Inland Spill Response Tactics Guide

ENBRIDGE
Life Takes Energy

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

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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 first 72 hours of the 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 document is also placed on the **emergencyresponderinfo.com** site for use by first responders.

Introduction

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 prior training, field experience, technical instruction and equipment operation knowledge. 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 6 Lifesaving Rules, which are founded on real-life incidents at Enbridge and focus on areas of high risk and high consequence.

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Safety

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2.1 | Safety Message

Rule 1:
HAZARD MANAGEMENT

Rule 2:
DRIVING SAFETY

Rule 3:
CONFINED SPACE ENTRY

Rule 4:
GROUND DISTURBANCE

Rule 5:
ISOLATION OF ENERGIZED SYSTEMS

Rule 6:
REPORTING SAFETY INCIDENTS

Lifesaving Rules

Lifesaving Rules

Working for Enbridge means working safely. At Enbridge we value the safety of our communities, customers, contractors and employees.

The Lifesaving Rules are founded on real incidents at Enbridge at the heart of our commitment to safety.

For more information visit **ELink** and search **'Lifesaving Rules'**

2.1 | Safety Message

1. All injuries, incidents, and occupational illnesses can be prevented.
2. All operating exposures can be controlled.
3. Leaders are accountable for safety performance.
4. All employees/contractors are responsible for safety.
5. Assessment and improvement are a must.
6. We promote off-the-job health and safety for our employees 24/7.

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 Integrity, Safety and Respect 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.

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

Our Path to Zero

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.

In Case of Emergency – 24 Hour Contact

US Regions	**1-800-858-5253**
North Dakota Region	**1-888-838-4534**
CND Region	**1-877-420-8800**
Athabasca Region	**1-888-813-6844**
In Quebec	**1-780-420-8899**
Enbridge Media Hotline Canada/US	**1-888-992-0997**

2.2 | Responder's Duty

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 to include the wearing of PFD's near water and procedures for ground disturbance.

2.3 | Initial Discovery/Response Actions

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

Explore

- ☐ Ensure safety of personnel in the area.
- ☐ Determine the wind direction and approach cautiously from upwind.
- ☐ Explore the suspected release area only when wearing appropriate PPE, using the buddy system if possible.
- ☐ Conduct a hazard assessment to determine the potential for fire, explosion and hazardous toxic vapors.
- ☐ Eliminate or shut off all potential ignition sources in the immediate area.
- ☐ Use intrinsically safe equipment (e.g., flashlights, two-way radios, gas detectors with audible alarms).
- ☐ Maintain regular/scheduled communication with the Control Centre and Regional Management/on-call person.

Approach

- ☐ Verify wind direction and stay upwind.
- ☐ Are people injured or trapped?
- ☐ Are there external people involved in rescue or evacuation?

Are there immediate signs of potential hazards such as:

- ☐ Electrical lines down or overhead?
- ☐ Unidentified liquid or solid products visible?
- ☐ Vapors visible?
- ☐ Smells or breathing hazards evident?
- ☐ Fires, sparks or ignition sources visible?
- ☐ Holes, caverns, deep ditches, fast water or cliffs near?
- ☐ Is local traffic a potential problem?
- ☐ Ground conditions - ☐ Dry ☐ Wet ☐ Icy

Considerations

- ☐ If possible, photograph the area for situational awareness.
- ☐ Once support has arrived, conduct transfer of command and start preparing for tactical and planning meetings.
- ☐ If appropriate, request surveillance fly-over to determine:
  - Size and description of oil slick
  - Direction of movement
  - Coordinates of leading and trailing edge of oil slick
  - Sensitivities endangered
  - Areas of population that are threatened

2.3 | Initial Discovery/Response Actions

Confirm and Control

- ☐ Confirm identification of spilled material and check the SDS/MSDS sheets.
- ☐ Assess the spill threat, site safety and parameters such as spill volume, extent and direction of movement.
- ☐ Has pipeline(s) been shut down?
- ☐ If on water, consult Control Point and High Consequence Area (HCA) maps for appropriate response strategies for incoming resources.
- ☐ Has wind direction been confirmed and windsock erected?
- ☐ Has the public been protected or evacuation considered if necessary?
- ☐ Have all ignition sources been identified and eliminated?
- ☐ Establish exclusion zone and safe work areas (hot, warm and cold).
- ☐ Have personal protection and safety requirements been established and communicated?
- ☐ Is adequate fire protection equipment available and in place?
- ☐ Have valves been locked out if necessary?
- ☐ Are tank and VAC-truck electrical equipment properly grounded?
- ☐ Have decontamination sites and procedures been established?
- ☐ Are activities and events being logged/documented?

Communication

- ☐ Initiate actions to notify government agencies including local authorities of area affected or at risk areas via the Control Centre, Regional Management or designate.
- ☐ Complete notifications for emergency call-out, including regulatory agencies. This will be done by the Regional Management or designate.
- ☐ If excavating, has One-Call agency been notified?
- ☐ Has a Preliminary Incident Report been issued?
- ☐ Has a radio channel been established for communication between the site and other personnel in field?

2.4 | Decontamination

During investigation and mitigation operations, 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. A representative decontamination corridor for personnel is depicted in Diagram 2.4a REPRESENTATIVE DECONTAMINATION CORRIDOR. For boats, heavy or vehicular equipment, a formal decontamination cell is usually constructed in the Warm Zone, separate from the personnel decontamination area. Depending on the scope of the emergency incident, a Decontamination Plan may be developed and approved by Incident Command.

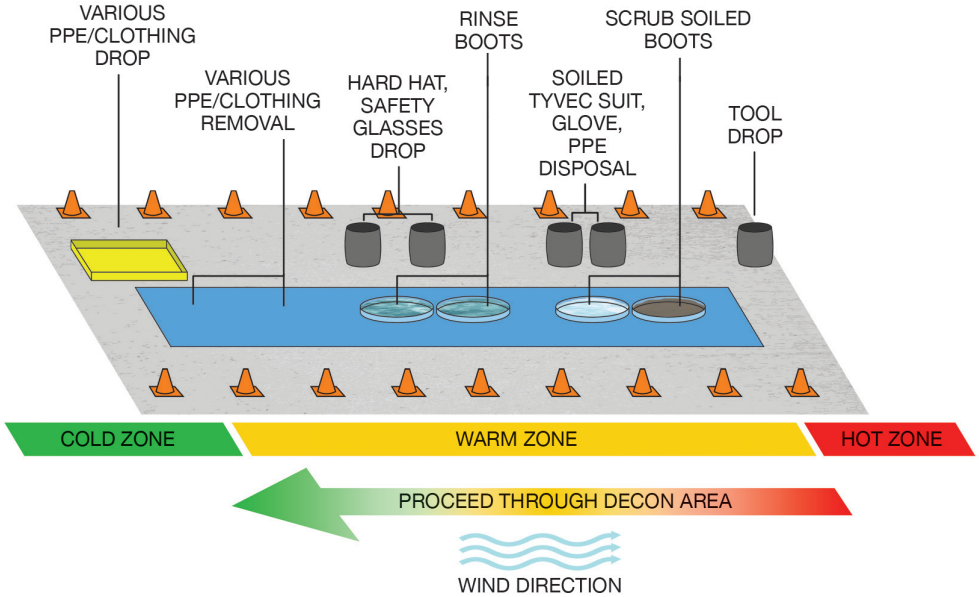

Diagram 2.4a Representative Decontamination Corridor

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Inland Spill Control Tactics

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- 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 methods to control, contain and recover spilled oil vary depending on safety, practicality, and 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? How far downstream would Control Points have to be to allow time to mobilize and travel to the Control Point?
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 called “reverse containment” can be deployed. Reverse containment seeks to exclude oil from identified resources.

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 spread downhill or percolate vertically into the soil. While the latter mechanism is usually gradual and difficult to control, horizontal spreading by gravity can frequently be contained using local materials. This section provides some useful tactics for containing spills by creating 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

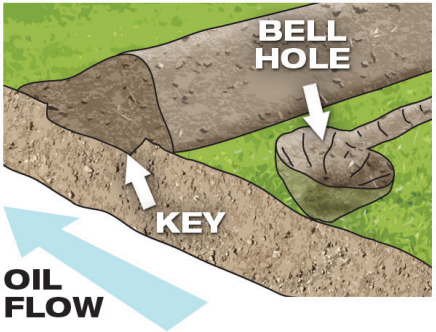


Diagram 3.1.1a
Clay Berm with Key

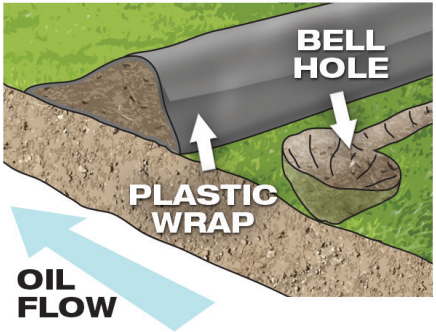


Diagram 3.1.1b
Clay Berm with Plastic Wrap

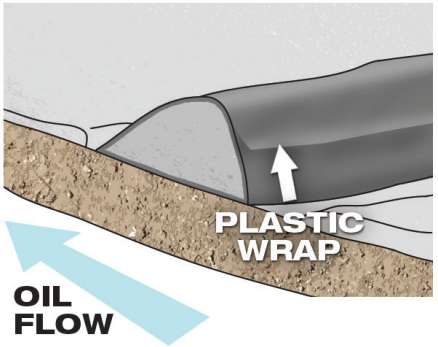


Diagram 3.1.1c
Snow Berm with Plastic Wrap
(or lightly sprayed with water)

Note: Pack snow tightly with shovel or board before spraying with water.

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: Sorbents, skimmer, pump, hoses, hose strainer, temporary liquid storage capacity, vacuum truck

Waste disposal bags and tags if sorbents are to be used

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. Pile soils/snow on downstream side of plastic (away from approaching oil).
3. Flip upstream side of plastic over berm to prevent contamination of berm contents.

3.1.2 | Land | Interceptor Trench

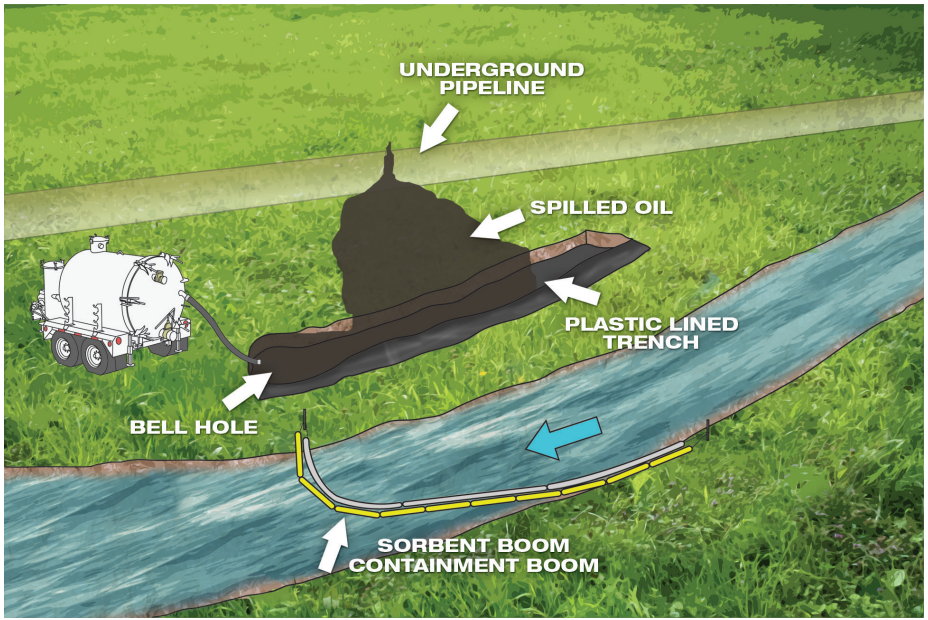


Diagram 3.1.2a Interceptor Trench

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: Sorbents, skimmer, pump, hoses, hose strainer, temporary liquid storage capacity, vacuum truck

Waste disposal bags and tags if sorbents are to be used

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

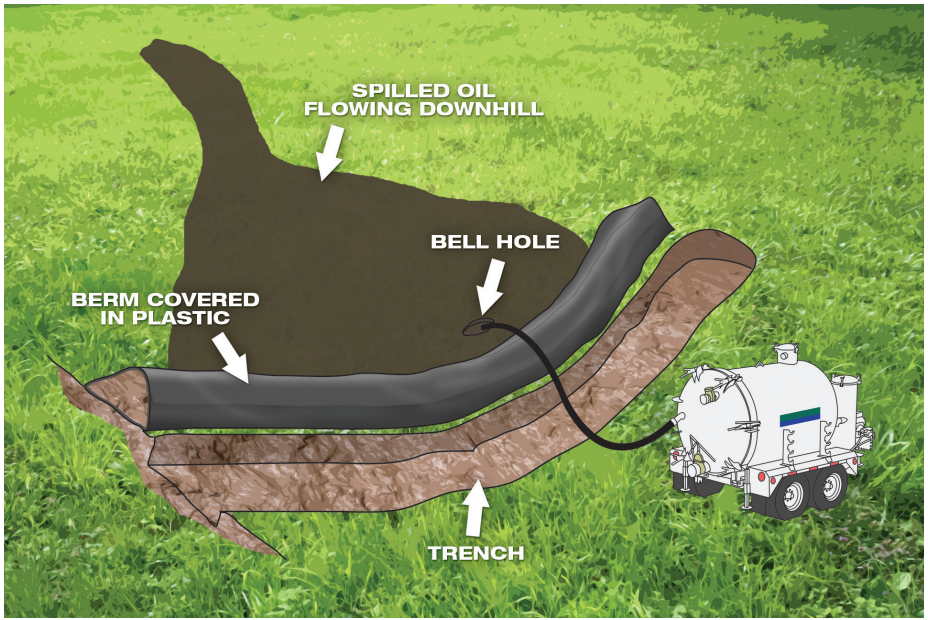


Diagram 3.1.3a Trench and Berm

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: Sorbents, skimmer, pump, hoses, hose strainer, temporary liquid storage capacity, vacuum truck.

Waste disposal bags and tags if sorbents are to be used

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 metres (33 feet) wide, a half metre 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.

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

- Pin anchors driven upstream and underflow pipe installed to pass water beneath.

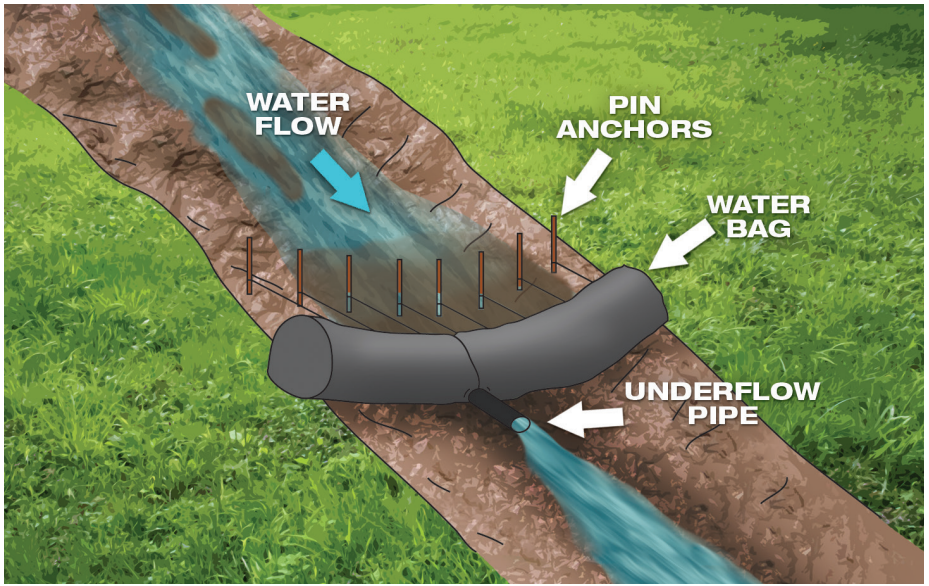


Diagram 3.2.1a Water Bag

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.

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

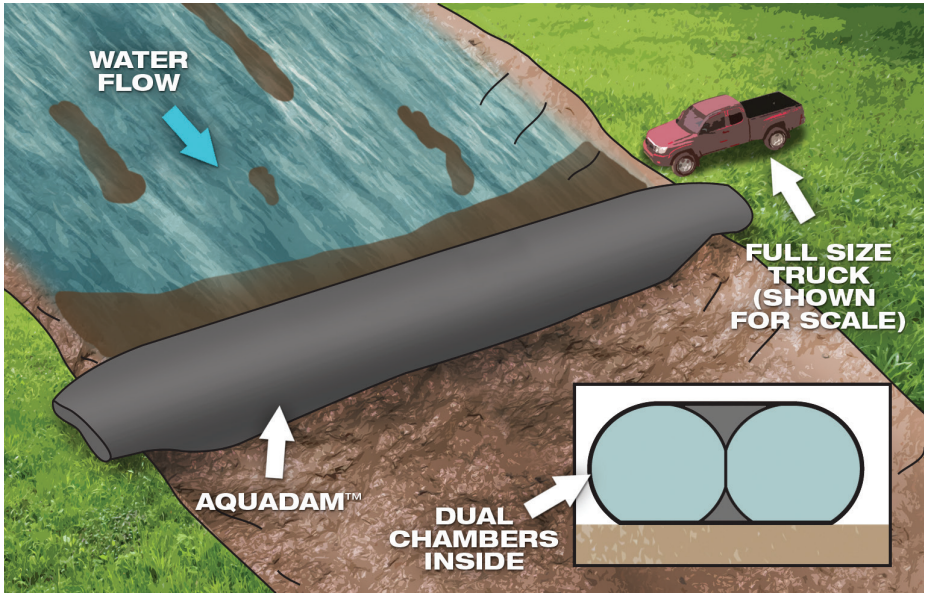


Diagram 3.2.1b Aquadam™

AquaDams™ is a registered trademark of Layfield

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.

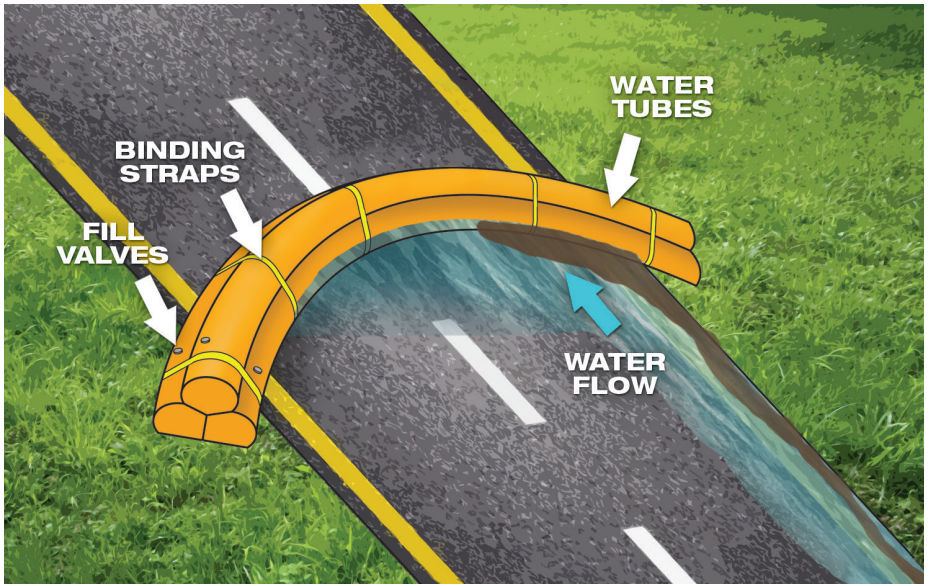


Diagram 3.2.1c Tiger Dam®

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.

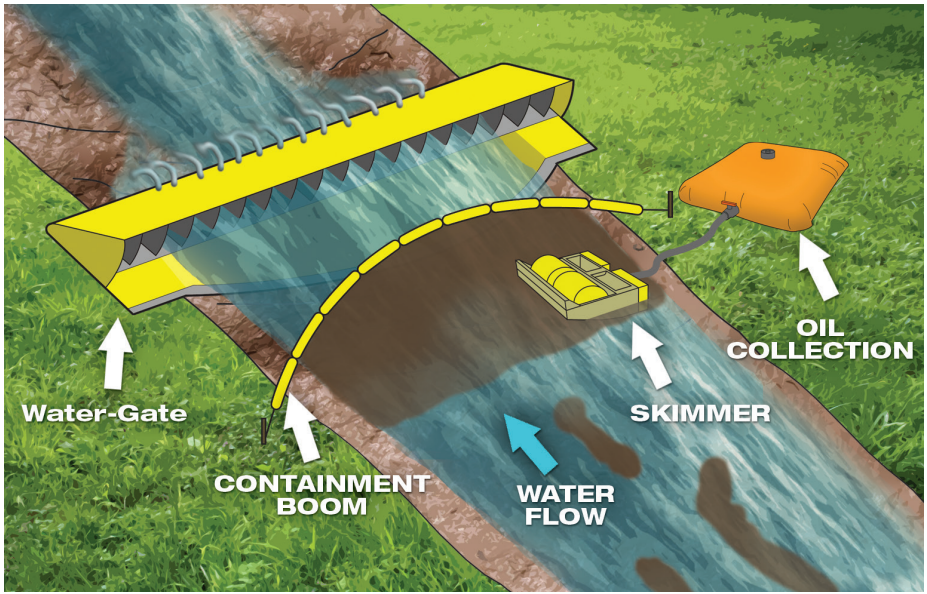


Diagram 3.2.1d Water-Gate

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: Sorbents, skimmer, pump, hoses, hose strainer, temporary liquid storage capacity, 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

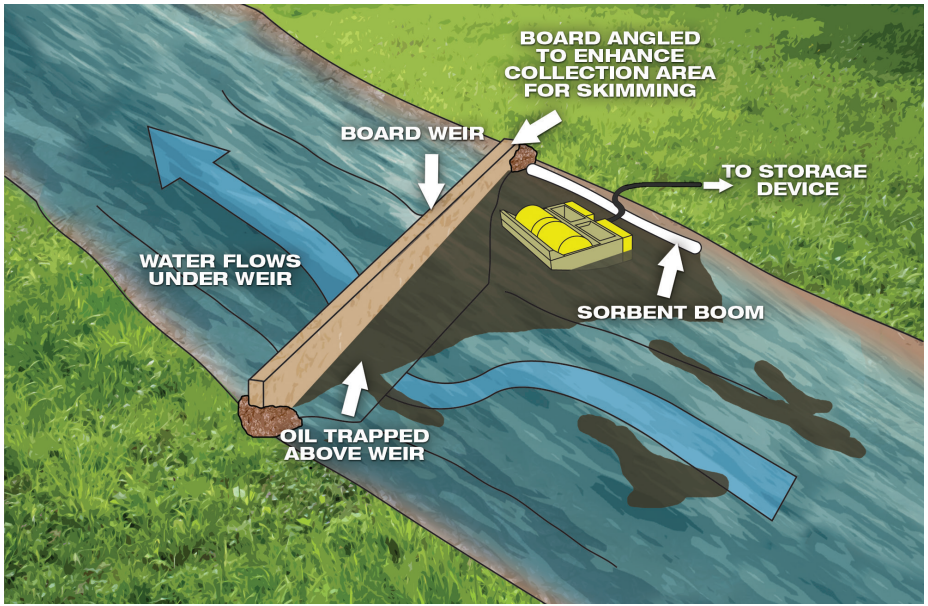


Diagram 3.2.2a Board Weir

3.2.2 | 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: Sorbents, skimmer, pump, hoses, liquid storage device or vacuum truck, as appropriate

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 | Culvert Block

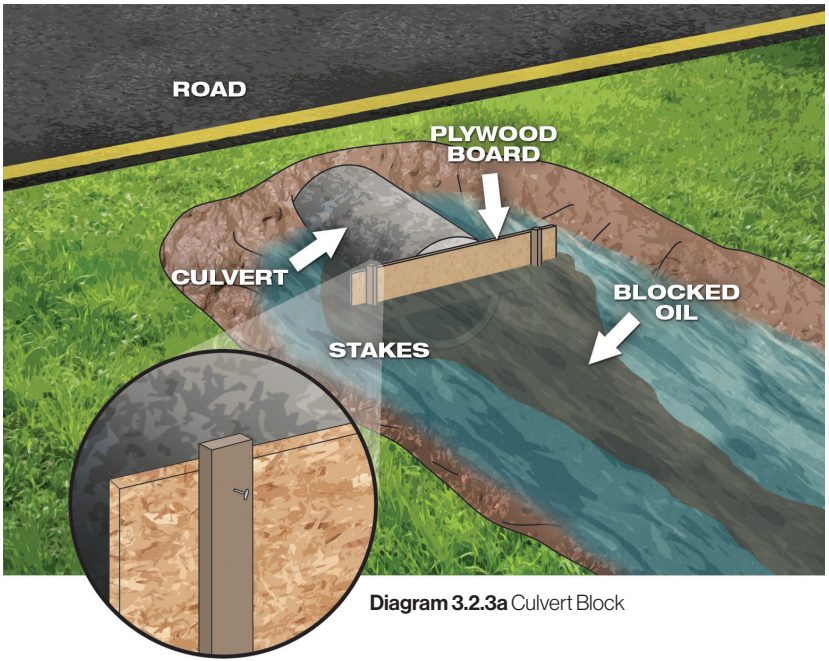


Diagram 3.2.3a Culvert Block

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: Sorbents, skimmer, pump, hoses, temporary liquid storage, 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.

3.2.4 | Small Watercourses | Filter Fence

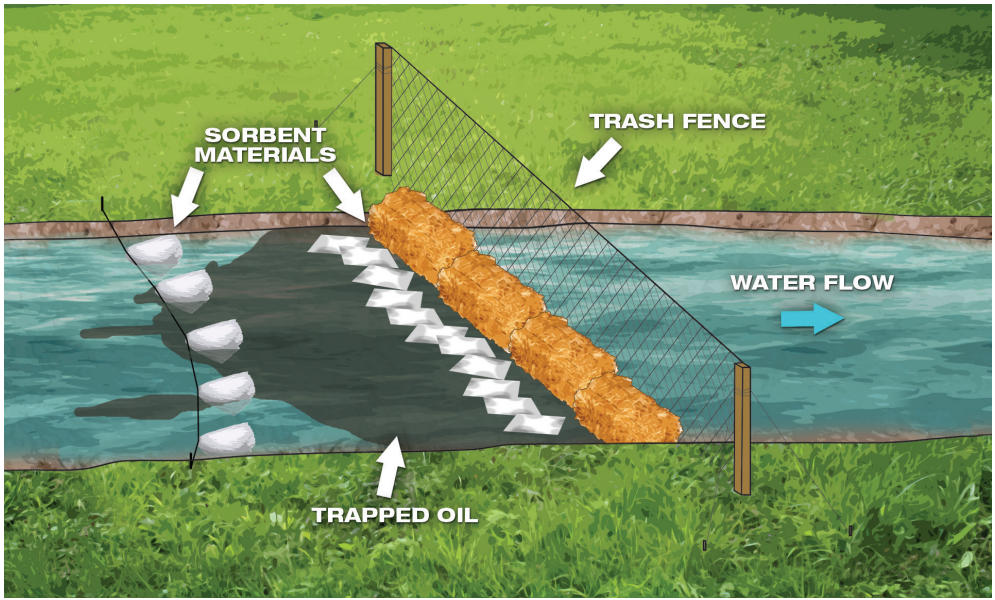


Diagram 3.2.4a Filter Fence

3.2.4 | Small Watercourses | Filter Fence

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.

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 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: Stakes/T-posts (2), sledge hammer/post driver (safety glasses /goggles), wire, wire staples, claw hammer, wire cutters, chicken wire (roll), hay/straw bales, sorbent booms, pom-poms or similar absorbent materials, waste disposal bags and tags, shovel(s). Waders, safety harness and line, and PFD may be required.

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. Firmly anchor stakes in ground; use guy wires if necessary. Central stream stakes may be required.
2. Affix chicken wire to stakes. Run wire stake-to-stake to support the chicken wire.
3. Place sorbent materials on upstream side of device. Monitor and replace sorbent as necessary. If significant amounts of product are expected, consider repeating several installations. Add sorbents on upstream side of the fence as necessary.

3.2.5 | Small Watercourses | Flexible Hose Siphon Dam

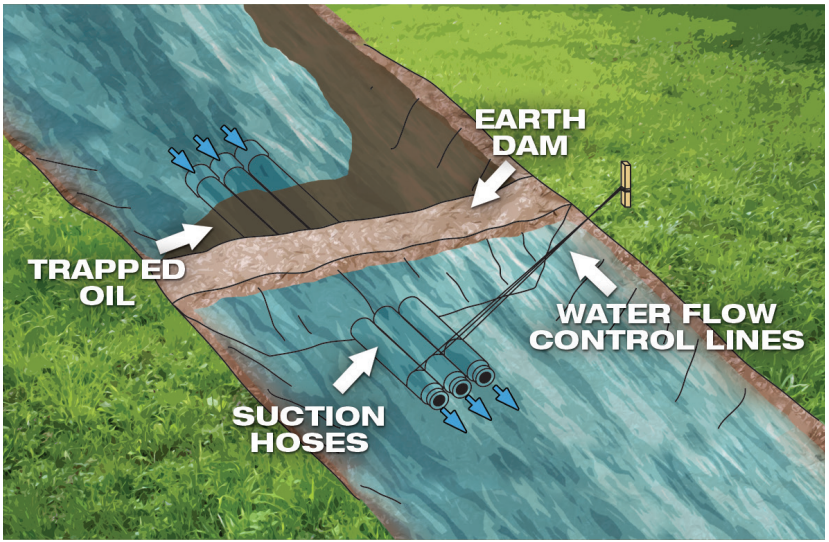


Diagram 3.2.5a Flexible Hose Siphon Dam

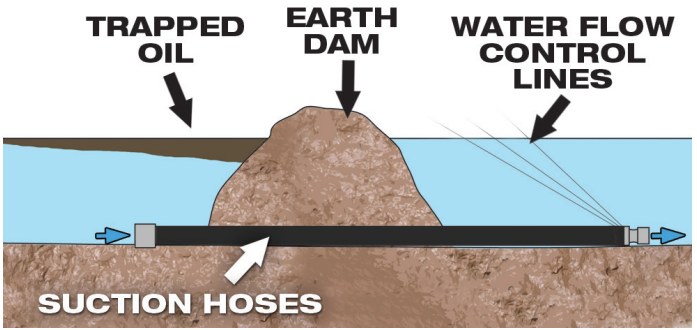


Diagram 3.2.5b Side View of Siphon Dam

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.

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: Sorbents, vacuum truck or skimmer with hoses, pump and temporary liquid storage.

Waste disposal bags and tags if sorbents are to be used

Waders, safety harness and line plus PFD may be required.

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

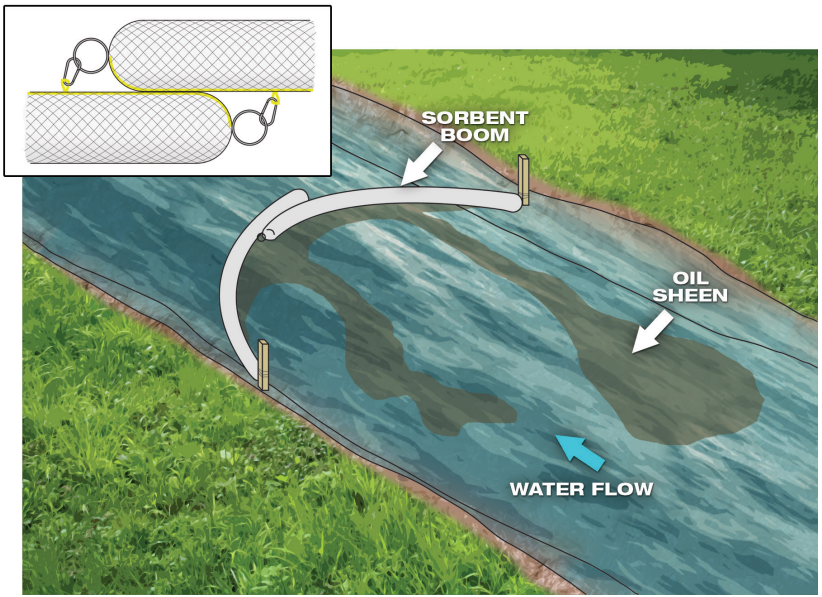


Diagram 3.2.6a Sorbent Booms

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.

Tip: This tactic is less effective in faster flowing water.

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

Application: Can be used as a containment boom liner, shore-line protection and for sheen management.

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

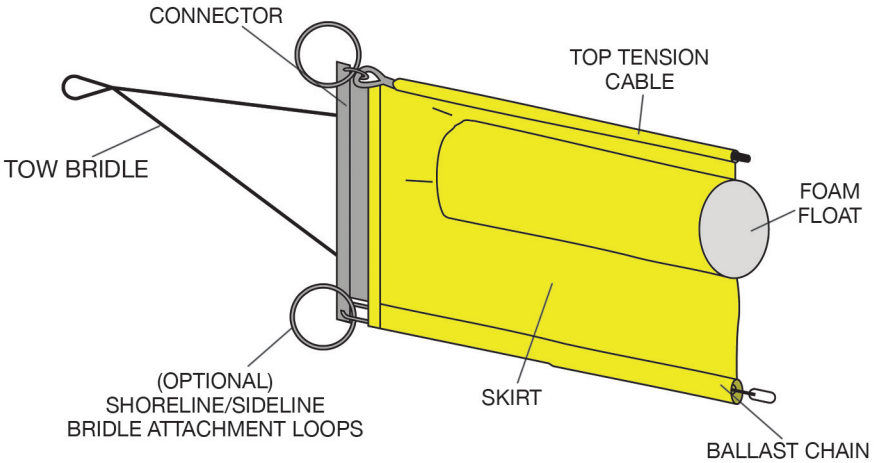
Equipment Required: "Hydrocarbon-only" sorbent boom or booms as appropriate. Stakes/T-posts, shore anchors or shoreline fixtures may be used to secure the boom(s). Rope, knife, waste disposal bags and tags. Waders, safety harness and line, and PFD may be required.

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, consider several installations or additional hydrocarbon-only pads and/or pillows on the upstream side.
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.



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. ASTM[1] 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.

The key to using boom to contain or redirect spilled oil is remembering that, regardless of the size selected, it will not retain oil when used in currents greater than about 3/4 of a knot (measured "normal to" or perpendicular to the plane of the boom itself). This is important and is illustrated in Diagram 3.3.1.a Maximum Boom Angles for Various Currents (on page 39). The maximum river currents consistent with 3/4 of a knot normal velocity are shown as a function of the angle the boom makes with the incident current.

* 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

A boom stretched directly across the stream (90 degrees to the current) can only be expected to contain oil in currents up to 3/4 of a knot (0.86 mph or 1.39 kph), while a boom angled at 30 degrees can provide effective containment in twice that velocity.

Tip: It is Enbridge's recommended practice, when current is present, that boom not be installed at a degree greater than 45°.

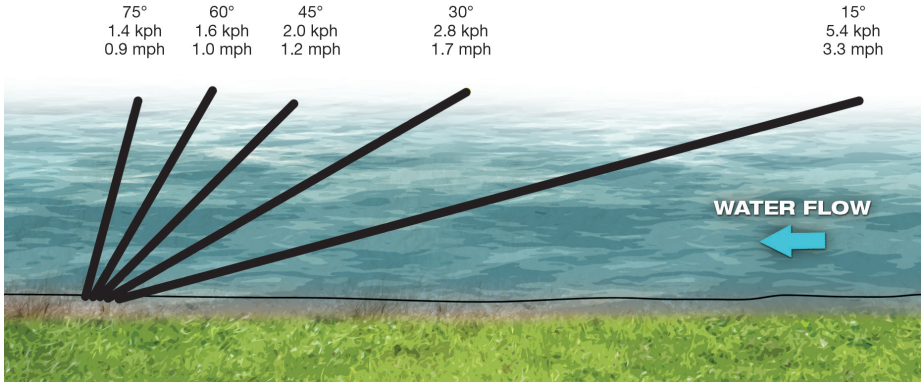


Diagram 3.3.1b Maximum Boom Anfles for Various Currents

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.

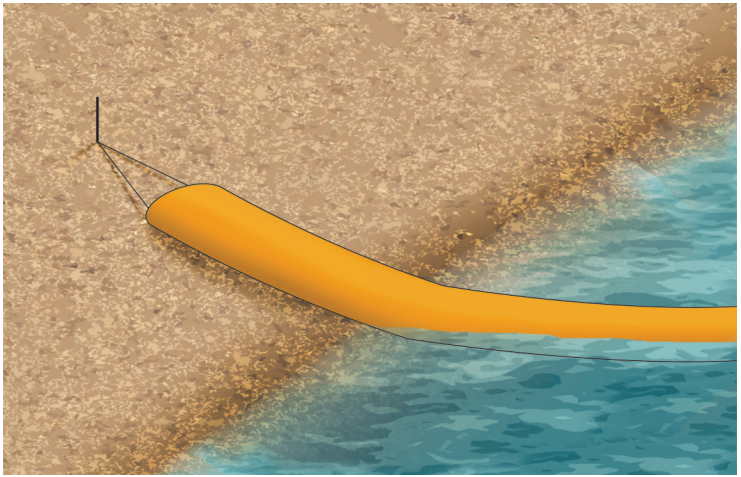


Diagram 3.3.2a Shore Seal Boom

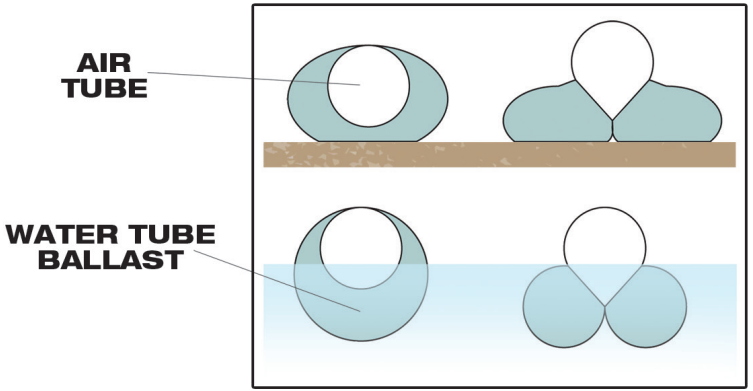


Diagram 3.3.2b Cross-Section of Shore Seal Boom

3.3.3 | Larger Watercourses | Deflection/Exclusion 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 reverse containment, or exclusionary booming. Exclusion and deflection tactics are highly sensitive to watercourse velocity.

The goal of exclusionary booming is to prevent spilled product from entering particularly sensitive areas, in hopes of being able to deal with it somewhere downstream. 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 | Larger Watercourses | Deflection/Exclusion Booming | Estimating Stream Speed

There are a number of methods commonly used to identify river speed. The use of a stream speed meter and the manual stick in the stream technique are described below. Measure water flow speeds with flow meter or by the following:

1. Place two markers along shoreline 30.5 metres (100 feet) apart.
2. Throw a stick or other floating object into the river where the surface velocity appears fastest, approximately six metres (20 feet) upstream of the first marker.
3. Determine the time it takes the object to transit the distance between the two markers in seconds.
4. Use Table3.3.3a Stream Speed Estimating on page 42 to estimate water speed. This will aid in determining the proper boom angle and length, using Table 3.3.3b Boom Configuration and Length as a Function of Various Currents on page 53.

Tip: In all cases, the fastest flow of the water body must be selected for measurement. This provides planners with the most conservative basis for estimating resource requirements.

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming | Stream Speed Table

Table 3.3.3a Stream Speed Estimating

Time for Object to Travel				
30m (100ft)				Current
sec	km/hr	m/s	mr/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 Table 3.3.3b Boom Configuration and Length as a Function of Various Currents on page 43 to estimate the angle that deflection or diversion boom should make with the current and approximate length of boom required to avoid entrainment.

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming | Estimating Boom Length

Table 3.3.3b Boom Configuration and Length as a Function of Various Currents

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

3.3.3.1 | Larger Watercourses | Deflection/Exclusion Booming

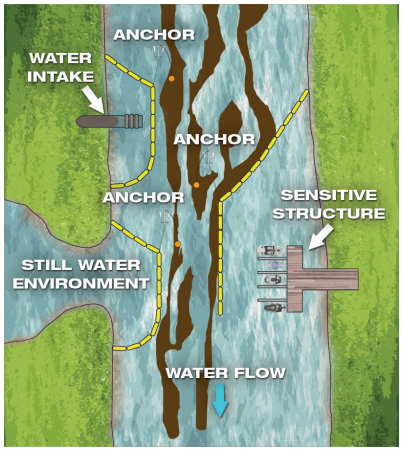


Diagram 3.3.3.1a Protection of Shoreline Resources by Exclusion Booming

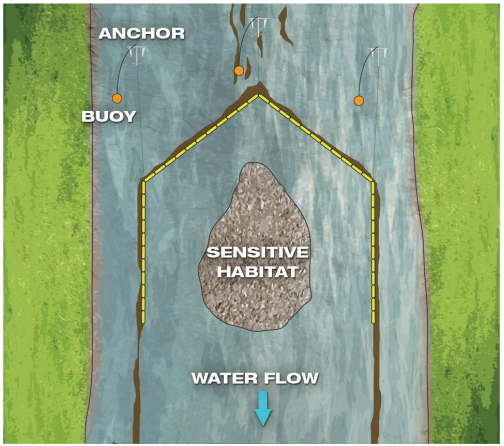


Diagram 3.3.3.1b Protection of In-Stream Sensitive Resources by Exclusion Booming

Oil is being excluded from the water intake and still water environment on the left side of Diagram 3.3.3.1a. At the same time, deflection booms are being used to divert any passing oil around the structure located on the right side of Diagram3.3.3.1a. Diagram 3.3.3.1b shows how a mid-stream sensitive resource can be protected using exclusion 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/Exclusion 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 direct containment is not an 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), sideline 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 post driver 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 when sideline bridles are 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/Exclusion Booming Cascade System Using Booms/Anchors

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.

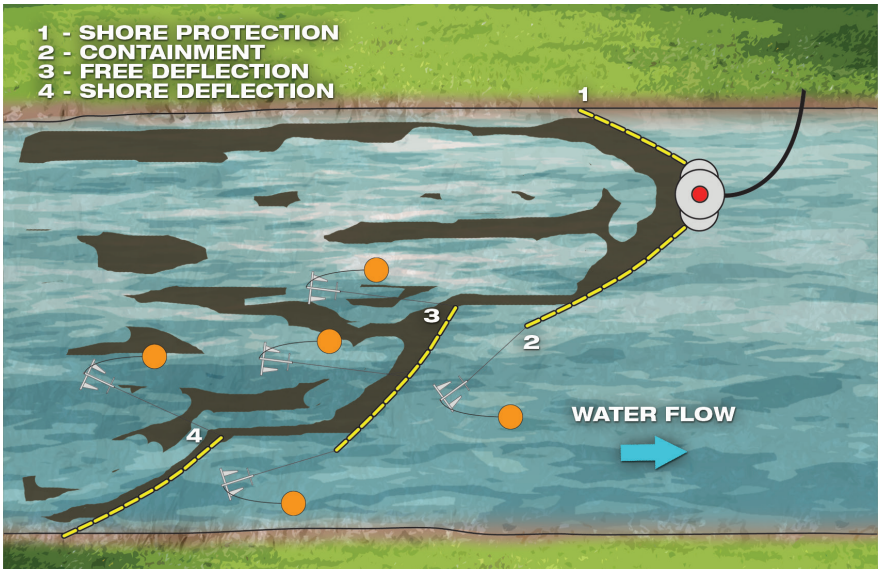


Diagram 3.3.3.2A Deflection/Exclusion Booming Cascade System Using Booms/Anchors

3.3.3.2 | Larger Watercourses | Deflection/Exclusion Booming Cascade System Using Booms/Anchors

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.

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 mooring line to the tow bridle at each end. Intermediate anchors can be attached using sideline 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 gentle curve or slight "J" with the section overlapping to feed the next downstream component.

3.3.3.3 | Larger Watercourses | Boom Deployment River Bed Anchor

Installing deflection booms and a skimming system to recover oil from a watercourse is traditionally done in stages. Components are laid out in groups for staged installation.

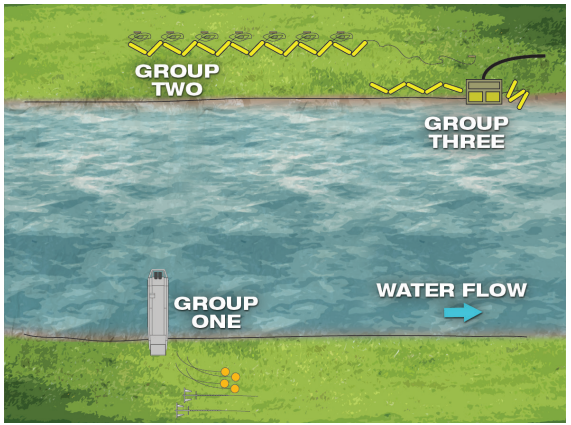


Diagram 3.3.3.3a Boom Deployment River Bed Anchor: Boat preparing to install ground tackle (Group One)

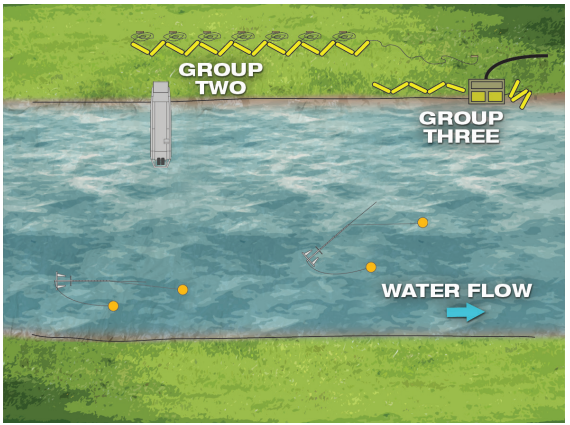


Diagram 3.3.3.3b Boom Deployment River Bed Anchor: Anchors installed. Boat preparing to secure diversion booms (Group Two) to installed anchors

3.3.3.3 | Larger Watercourses | Boom Deployment River Bed Anchor

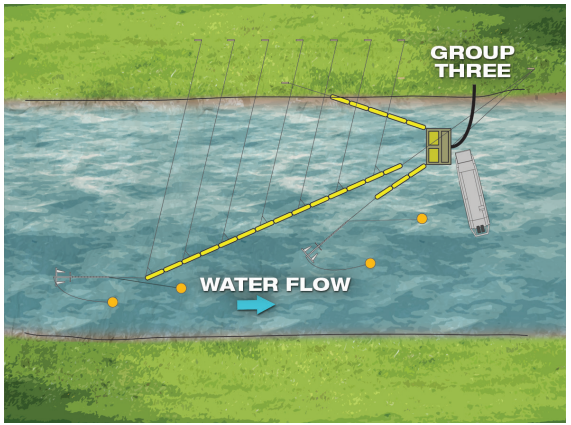


Diagram 3.3.3.3c Boom Deployment River Bed Anchor: Diversion booms installed. Boat installing skimmer (Group Three) at the downstream end of the diversion booms.

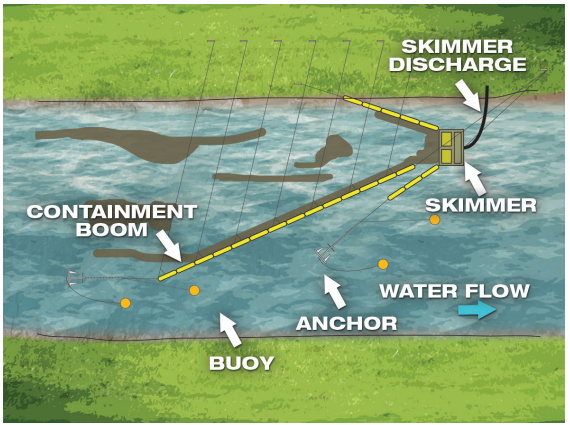


Diagram 3.3.3.3d Boom Deployment River Bed Anchor: Completed diversion and collection installation

Tips: - Note the overlapping booms at the skimmer. Easier to install than a single boom leg connected directly to the skimmer.

- Boom shape can be held at the optimum angle with intermediate control lines running to shore.

3.3.3.3 | Larger Watercourses | Boom Deployment River Bed 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:

Note: This description involves using stub booms (outboard and shore protection) rather than joining the containment boom length directly to the skimmer. It has been found that there is less site congestion during assembly when the two modules (containment boom and recovery) are built simultaneously but deployed separately (better manpower utilization). The containment boom angle can subsequently be adjusted easily without disturbing the recovery component. A responder can connect the main boom length directly to the skimmer or even run it past the skimmer to shore, although the latter presents more opportunities for the spill to escape the skimming device.

3.3.3.3 | Larger Watercourses | Boom Deployment River Bed Anchor

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.

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™ Deploying Containment/Recovery/Deflection Modes

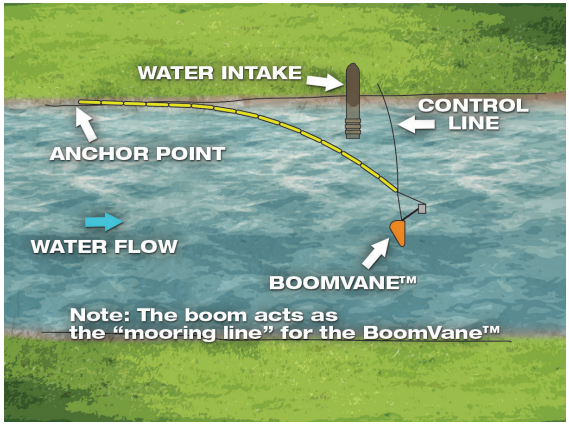


Diagram 3.3.3.4a BoomVane™ Deploying Containment/Recovery/Deflection Modes

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

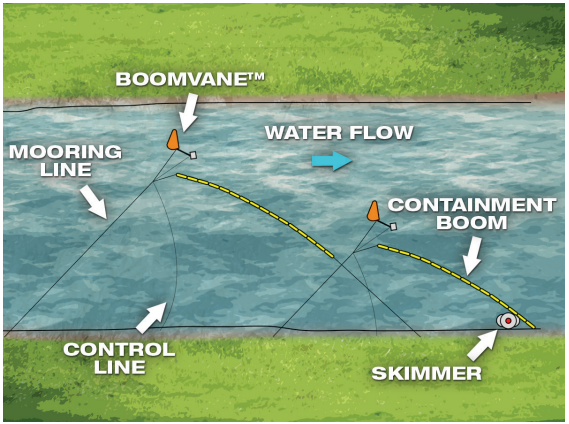


Diagram 3.3.3.4b BoomVane™ Deploying Containment/Recovery/Deflection Modes

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

3.3.3.4 | Larger Watercourses | BoomVane™ Deployment Containment/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)

PFDs, waders, safety harnesses and lifelines

Operation:

1. Place boom along water's edge in the desired deployment location. Linking together the boom sections along the shore in slight zigzag provides the boom for the curve that will be created once the BoomVane deploys the boom. Attach upstream and downstream end (tow) bridles to boom ends.

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

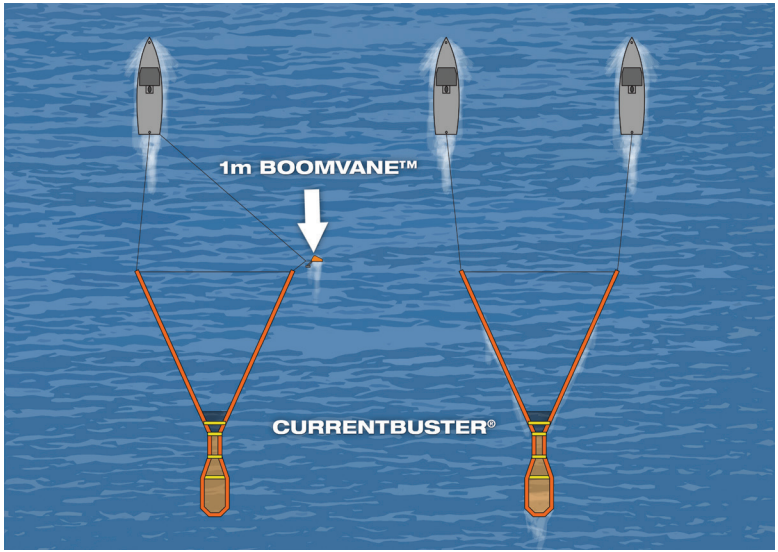


Diagram 3.4.1a NOFI Current Buster® Technology Shown with a Single Vessel Configuration with BoomVane™(Left) and NOFI Current Buster® Technology Shown with a Double Vessel Configuration (Right).

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: QualiTech 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, QualiTech 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

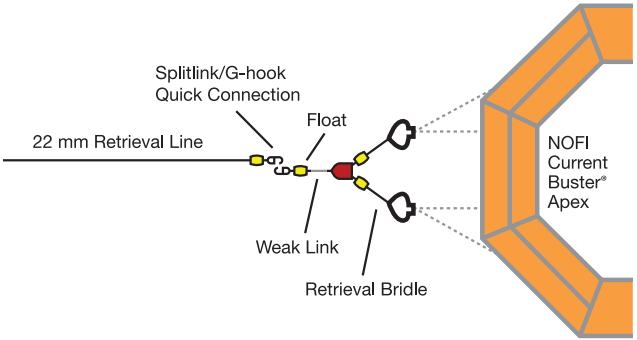


Diagram 3.4.1b NOFI Current Buster® Retrieval

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

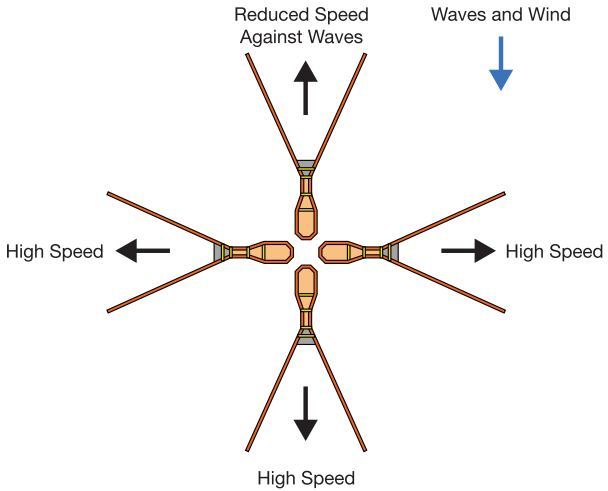


Diagram 3.4.1c NOFI Current Buster® Towing Speed

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

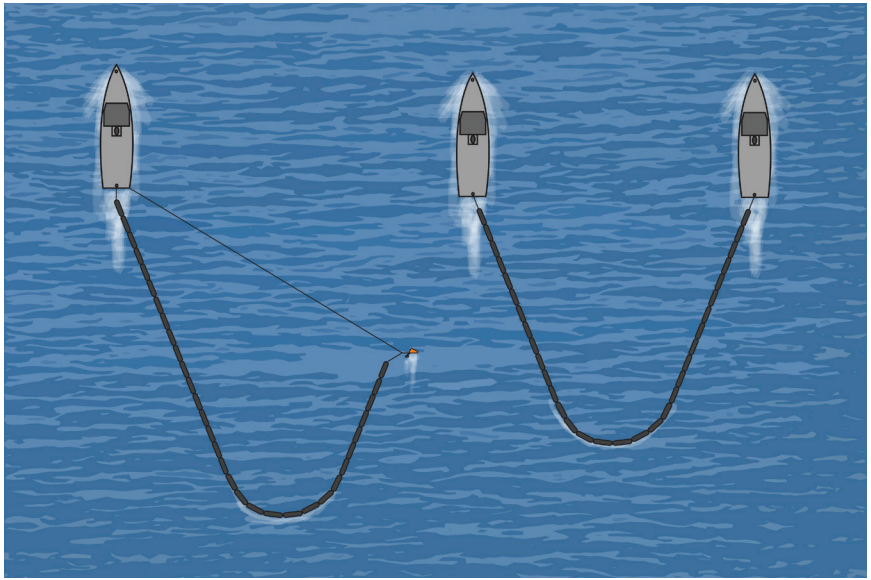


Diagram 3.4.2a Sea Sentry II Boom with Single Vessel / 1m BoomVane™ Configuration (Left)
Sea Sentry II Boom with Two Vessel Configuration

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

Purpose: To contain and collect oil at speeds up to 0.8 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: QualiTech 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)

Operation/Development:

1. Deploy and recover with inflation valves facing up. Each air chamber is 15 feet / 4.6 metres in length and has two Monsun air valves per chamber. There are seven flotation chambers per 110 foot / 33.5 metres section of boom.
2. Stage the boom on land or on the deck of a vessel to inflate, or inflate the boom from the reel as it is deployed from land or sea.
3. The ballast chain will "sink" keeping the boom upright and the draft taught.

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 outter cap.

Operation/Retrieval:

1. A rope or tag line may be used to connect to the tow bridle to recover the 550 feet /168 metres 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 upwards of 0.8 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.

3.4.1 | 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 0.8 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

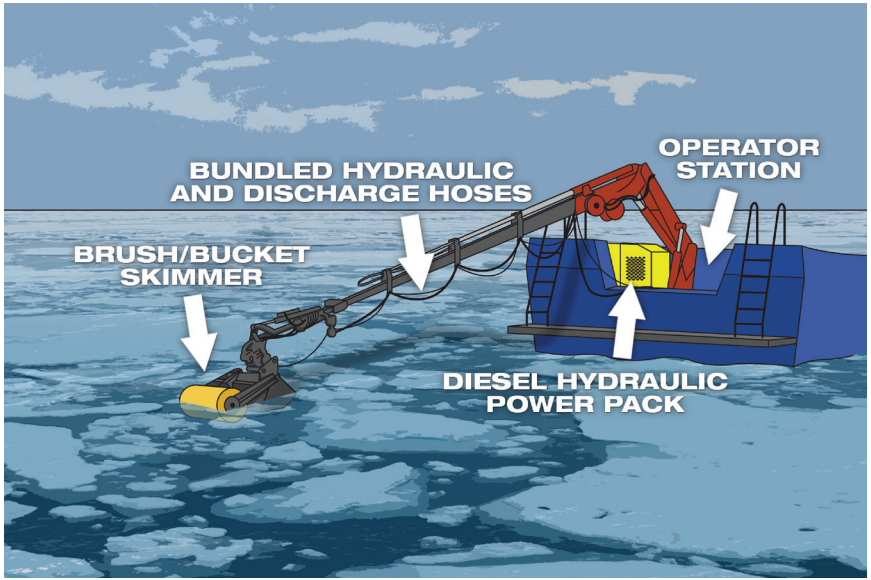


Diagram 3.4.3a Arctic Brush Bucket System Tactical Illustration

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.

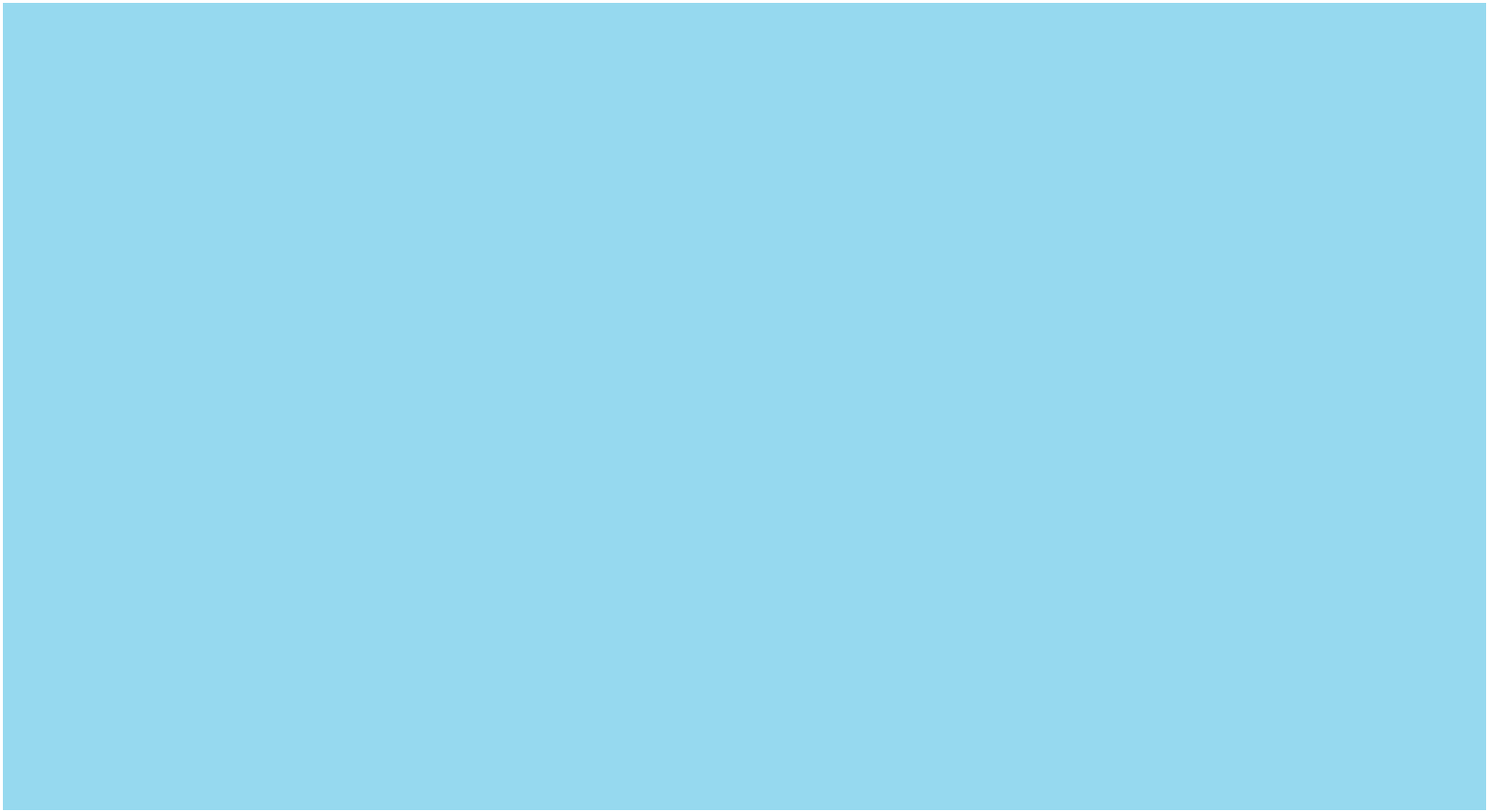
Application: To recover oil that is contained against the edge of ice or in the apex of a containment boom or pooled on land.

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: 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 | 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 below ice require responders to conduct an ice assessment to ensure that the load capacity of the ice will support operations. Detecting and tracking a product release 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 permissible load of the ice cover and available equipment.

4.1.1 | Ice Tactics | Ice Assessment

Use appropriate life safety measures when working on ice: survival suits, PFDs and harnesses.

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.

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

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, survival suits/PFD, ice depth measuring device, ice cleats and safety line.

Operation:

1. Two responders with ice rescue package must be present before ice assessment team begins.
2. 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

Tip: - Calculate the load capacity in multiple areas, as the ice thickness may change significantly throughout the work area.

If safe to do so, one responder attached to safety line will proceed out onto ice while other responder will 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:

Total effective ice thickness = (Clear + ½ White) x Temp x 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 0ºC 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	Unsafe conditions, discontinue on-ice work

Table 4.1.1b Safety Multiplier for Cracks in the 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

Examples of Total Effective Ice Thickness

1. The location has 60 inches / 1.53 metres of clear, blue ice and 10 inches / 0.25 metres 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) x 1.0 x 1.0 = 65 inches / 1.65 metres

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

Non-intersecting wet cracks are present.

Total Effective Ice Thickness = (40 + 20/2) x 0.8 x 0.7 = 28 inches / 0.71 metres

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
3.1 / 7.9	3.5 / 8.9	Group, in single file
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 / 29.9	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 / 108.1	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.

Use appropriate life safety measures when working on ice: survival suits, PFDs and harnesses.

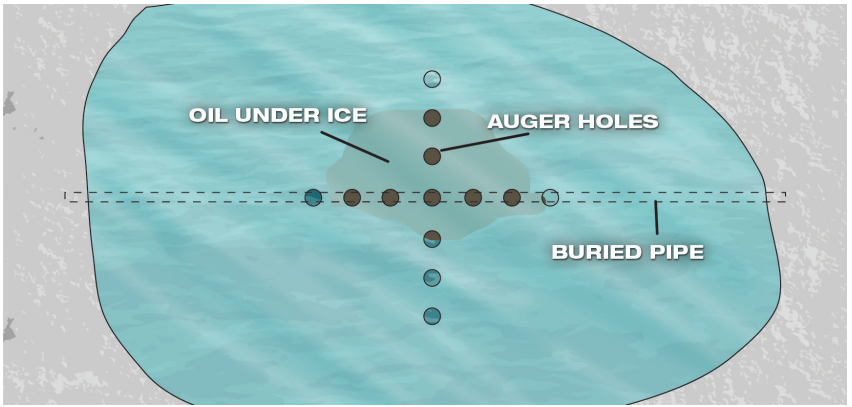


Diagram 4.1.2a Oil Detection Under Ice

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 metres/ 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.

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, survival suits/PFD, ice depth measuring device, ice cleats and safety line, 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. Begin making auger holes in a cross pattern to delineate surface area of spill.
4. Measure ice depth on auger holes as load capacity may change.
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, continue to auger ice downstream until a recovery point is determined.
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

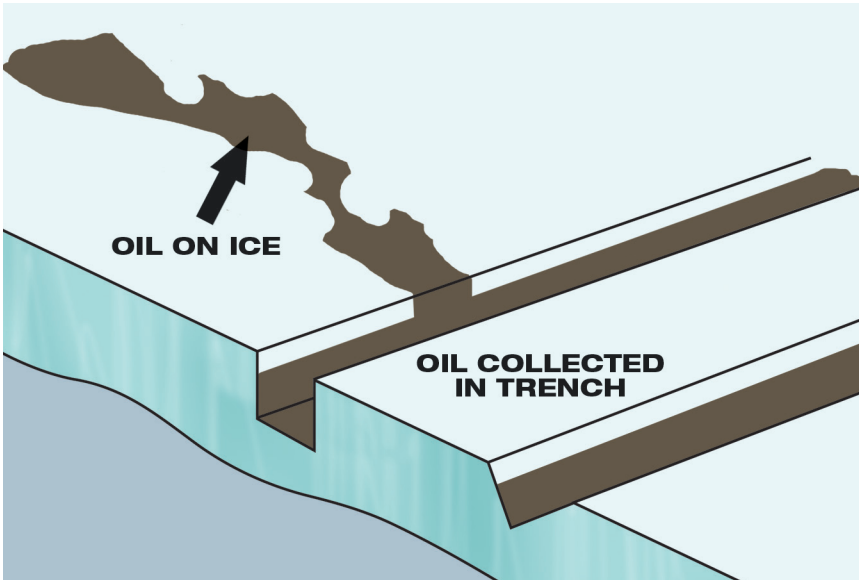


Diagram 4.1.3a Trench on Ice Sheet

4.1.3 | Ice Tactics | Trench on Ice Sheet

Ensure ice assessment has been completed.

Tips: - A chain saw can be used to cut a V-shape trench as an alternative.

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

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: Ditch Witch, a backhoe (Caution: do not break through or fracture the ice.), ice scrapers, picks and shovels, chain saws, ice augers, squeegees and brushes.

Optional Equipment: Commercial ice resurfacer.

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

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 | Trench on Ice Sheet

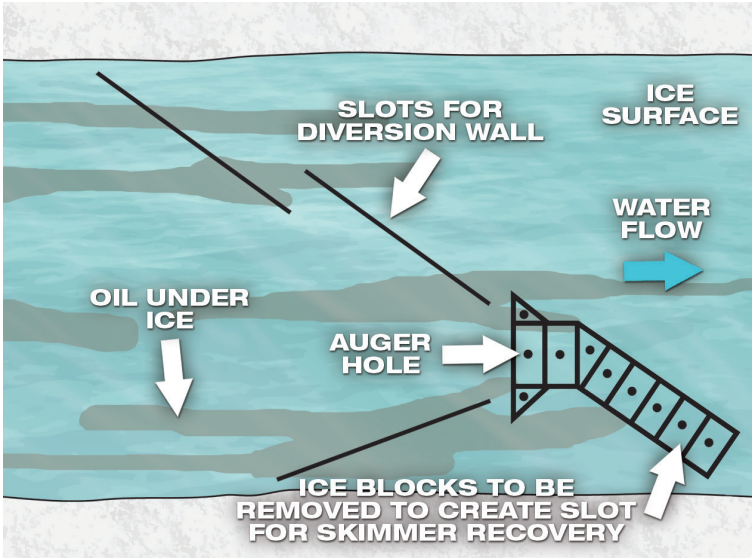


Diagram 4.1.4a Ice Slotting on Rivers

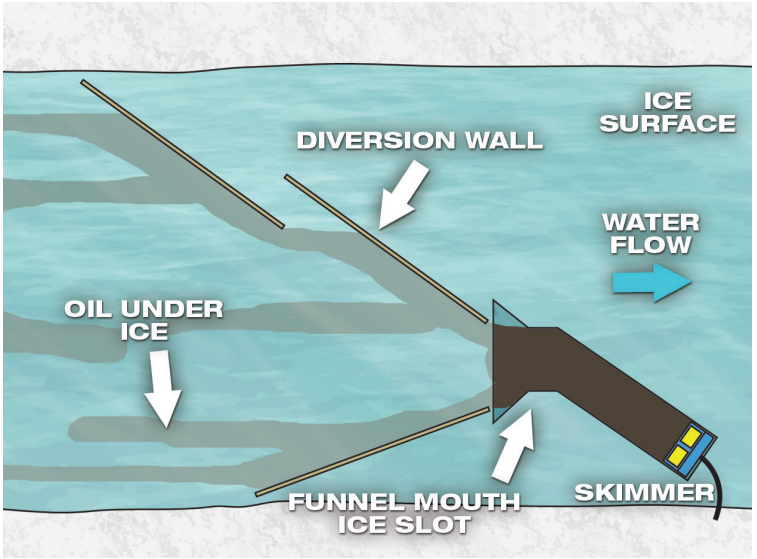


Diagram 4.1.4b Ice Slotting on Rivers

4.1.3 | Ice Tactics | Trench on Ice Sheet

Tip: - 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.

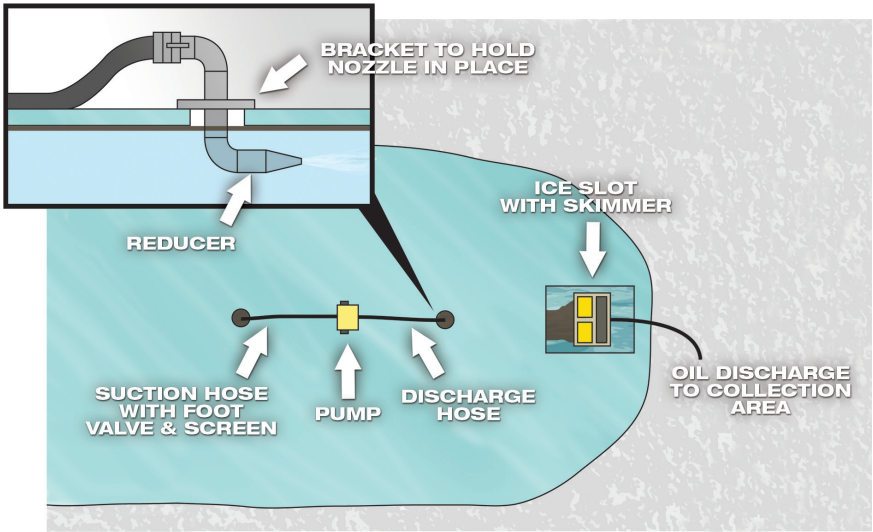


Diagram 4.1.4c Ice Slotting

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.

Wear chain saw chaps when 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 metre), rope, chalkline, aerosol paint (not white), crane, ice hooks, A-frame hoist, T-bar, shovels, ice cleats and safety line Mechanical snow removal equipment (for site snow clearing once site has been approved for operations), snow fence and stakes, vegetable oil for lubrication (optional), 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 (optional).

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

4.1.4 | Ice Tactics | Ice Slotting

Tips: - If blocks are cut at a 15 to 20 degree angle, they may 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 can be attached to slide block away.

Operation:

- Ensure an ice assessment has been performed before beginning any operations.
- Use a J-slot template (upstream portion of J-slot cut with the current and base of J-slot at an angle suitable to current toward recovery location). The angle is determined from the stream speed/slot angle table. The length should be sufficient to permit the maximum amount of oil to surface and provide surface storage capacity that the skimmer recovery rate can handle, bearing in mind the water flow will carry the oil to the downstream (skimmer) slot end. The width will be that of the skimmer, which is usually in the 24 to 36 inches / 60 to 90 cm width range. Mark cutting lines using chalkline. Overspray chalkline with aerosol paint. A rope acting as a guide and chain saw can also be used to score the cutting lines. (Refer to pages 94 and 95.).
- 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.
- 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

Tips: - Calculating the approximate weight of the blocks will determine what size blocks will be cut and if mechanical lifting aids will be required.

a) Lake ice (clear) weighs 56 lbs per cubic foot / 900 kg per cubic metre.

b) To calculate volume, multiply depth by length by width.

c) Weight in kg equals 900 multiplied by the volume in cubic metres or weight in pounds equals 56 multiplied by the volume in cubic feet.

For example, an ice block measuring 1 m x 1 m x 1 m would weigh ~2,000 lbs / 900 kg.

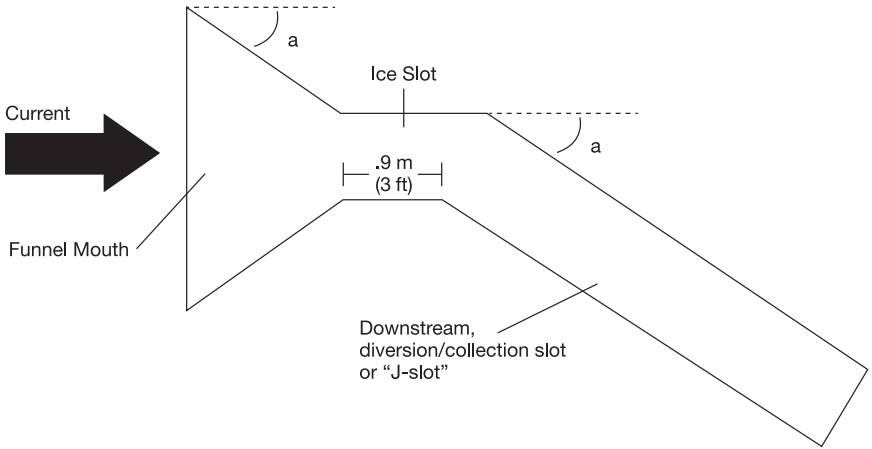


Diagram 4.1.4d J-Slot Template

4.1.3 | Ice Tactics | Ice Slotting

Table 4.1.4a J-slot Angle as a Function of Current

Maximum Current, Knots	Maximum Angle (a), Degrees, Relative to the Direction of Flow
0.8	75
0.9	60
1.1	45
1.5	30
2.9	15

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.

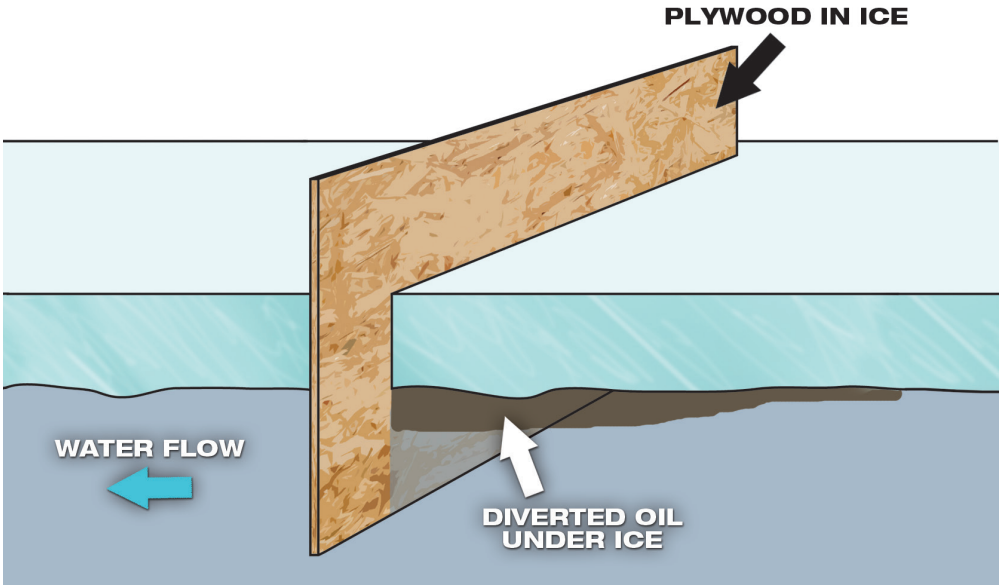


Diagram 4.1.5a Through Ice-deflector/Diversion Wall

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

The deflection walls are made by installing a barrier (plywood or melamine 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 and faster moving watercourses under ice.

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 metres 1/2 or 3/4 inch / 12.7 or 19 mm thick plywood sheet(s), 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: Wooden wedges, if required, sledge hammer/post driver.

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 over 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 at the required depth with 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

Equipment for Material Recovery or Alternative Removal

5

5 | 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.

The boom tactics described in Section 3 assume that boom and skimmers can be held in place in moving water. The anchors most commonly used in water are categorized as drag embedment anchors. They rely on the flukes of the anchor biting into the bottom sediment to generate holding power.

A proper anchor setup should include, at a minimum, 10 feet / 3 metres of the appropriate rated chain attached directly to the anchor. An anchor line will be attached to the anchor chain and the entire length of the anchor line, including the chain, shall be at least six times longer than the water depth. A long anchor line reduces uplift at the anchor. Uplift can make the anchor lose its grip.

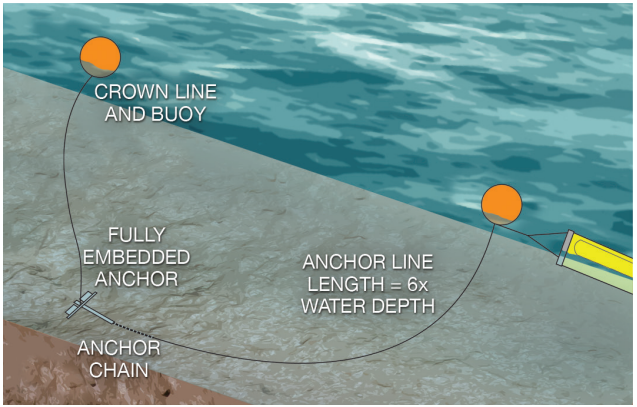


Diagram 5.1a Typical Anchoring System

A typical anchoring system is shown in Diagram 5.1a. It includes an anchor buoy and a second buoy and line called a “crown line” because it is attached to the crown of the anchor. The crown line gives responders a more accurate view of where the anchor is relative to what they are trying to hold in place. It is also used to retrieve and reposition the anchor.

Information on the holding capacity of anchors and the strength of commonly used tension members is included in section 6.6.

Among the most commonly found drag embedment anchors is the Danforth-style anchor. It is capable of resisting a horizontal pull of 7 to 14 times its own weight when properly set. Another drag embedment anchor in use in Canada and the United States is called the Sarca anchor. It does not require a trip line or crown line. It can resist a horizontal pull of up to 20 times its own weight. By comparison, a rock or a cement block is categorized as a “deadweight anchor” and will resist only a fraction of its own weight when pulled horizontally.

When installing drag embedment anchors, it is critical to remember that they may drag many metres across the bottom before they embed themselves in the soil and develop holding capacity. Whenever possible, they should be installed and “set” before booms or other equipment are tied off to them. This can be achieved from a power boat.

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

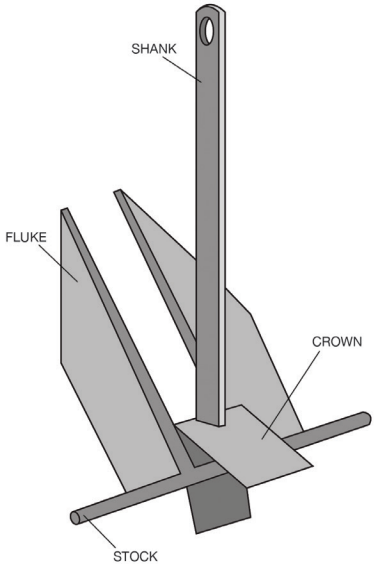


Diagram 5.1.1a Danforth Anchor

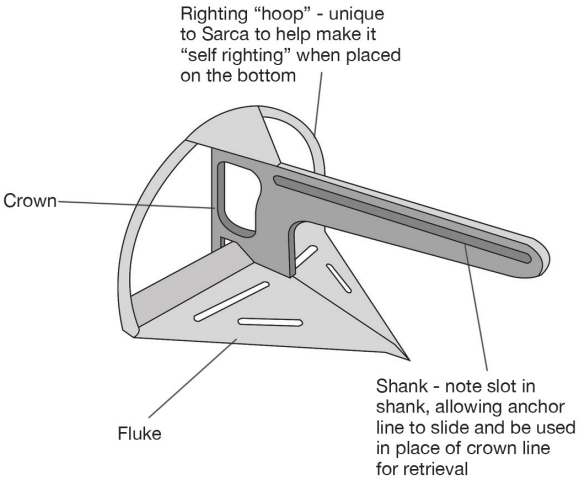


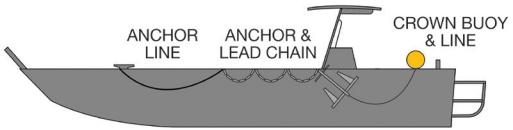
Diagram 5.1.1b Sarca Anchor

5.1.2 | Ground Tackle and Anchors | Anchor Deployment from Boat

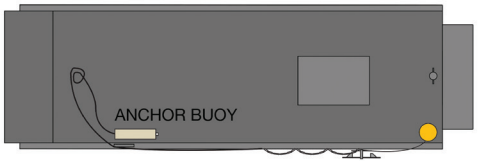
If a boat is used to deploy anchors, experience has shown that it is advisable to assemble ground tackle system (anchor, anchor line, buoy, crown line and crown buoy) entirely before commencing installation. Smaller mooring systems, where anchors, buoys and other components are easily moved by hand, are not difficult to install. Keep in mind, though that it is wise to hold onto the anchor/mooring line and buoy, so that the boat can pull on the mooring line to "set" the anchor.

For larger systems, it may be safer to rig the anchor system for deployment on the outside of the boat using sacrificial lines that can be cut to allow the heavier components to fall. Even tension members should be rigged on the outside of the boat so that running lines do not present a safety hazard to personnel on the boat. The sequence of diagrams below illustrates how a larger mooring system might be installed from a boat.

Caution: Installing anchors, particularly in moving water, requires skill and experience. It should only be attempted by skilled boat handlers under competent supervision.

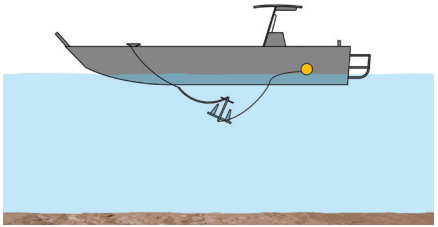


1. Assemble the entire set of ground tackle on the boat before starting.
   - a. Crown buoy and line (if used)
   - b. Anchor
   - c. Anchor lead chain
   - d. Anchor line
   - e. Anchor buoy

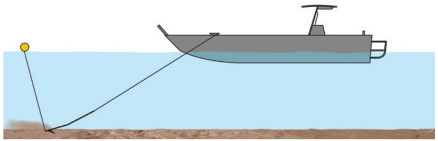


2. Tie off the anchor line near the anchor buoy to the towing point of the boat.
3. Once near the desired location of the anchor, overboard the crown line and buoy.

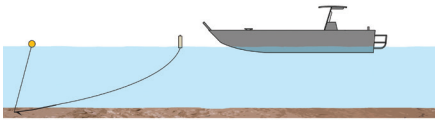
5.1.2 | Ground Tackle and Anchors | Anchor Deployment from Boat



4. Drop the anchor and chain several metres from the desired anchor location and away from the direction of pull.



5. Use the boat's power to pull gently against the anchor line until the anchor stops dragging. Gradually increase power to completely set (embed) the anchor.



6. Release the anchor line and overboard the mooring buoy.

Tip: - A proper line will be at least six times longer than the water depth.

5.1.3 | 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.

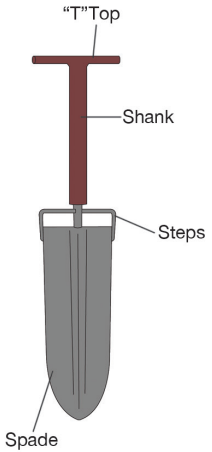


Diagram 5.1.3a Spade Anchor

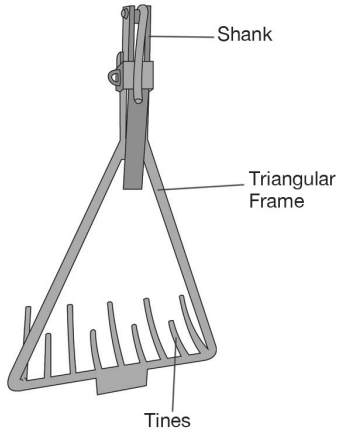


Diagram 5.1.3b Rake Anchor

5.1.3 | Ground Tackle and Anchors | Shoreline Anchors

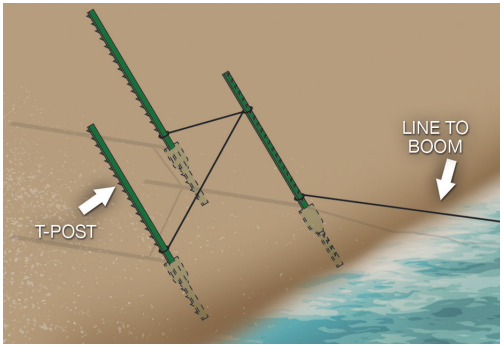


Diagram 5.1.3c T-Post Anchor

T-Post Anchor

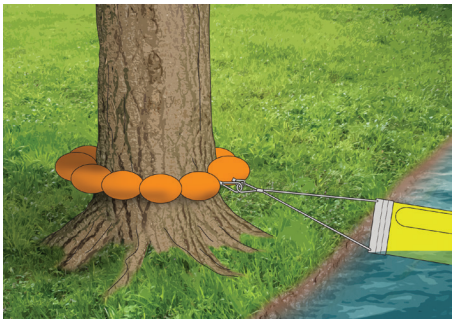
Some points of interest for the T-post anchor set:

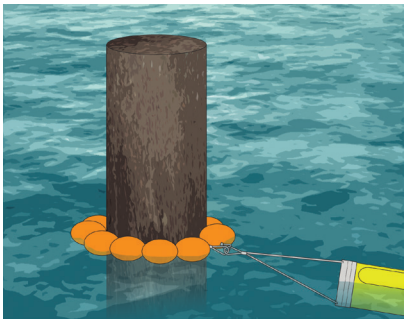
- Tie rope from front top to rear bottom.
- Face T-post nubs forward (toward the boom) on the front post and backward (away from the boom) on the rear posts.
- Overlap rope wraps on the rear post before tying to help prevent them from sliding up the post.
- Pound T-posts in, angled away from the boom 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.

Use a post pounder and wear safety glasses/goggles.

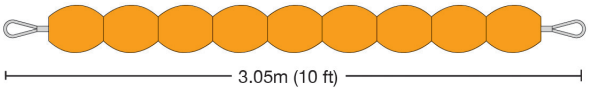
5.1.4 | Ground Tackle and Anchors | Anchors of Opportunity

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.

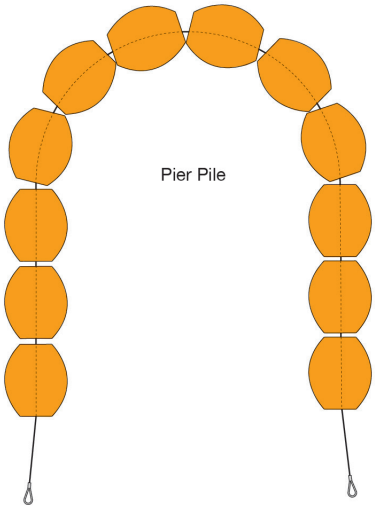




Tip: - Piling bridles can be used to protect trees.



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 two sizes of BoomVane in regular use in inland waters, the 1 metre standard model and the 0.5 metre shallow version. 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.

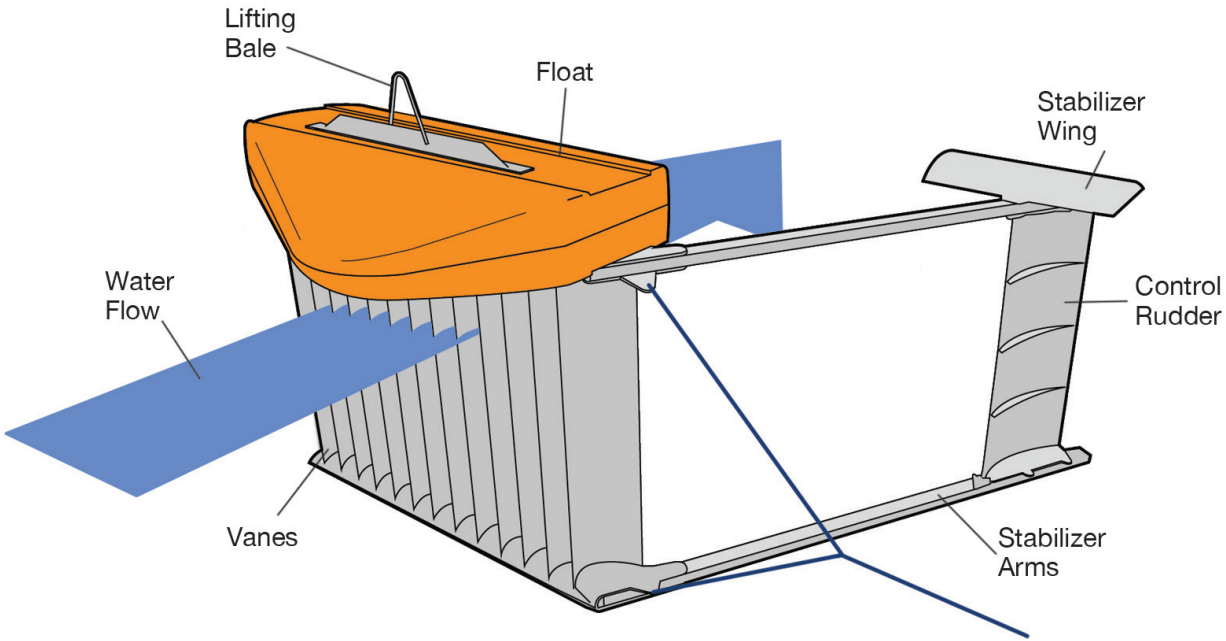


Diagram 5.2a 1.0 Metre Standard Boom Vane

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.

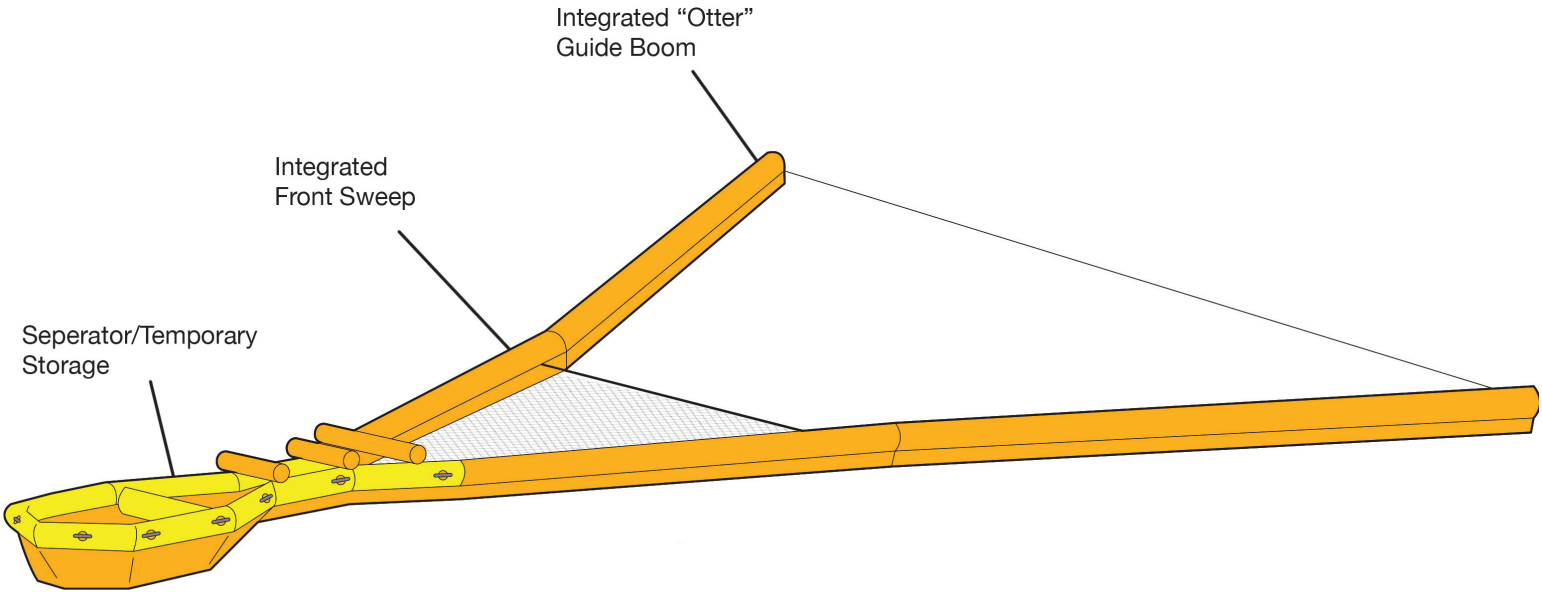


Diagram 5.3a NOFI Current Buster®

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.

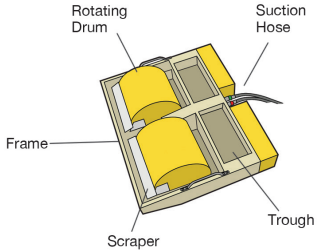


Diagram 5.4.1a Drum Skimmer

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.

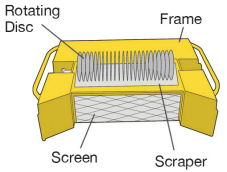


Diagram 5.4.1b Disc Skimmer

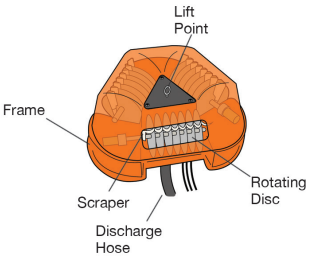


Diagram 5.4.1b Multi-Sided Skimmer

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.

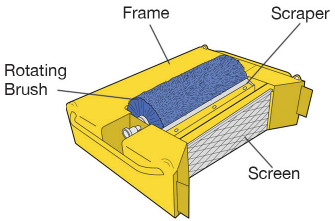


Diagram 5.4.1c Brush Skimmer

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.

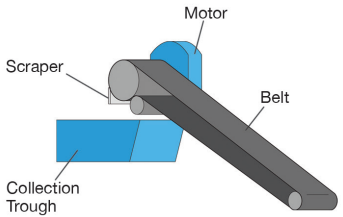


Diagram 5.4.1d Belt Skimmer

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.

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.

5.4.1f | Arctic Bucket Brush

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.)

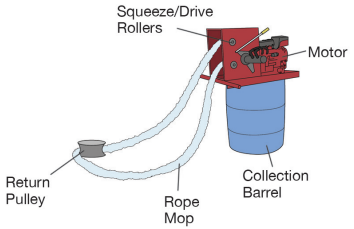


Diagram 5.4.1b Multi-Sided Skimmer

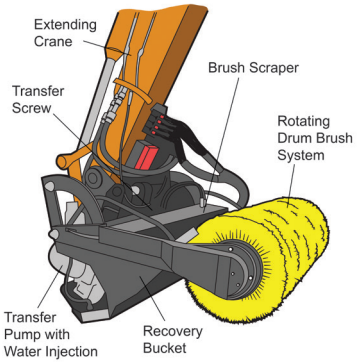


Diagram 5.4.1b Multi-Sided Skimmer

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.

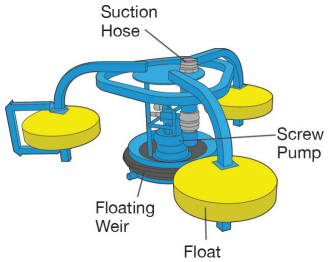


Diagram 5.4.2a Seaskater Weir Skimmer

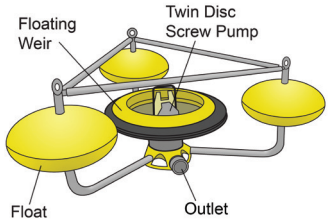


Diagram 5.4.2a Foilex Weir Skimmer

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.

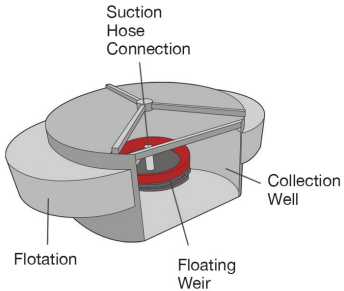


Diagram 5.4.2b Circus Skimmer

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.

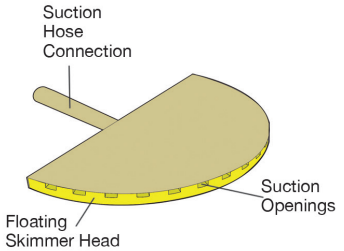


Diagram 5.4.2c Broad Suction Skimmer

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 metre wide with one spill recovery pipe and the 1.2 metre 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.

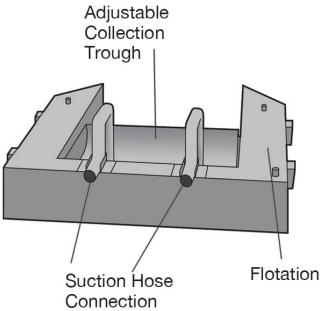


Diagram 5.4.2d Adjustable, Half-Barrel Weir-Type Skimmer

5.5 | 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.

5.5.1 | Skeets, Pads, Pillows, Rolls

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

5.5.2 | 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.

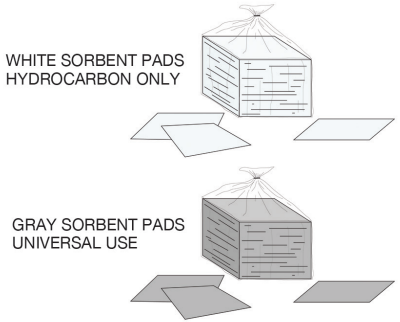


Diagram 5.5.1a Sheets, Pads, Pillows, Rolls

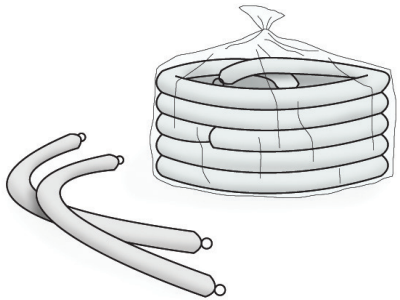


Diagram 5.5.2a Sorbent Booms

5.5.3 | 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.

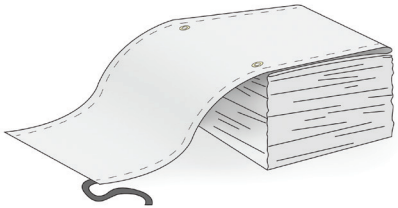


Diagram 5.5.3 Sorbent Sweeps

5.5.4 | 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".

Diagram 5.5.4a Pom-Poms/Snares

5.5.5 | Sorbent Socks

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

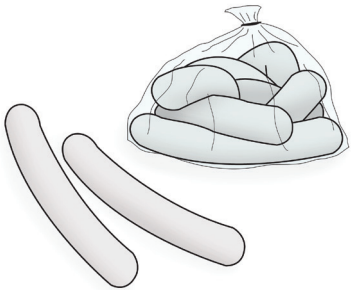


Diagram 5.5.5a Sorbent Socks

5.6 | 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.

5.6.1 | 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 litres).

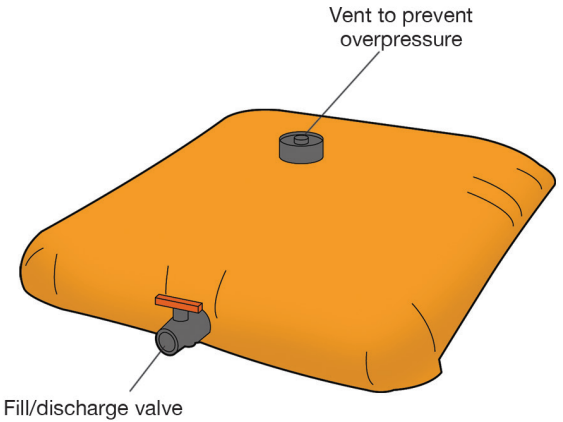


Diagram 5.6.1a Pillow Tank

5.6.2 | 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 litres to 20,000 gallons / 75,708 litres. The next three diagrams are examples.

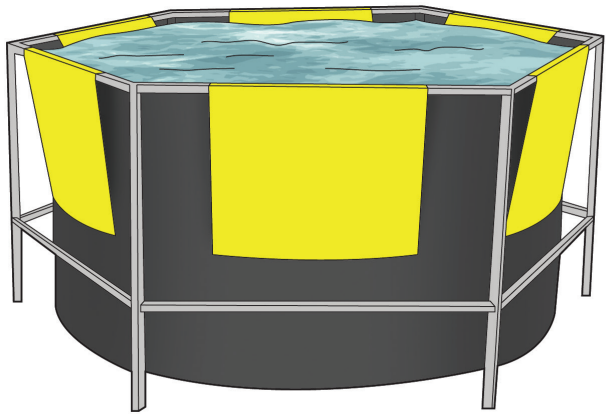


Diagram 5.6.2a Open Storage - Rigid Frame

5.6.2 | Open Storage Devices - Rigid Frame

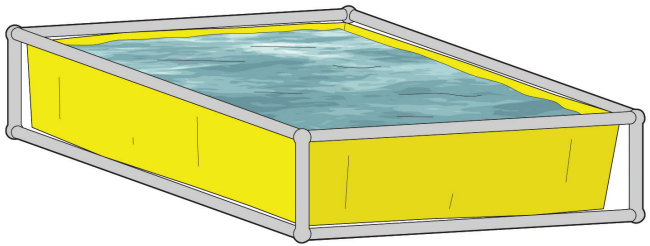


Diagram 5.6.2b Open Storage - Rigid Frame

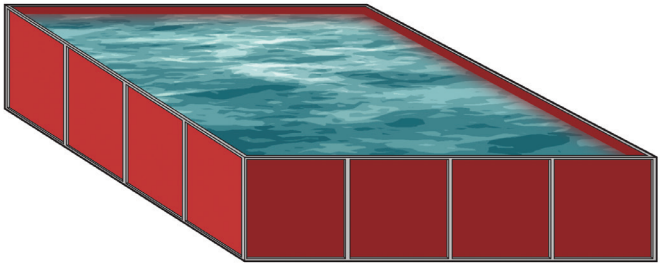


Diagram 5.6.2c Open Storage - Rigid Frame

5.6.3 | Open Storage Devices - Frameless

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

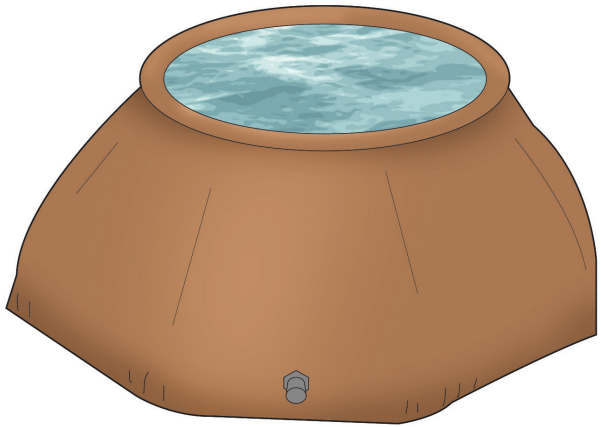


Diagram 5.6.3a Open Storage - Frameless

5.7 | Vacuums

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

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

5.7.1 | Vacuums | Towable Vacuum Unit and Vacuum Tank

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

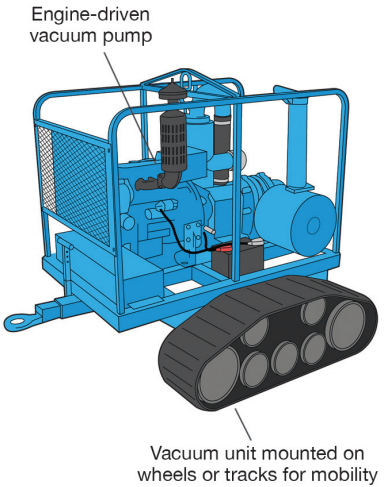


Diagram 5.7.1a Towable Vacuum Unit

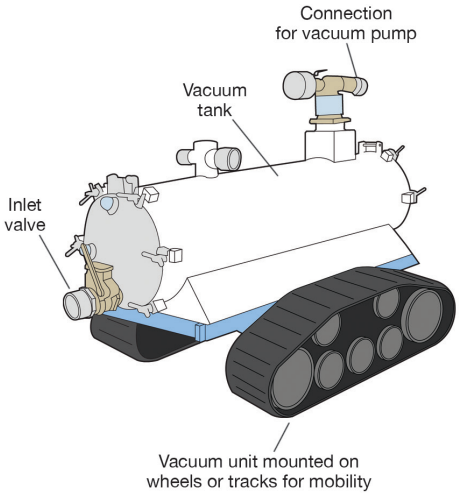


Diagram 5.7.1b Towable Vacuum Tank

5.7.2 | Vacuums | PortableVacuum Unit

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

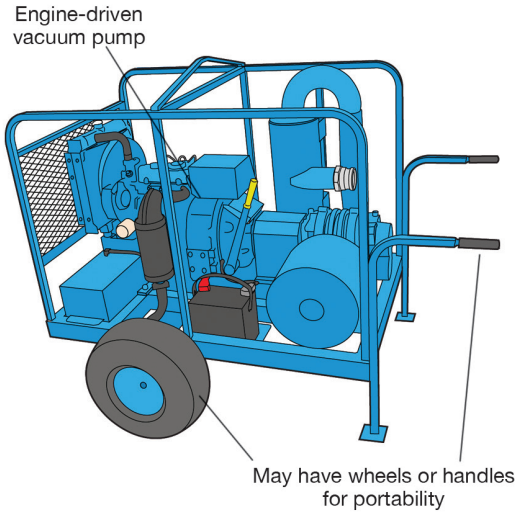


Diagram 5.7.2a Portable Vacuum Unit

5.8 | Boom, Tow Bridles and Other Attachment Devices

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

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

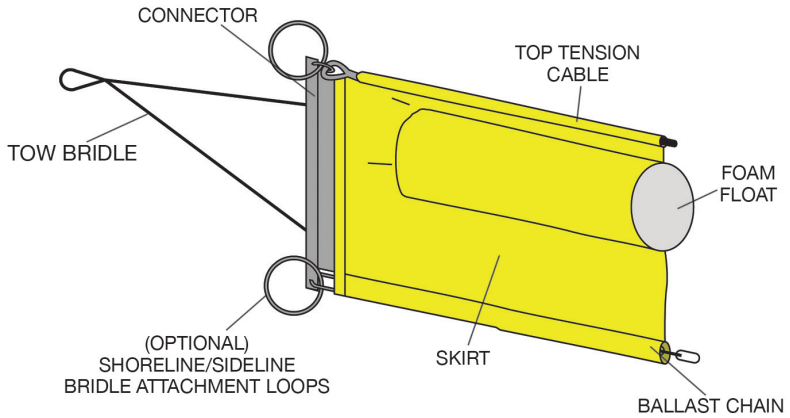


Diagram 5.8.1a Containment Boom

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

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

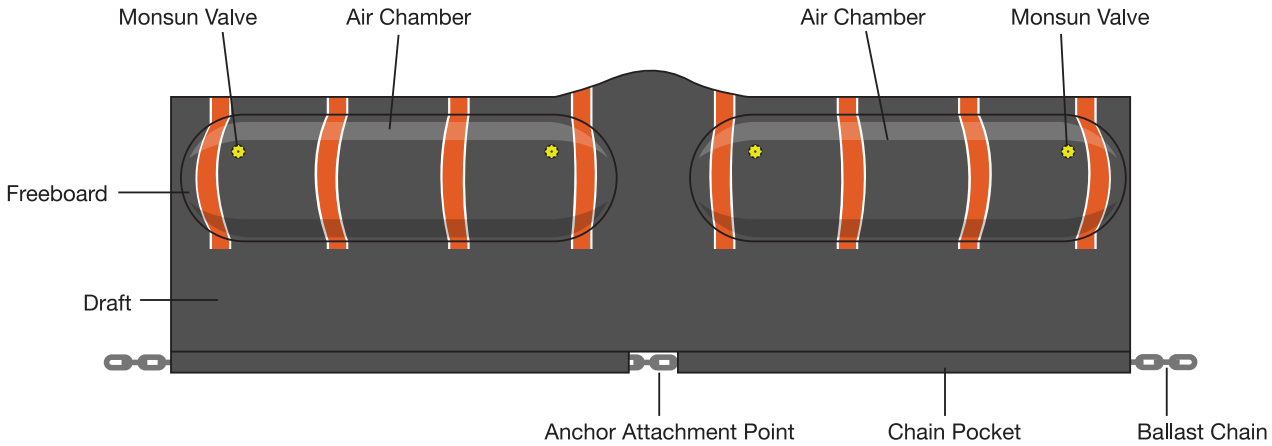


Diagram 5.8.2a Sea Sentry II Boom

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

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

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

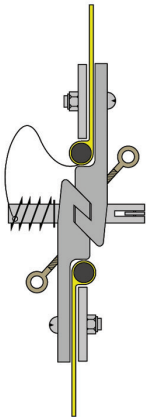


Diagram 5.8.3a
ASTM "Z" Connector

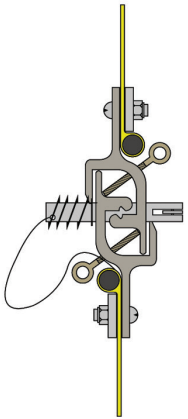


Diagram 5.8.3b
Light Duty Mini Slide Connector

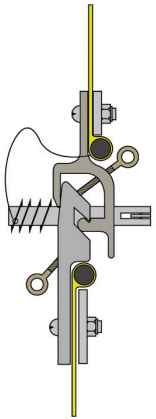


Diagram 5.8.3c
ASTM "Z" Connector with Mini Slide Connector

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

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

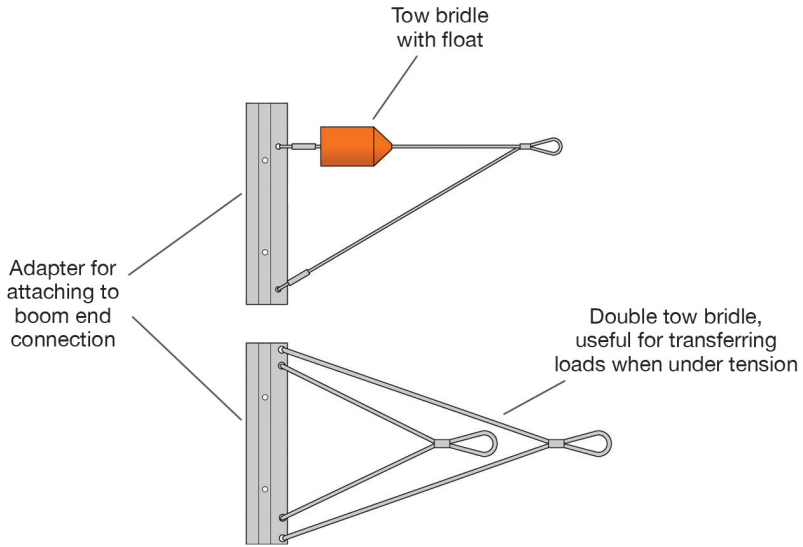


Diagram 5.8.4a Tow Bridle with Bullet Flo

Diagram 5.8.4b Double Bridle

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

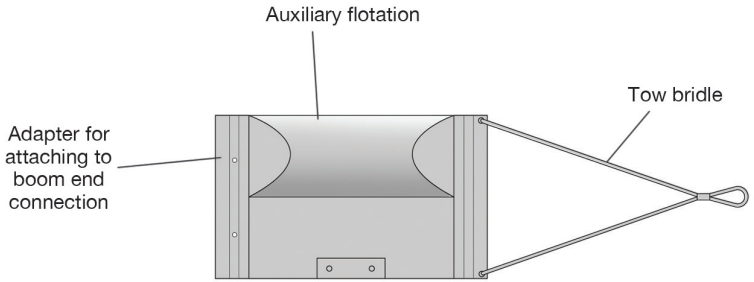


Diagram 5.8.4c Paravane

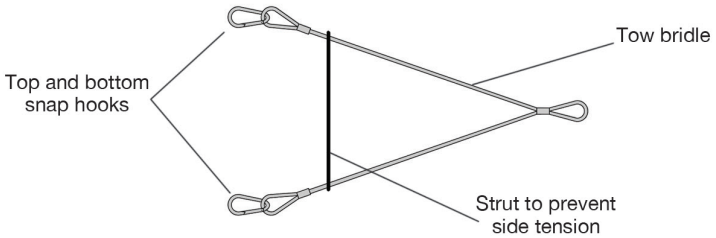
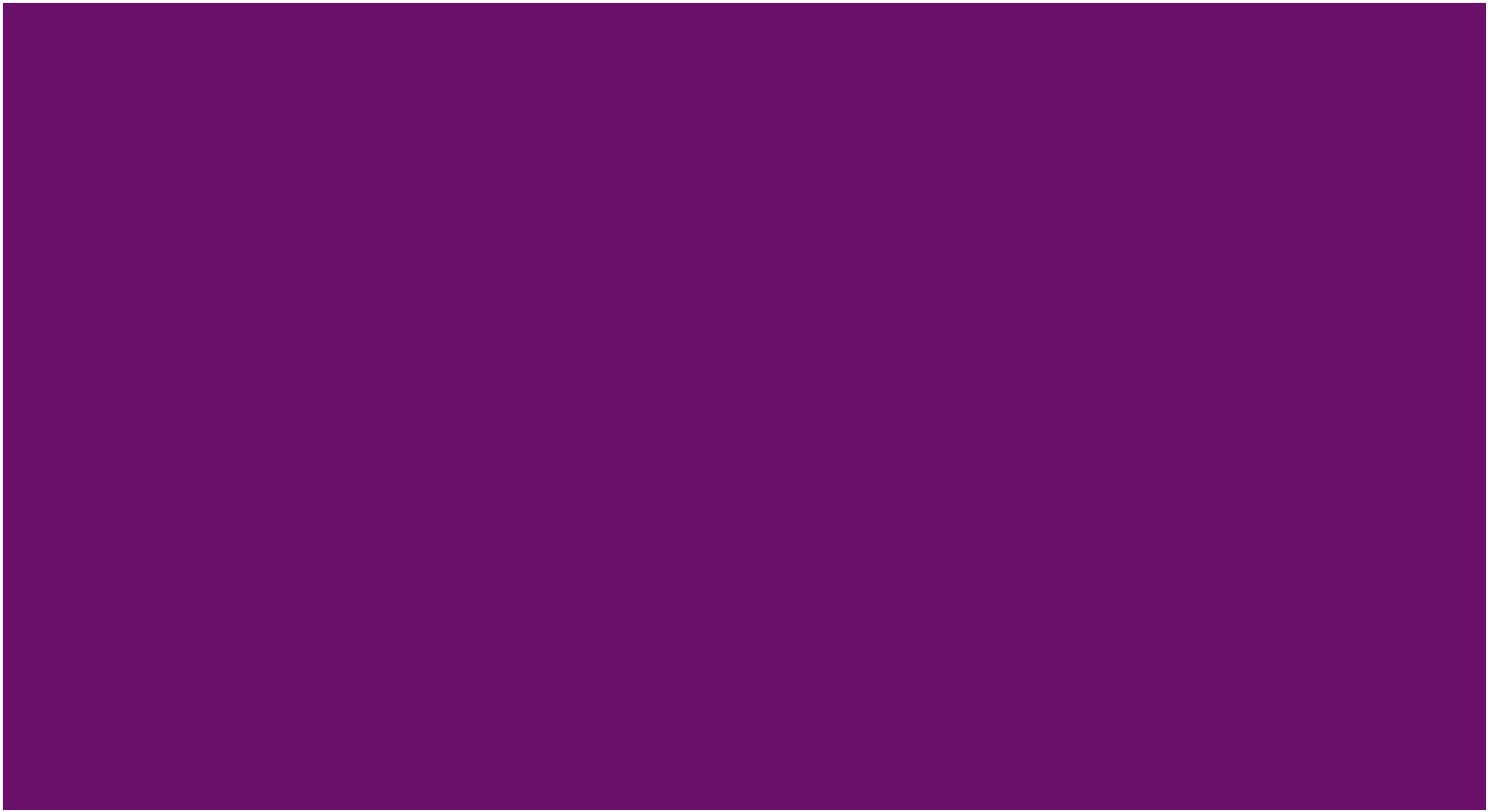


Diagram 5.8.4d Sideline Bridle

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



Inland Spill Response Tactics Guide

Charts, Tables & Calculators

6

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

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

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

6.2 | ASTM Guide for Boom Selection

Table 6.2a ASTM Guide for Boom Selection

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

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

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

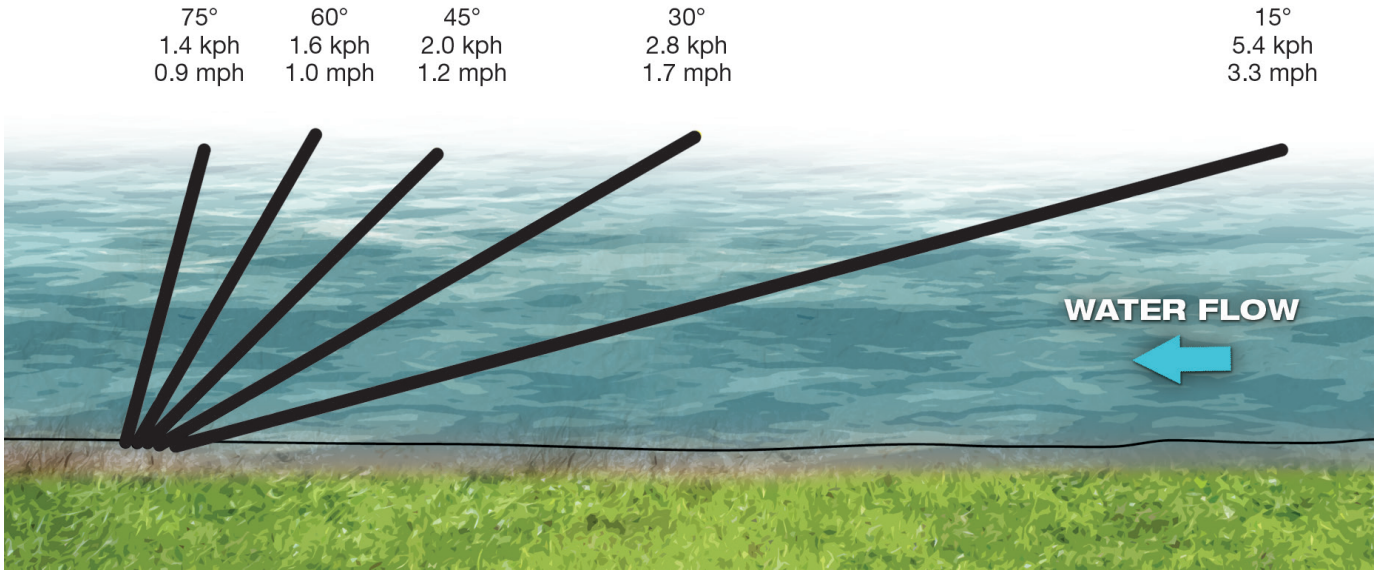
6.3 | Stream Speed Table

Table 6.3a Stream Speed Table

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

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

6.4 | Boom Angles



6.5 | Anchor Holding Capacities

Table 6.5a Anchor Holding Capacities Table

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

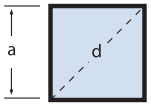
6.6 | Rope & Chain Minimum Breaking Strength

Table 6.6a Rope & Chain Minimum Breaking Strength

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

6.7 | Commonly Used Formulae

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

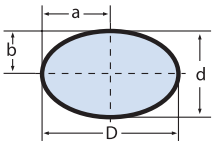


Square

$A = a^2$

$a = \sqrt{A}$

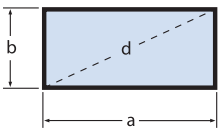
$d = a\sqrt{2}$



Ellipse

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

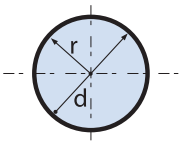
$C = \frac{D+d}{2}\pi$



Rectangle

$A = ab$

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



Circle

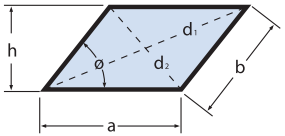
$A = \frac{d^2\pi}{4} = r^2\pi$

$\cong 0.785\ d^2$

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

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

6.7 | Commonly Used Formulae

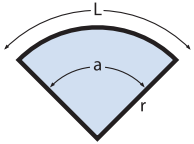


Parallelogram

$A = ah = ab \sin ø$

$d_1 = \sqrt{(a + h \cot ø)^2 + h^2}$

$d_2 = \sqrt{(a - h \cot ø)^2 + h^2}$



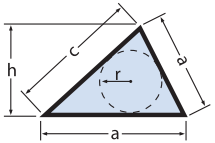
Sector of Circle

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

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

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

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

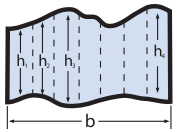


Triangle

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

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

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



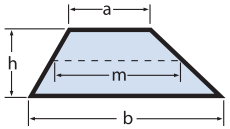
Irregular shape: divide length into parallel strips of equal width.

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

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

6.7 | Commonly Used Formulae

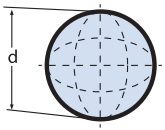
Estimating volume is as important as estimating area. For instance, it may be necessary to estimate the amount of solid waste in a debris pile to know how many roll-off boxes may be required for transport and disposal. As with areas, a quick estimate can be made by selecting a geometric shape most closely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



Trapezoid

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

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

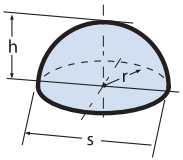


Sphere

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

$\cong 4.189\,r^3$

$A_{ø}=4\pi r^2=\pi d^2$



Segment of a Sphere

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

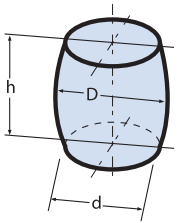
$=\pi h^2\,(r-\frac{h}{3})$

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

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

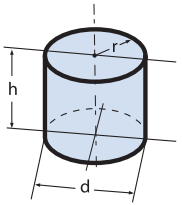
6.7 | Commonly Used Formulae

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



Barrel

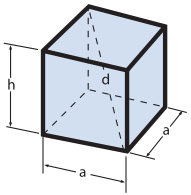
$V=\frac{h\pi}{12}(2D^2+d^2)$



Cylinder

$V=\pi r^2 h$

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

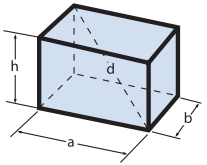


Cube

$V=a^3$

$A_o=6a^2$

$d=a\sqrt{3}$



Cuboid

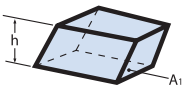
$V=abc$

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

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

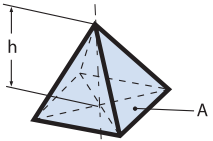
NOTE: A = area C = circumference s = semi-perimeter $\pi = 3.1416$

6.7 | Commonly Used Formulae



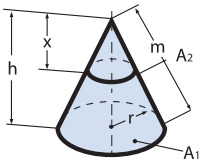
Parallelepiped

$V = A_1 h$



Pyramid

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



Cone

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

$A_m = r\pi m$

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

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

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

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

6.8 | Weights of Common Gases, Liquids and Solids

Table 6.8a Weights of Common Gases, Liquids and Solids

Substance	Unit Weight (lbs / 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

6.9 | English/Metric Conversions

Table 6.9a English/Metric Conversions

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

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

6.9 | English/Metric Conversions

Table 6.9a English/Metric Conversions

English to Metric	
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° = (C° (9) ÷ 5) + 32	
Pressure	
1 pound per square ince (psi)	0.0689 bar
1 pound per square ince (psi)	6.89 kilopascals (kPa)
1 pound per square ince (psi)	0.704 metre (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 metre^3 per hour (m^3/hr)
1 cubic foot per minute (cfm)	1.699 cubic metres per hour (m^3/hr)
1 barrel per day (bpd)	0.1104 litres 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 litres at 60ºF, often used to measure volume in oil production, transportation and trade

Bell Hole

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

Berm

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

Board Weir

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

Boom

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

Boom Angle

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

Bridge Pier

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

Collection Point

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

Containment Capacity

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

Control Point

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

Culvert Block

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

Current

The velocity or rate of flow

Decontamination

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

Deflection/Diversion Booming

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

Filter Fence

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

Entrainment

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

Environmental Damage

Any change or disturbance to the environment that is considered detrimental

Exclusion Booming

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

Ground Tackle

Equipment used in anchoring

Hydrophobic

Having an aversion to water. Hydrophobic substances repel water.

Incident Commander (IC)

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

Incident Command System (ICS)

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

In-Situ Burning

A tactic that involves the controlled burning of an oil spill at the location of the spill

Interceptor Trench

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

Leading Edge

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

Mechanical Containment

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

Mechanical Recovery

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

Oil Spill

Release of oil into the environment

Oleophilic

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

PFD

Personal Flotation Device (life vest, floater coat)

Piling

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

Pom-Poms

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

PPE

Personal Protective Equipment

Recovery

The process of collecting oil from an inadvertent release

Saw Sleigh

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

Sensitive Areas

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

Sheen

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

Siphon Dam

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

Skimmer

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

Sorbents

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

Spreading

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

T-posts

Manufactured metal rods used as posts to anchor temporary fences

Temporary Liquid Storage

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

Trench

Typically a long and narrow excavation in the ground

Viscosity

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

Weathering

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

Weir

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

Windrows

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

Inland Spill Response Tactics Guide

Appendix

8

8.1 | References

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

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8.2 | Diagram and Table Index

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