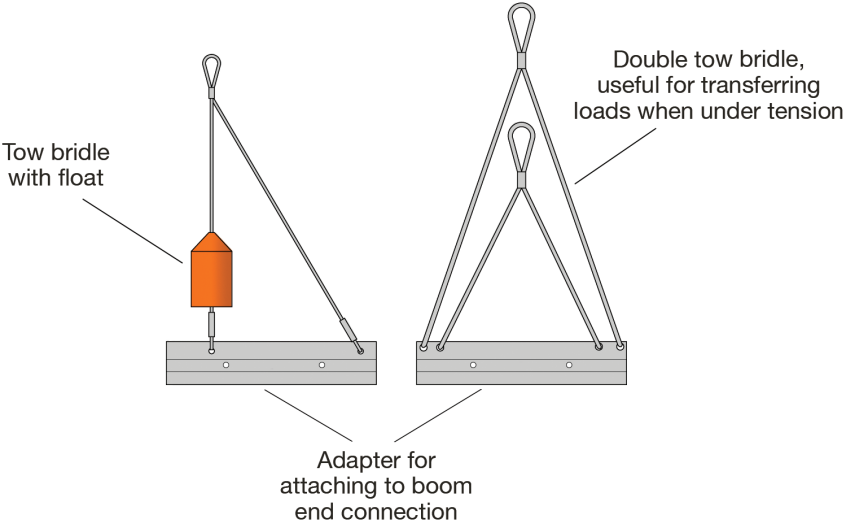


Diagram 5.9.4a Tow Bridle with Bullet Float

Diagram 5.9.4b Double Bridle

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

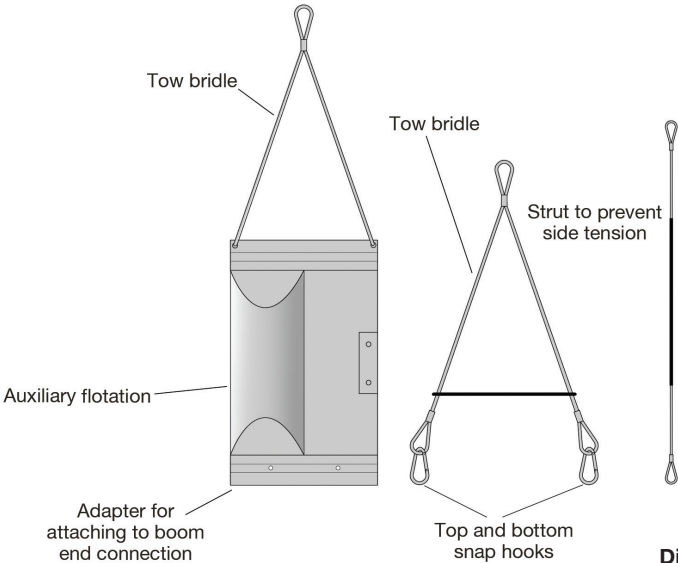


Diagram 5.9.4c Paravane

Diagram 5.9.4d Shoreline Bridle

Diagram 5.9.4e Bridge Pier Bridle
100 ft x 1 in / 30 m x 2.5 cm
Center 80 ft / 24 m rubber coated

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
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.

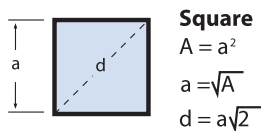
6.4 | Rope & Chain Minimum Breaking Strength

Table 6.4a 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

6.5 | 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.

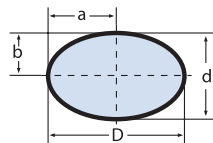


Square

$$A = a^2$$

$$a = \sqrt{A}$$

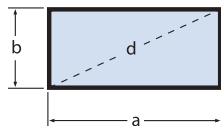
$$d = a\sqrt{2}$$



Ellipse

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

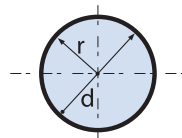
$$C = \frac{D+d}{2} \pi$$



Rectangle

$$A = ab$$

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



Circle

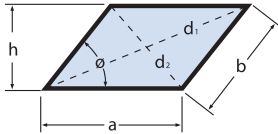
$$A = \frac{d^2\pi}{4} = r^2\pi$$

$$\approx 0.785 d^2$$

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

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

6.5 | Commonly Used Formulae

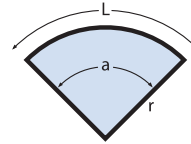


Parallelogram

$$A = ah = ab \sin \phi$$

$$d_1 = \sqrt{(a + h \cot \phi)^2 + h^2}$$

$$d_2 = \sqrt{(a - h \cot \phi)^2 + h^2}$$



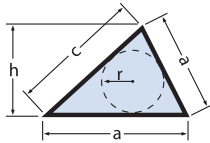
Sector of Circle

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

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

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

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

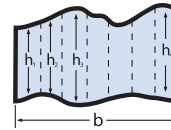


Triangle

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

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

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



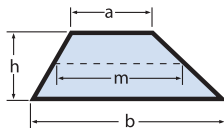
Irregular shape: divide length into parallel strips of equal width.

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

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

6.5 | Commonly Used Formulae

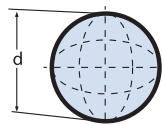
Estimating volume is as important as estimating area. For instance, it may be necessary to estimate the amount of solid waste in a debris pile to know how many roll-off boxes may be required for transport and disposal. As with areas, a quick estimate can be made by selecting a geometric shape most closely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



Trapezoid

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

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

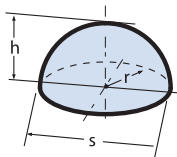


Sphere

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

$$\cong 4.189 r^3$$

$$A_o = 4\pi r^2 = \pi d^2$$



Segment of a Sphere

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

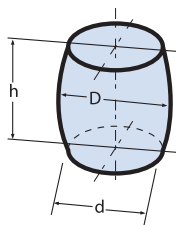
$$= \pi h^2 \left(r - \frac{h}{3} \right)$$

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

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

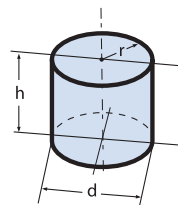
6.5 | Commonly Used Formulae

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

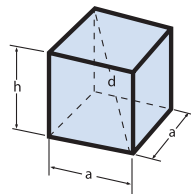
$$V = \frac{h\pi}{12} (2D^2 + d^2)$$



Cylinder

$$V = \pi r^2 h$$

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

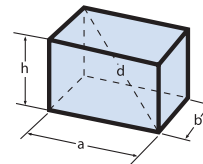


Cube

$$V = a^3$$

$$A_o = 6a^2$$

$$d = a\sqrt{3}$$



Cuboid

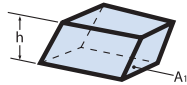
$$V = abc$$

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

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

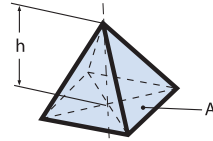
NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

6.5 | Commonly Used Formulae



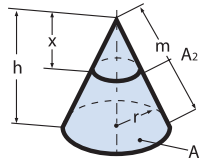
Parallelepiped

$$V = A_1 h$$



Pyramid

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



Cone

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

$$A_m = \pi m$$

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

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

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

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

6.6 | Weights of Common Gases, Liquids and Solids

Table 6.6a Weights of Common Gases, Liquids and Solids

Substance	Unit Weight (lbs / ft³)	Unit Weight (kg / m³)
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

6.7 | English/Metric Conversions

Table 6.7a English/Metric Conversions

English to Metric	
Length	
1 inch (in)	2.54 centimeters (cm)
1 foot (ft)	0.3048 meters (m)
1 mile (mi)	1.609 kilometers (km)
1 nautical mile (nm)	1.852 kilometers (km)
Area	
1 square foot (ft²)	929 square centimeters (cm²)
1 square foot (ft²)	0.0929 square meters (m²)
1 acre (ac)	4,047 square meters (m²)
1 square mile (mi²)	2.59 square kilometers (km²)
Volume	
1 US Gallon (US Gal)	3.785 liters (l)
1 Imperial Gallon (Imp Gal)	4.546 liters (l)
1 Barrel (bbl)	159 liters (l)
Velocity	
1 mile per hour (mph)	1.609 kilometers/hr (kph)
1 nautical mile per hour (knot)	1.852 kilometers/hr (kph)
1 foot per second (fps)	0.3048 meter/second (m/sec)
1 foot per second (fps)	1.097 kilometers/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 cm²	0.0129 ft²
1 m²	10.76 ft²
1,000 m²	0.247 ac
1 km	0.386 mi²
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

6.7 | English/Metric Conversions

Table 6.7a English/Metric Conversions

English to Metric	
Weight	
1 pound (lb)	0.454 kilograms (kg)
1 short ton (st)	0.907 tonne (mt)
1 long ton (lt)	1.016 tonne (mt)
Temperature	
$F^{\circ} = (C^{\circ} (9) \div 5) + 32$	
Pressure	
1 pound per square inch (psi)	0.0689 bar
1 pound per square inch (psi)	6.89 kilopascals (kPa)
1 pound per square inch (psi)	0.704 meter (water column) (mwc)
1 inch mercury (in Hg)	25.4 mm mercury (mm Hg)
1 atmosphere (atm)	1.033 kg/cm ²
1 atmosphere (atm)	760 mm mercury (mm Hg)
Flow	
1 gallon per minute (gpm)	0.227 meter ³ per hour (m ³ /hr)
1 cubic foot per minute (cfm)	1.699 cubic meters per hour (m ³ /hr)
1 barrel per day (bpd)	0.1104 liters per minute (lpm)
Power	
1 horsepower (hp)	0.746 kilowatt (kw)

Metric to English	
Weight	
1 kg	2.205 lb
1 mt	1.102 st
1 mt	0.984 lt
Pressure	
1 bar	14.504 psi
1 kPa	0.145 psi
1 mwc	1.42 psi
1 mm Hg	0.0394 in Hg
1 kg/cm ²	0.968 atm
1 mm Hg	0.00132 atm
Flow	
1 m ³ /hr	4.403 gpm
1 m ³ /hr	0.5886 cfm
1 lpm	9.057 bpd
Power	
1 kw	1.341 hp

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 liters at 60°F, 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.

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.

CONCAWE, 1983. A Field Guide to Inland Oil Spill Cleanup Techniques. Report No. 10/83, Oil Spill Cleanup Special Task Force No. 3, Den Haag.

Dickins, D.F., 2004. Advancing Oil Spill Response in Ice-covered Waters. Prepared for Prince William Sound Oil Spill Recovery Institute, Cordova, Alaska and United States Arctic Research Commission, Arlington, VA and Anchorage, AK.

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

Diagram 2.4a	Representative Decontamination Corridor	8	Diagram 3.3.1a	Components of Floating Containment Boom	34
Diagram 3.1.1a	Clay Berm with Key Profile	12	Table 3.3.1a	ASTM Guide for Boom Selection	35
Diagram 3.1.1b	Clay Berm with Key Profile and Plastic Wrap	12	Diagram 3.3.1b	Maximum Boom Angles for Various Currents	36
Diagram 3.1.1c	Snow Berm with Key Profile and Plastic Wrap	12	Diagram 3.3.2a	Shore Seal Boom	37
Diagram 3.1.2a	Interceptor Trench	14	Diagram 3.3.2b	Cross-Section of Shore Seal Boom	37
Diagram 3.1.3a	Trench and Berm	16	Diagram 3.3.3.1a	Protection of Shoreline Resources by Exclusion Booming	39
Diagram 3.2.1a	Water Bag	19	Diagram 3.3.3.1b	Protection of In-Stream Sensitive Resources by Exclusion Booming	39
Diagram 3.2.1b	AquaDam™	20	Diagram 3.3.3.2a	Deflection Booming Cascade System	41
Diagram 3.2.1c	Tiger Dam	21	Diagram 3.3.3.3a	Boom Deployment for River: Single Anchor	43
Diagram 3.2.1d	Water-Gate	22	Diagram 3.3.3.3b	Boom Deployment for River: Tandem Anchor	43
Diagram 3.2.2a	Board Weir	24	Diagram 3.3.3.4a	BoomVane™ Deflection Mode	45
Diagram 3.2.3a	Culvert Block	26	Diagram 3.3.3.4b	BoomVane™ Recovery Mode	45
Diagram 3.2.4a	Turner Valley Gate	28	Diagram 3.4.1a	NOFI Current Buster® Single and Double Vessel Configuration	48
Diagram 3.2.5a	Flexible Hose Siphon Dam	30	Diagram 3.4.1b	NOFI Current Buster® Retrieval	50
Diagram 3.2.5b	Side View of Siphon Dam	30	Diagram 3.4.1c	NOFI Current Buster® Towing Speed	51
Diagram 3.2.6a	Sorbent Booms	32	Diagram 3.4.2a	Sea Sentry Boom II Single and Double Vessel Configurations	52

8.2 | Diagram and Table Index

Diagram 3.4.3a	Arctic Brush Bucket System Tactical Illustration	56	Diagram 5.1.2b	Rake Anchor	81
Table 4.1.1a	Safety Multiplier for Temperature Effects	62	Diagram 5.1.2c	Screw Anchor	81
Table 4.1.1b	Safety Multiplier for Cracks in Ice	62	Diagram 5.1.2d	T-Post Anchor	82
Table 4.1.1c	Weight Bearing Capacity for Continuous Travel	65	Diagram 5.2a	BoomVanes™	84
Table 4.1.1d	Weight Bearing Capacity for Stationary Loads & Working on Ice	66	Diagram 5.2b	1.0 Meter BoomVane™	85
Diagram 4.1.2a	Oil Detection Under Ice	67	Diagram 5.3a	NOFI Current Buster®	87
Diagram 4.1.3a	Trench on Ice Sheet	69	Table 5.4a	ASTM Skimmer Selection Guide	89
Diagram 4.1.4a	Ice Slotting on Rivers	71	Diagram 5.4.1a	Drum Skimmer	90
Diagram 4.1.4b	Ice Slotting on Rivers	71	Diagram 5.4.1b	Disc Skimmer	90
Diagram 4.1.4c	Directing Oil Under Ice	72	Diagram 5.4.1b	Multi-Sided Skimmer	90
Diagram 4.1.4d	J-Slot Template	75	Diagram 5.4.1c	Brush Skimmer	91
Diagram 4.1.5a	Through Ice-Deflector/Diversion Wall	76	Diagram 5.4.1d	Belt Skimmer	91
Diagram 5.1.1a	Danforth Anchor	80	Diagram 5.4.1e	Rope Mop	92
Diagram 5.1.1b	Sarca Anchor	80	Diagram 5.4.1f	Arctic Bucket Brush	92
Diagram 5.1.1c	Rake Anchor	80	Diagram 5.4.2a	SeaSkater Weir Skimmer	93
Diagram 5.1.2a	Spade Anchor	81	Diagram 5.4.2a	Foilex Weir Skimmer	93

8.2 | Diagram and Table Index

Diagram 5.4.2b	Circus Skimmer	93	Diagram 5.8.1b	Towable Vacuum Tank	103
Diagram 5.4.2c	Broad Suction Skimmer	94	Diagram 5.8.2a	Portable Vacuum Unit	104
Diagram 5.4.2d	Adjustable, Half-Barrel Weir-Type Skimmer	94	Diagram 5.9.1a	Containment Boom	106
Diagram 5.5.1a	Pneumatic Unit	95	Diagram 5.9.2a	Sea Sentry II Boom	107
Diagram 5.5.1b	Hydraulic Unit	95	Diagram 5.9.3a	ASTM “Z” Connector	108
Diagram 5.6.1a	Sheets, Pads, Pillows, Rolls	96	Diagram 5.9.3b	Light Duty Mini Slide Connector	108
Diagram 5.6.2a	Sorbent Booms	96	Diagram 5.9.3c	ASTM “Z” Connector with Mini Slide Connector	108
Diagram 5.6.3a	Sorbent Sweeps	97	Diagram 5.9.4a	Tow Bridle with Bullet Float	109
Diagram 5.6.4a	Pom-Poms/Snares	97	Diagram 5.9.4b	Double Bridle	109
Diagram 5.6.5a	Sorbent Socks	97	Diagram 5.9.4c	ParaVane	110
Diagram 5.7.1a	Pillow Tank	98	Diagram 5.9.4d	Sideline Bridle	110
Diagram 5.7.2a	Open-Storage - Rigid Frame	99	Diagram 5.9.4e	Bridge Pier Bridle	110
Diagram 5.7.2b	Open-Storage - Rigid Frame	100			
Diagram 5.7.2c	Open-Storage - Rigid Frame	100			
Diagram 5.7.3a	Open-Storage - Frameless	101			
Diagram 5.8.1a	Towable Vacuum Unit	103			



enbridge.com