4.0 RESPONSIBILITY FOR CLEAN-UP AND RELEVANT LEGISLATION

4.1 RESPONSIBILITY

4.1.1 Responsibility of the Polluter

The responsibility for the costs of response and clean-up to ensure environmental protection lies with the owner or controller of the product spilled. This responsibility includes the provision of all personnel, equipment and resources for response clean-up, disposal and site restoration.

The owner or controller is also responsible for reporting all spills to the 24-hour spill report line. Informing government agencies in this manner ensures that both the polluter's and the government's legislative responsibilities are fulfilled and that clean-up proceeds in an environmentally sound manner.

4.1.2 Government Responsibilities

Government works under the principle that the owner or controller bears the primary responsibility for spill response and clean-up actions. Government agencies are responsible for initiating an evaluation of the spill event and monitoring of the clean-up activities to ensure protection of people, property and the environment and for providing technical advice on clean-up where required.

Active government participation in spill clean-up is not provided as a service for those responsible for the spill. It may be provided, however, under the following conditions:

a) the party responsible does not respond,
b) the party responsible does not have the available resources for immediate response, or
c) the actions being taken are not adequate to ensure public safety and environmental protection.

If government undertakes these actions, reasonable costs for use of government staff and resources are recovered from the party responsible by normal billing methods or, if necessary, by legal actions.

The primary responsibility of government is to enforce its own legislation pertaining to environmental authorities.

4.2 RELEVANT LEGISLATION

Legislation relating to spill response and clean-up in the Northwest Territories may be enforced through various Acts and regulations. Both the Federal and Territorial governments have legislation relating to oil and hazardous material spills.

The government agencies most frequently involved in spill response in the Northwest Territories are:

* Department of Renewable Resources, Government of the Northwest Territories

* Indian and Northern Affairs Canada

* Environmental Protection Service, Environment Canada

Less frequent spills involving radioactive materials, atmospheric emissions of hazardous materials or spills which threaten community and public health may require involvement by other government agencies.

Legislation applicable to spill response and clean-up is summarized in Table 4.

4.3 JURISDICTIONAL RESPONSIBILITY

In order to provide a clear understanding of which government agency has the lead role in spill response for specific situations and to avoid jurisdictional overlap, a working agreement has been reached (NAP, 1985) and is summarized in Table 5.

TABLE 4

LEGISLATION TO SUPPORT GOVERNMENT RESPONSE TO SPILLS

GOVERNMENT AGENCY	LEGISLATIVE AUTHORITY
Government of the Northwest Territories	Environmental Protection Act Transportation of Dangerous Goods Act Commissioner's Land Act Pesticide Act
Indian and Northern Affairs Canada	Northern Inland Waters Act and Regulations Arctic Waters Pollution Prevention Act and Regulations Territorial Lands Act and Land Use Regulations Public Lands Grants Act and Regulations Department of Indian Affairs and Northern Development Act
Environmental Protection Service, Environment Canada	Fisheries Act, Section 33 Ocean Dumping Control Act
Canada Oil & Gas Lands Administration	Canada Oil and Gas Act Canada Oil and Gas Drilling Regulations
Department of Transport	Canada Shipping Act and Oil Pollution Prevention Regulations Navigable Waters Protection Act
Atomic Energy Control Board	Atomic Energy Control Act
Emergency Planning Canada	
Department of National Health and Welfare	Public Health Act

TABLE 1

JURISDICTIONAL RESPONSIBILITY FOR GOVERNMENT RESPONSE TO SPILLS IN THE N.W.T.

SPILL INCIDENT	LEAD AGENCY
1. Spills on Territorial Land[1]	INAC (Indian and Northern Affairs Canada)
Except:	
a) Spills at Federal Facilities[2] not permitted under Federal or Territorial legislation.	EPS (Environment Canada)
b) Spills at oil and gas exploration and production facilities which affect the integrity or safety of the operation.	COGLA (Canadian Oil and Gas Lands Administration)
c) Spills in National Parks.	EPS
2. Spills on Commissioner's Land[3] (i.e. Territorial Highways[4], communities)	GNWT (Government of the N.W.T.)
Except:	
a) Spills at Federal Facilities[2] not permitted under Federal or Territorial legislation.	EPS
b) Spills at oil and gas exploration and production facilities which affect the integrity or safety of the operation.	COGLA
c) Spills at facilities permitted under Federal legislation.	INAC
3. Spills on Water[5]	INAC
Except:	
a) Spills at Federal Facilities[2] not permitted under Federal or Territorial legislation.	EPS
b) Spills at oil and gas exploration and production facilities which affect the integrity or safety of the operation.	COGLA
c) Spills from ships.	CCG (Canadian Coast Guard)

TABLE 5 (continued)

FOOTNOTES:

1) Territorial Land means lands in the Northwest Territories that are vested in the Crown or of which the Government of Canada has power to dispose.

2) Federal Facilities means any facility such as DEW Line Stations, High Arctic Weather Stations, Research Centres and Research Ships, operated directly or indirectly by the following agents of the Crown.
   a) Department of Communications;
   b) Department of Fisheries and Oceans;
   c) Department of Indian Affairs and Northern Development
   d) Environment Canada
   e) Energy, Mines and Resources;
   f) National Health and Welfare;
   g) Department of National Defence;
   h) Transport Canada;
   i) Department of Public Works;
   j) Department of Justice (RCMP)
   k) Canada Post;
   l) Crown Corporations, such as CN, CBC, CMHC, Petro Canada, Freshwater Fish Marketing Corp and formerly NCPC and NorthwesTel.

3) Commissioner's Land means lands in the Northwest Territories transferred by Order in Council to the Government of the Northwest Territories.

4) Territorial Highways include #1 -- #8, access roads and land portions of winter roads that do not require a federal permit; eg. Jean Marie River, Lac La Martre, and Norman Wells.

5) Water means inland and arctic waters as defined in the Northern Inland Waters Act and Arctic Waters Pollution Prevention Act. In cases where a spill on land enters water, the lead government response shall remain with the agency with responsibility for land spills.

5.0 SPILL RESPONSE

Spill response consists of a series of steps which are meant to allow the clean up of the spilled product without endangering people, property or the environment. The steps which should be taken when responding to a spill are:

a) identify the product spilled;

b) assess the dangers and hazards associated with the spill;

c) stop the flow at the source, **if safe to do so;**

d) take actions to contain the spilled product;

e) report the spill to the 24 hour spill report line; and

f) clean up the spill.

5.1 SPILL PRODUCT IDENTIFICATION

An immediate identification of the material spilled is required upon arrival at the spill site. Identification provides a basis for making assessments of the dangers and hazards to the environment, the public and response personnel.

In the majority of cases, identification of the spilled product is made immediately through information received from the driver or captain, through familiarity with storage facilities, or from local knowledge of material uses. In the event that immediate identification is not possible the following procedures should be followed. These procedures should also be used to confirm the identity of known materials.

Placards and Product Identification Numbers

Transport Canada's Training Section - Transportation of Dangerous Goods has developed a consistent and uniform approach for product identification. Nine classes of dangerous goods are defined and are uniquely identified by placards and product identification numbers (PIN) mounted on the containers or vessels in which the materials are shipped or stored.

Shipping Documents

One or more of the following documents may be available in the vehicle or at the shipper's office:

1) Hazard Information Emergency Response Forms;
2) Air Waybills and Manifests; or
3) Manifests required under the Transportation of Dangerous Goods Act.

Location and Container/Vessel Type

The majority of spills in the Northwest Territories are petroleum products. These products are commonly transported by barge or truck in bulk or in 45 gallon drums. The routes, schedules and container or vessel types for these products are often known through local knowledge and familiarity.

For stationary sources, location of the source may provide for identification of the product.

IF THE PRODUCT CANNOT BE IDENTIFIED, ASSUME THAT THE MATERIAL IS DANGEROUS. DO NOT ATTEMPT TO IDENTIFY BY SMELLING OR TOUCHING THE MATERIAL.

5.2 ASSESSMENT OF DANGERS AND HAZARDS

The assessment of the type of material spilled and the magnitude and conditions of the spill provides a basis for identifying the hazards and the dangers inherent in controlling the spill. These assessments will be critical in preventing loss of life and personal injury, in ensuring public safety, and developing a plan for approaching the spill site. The identification of hazards and dangers associated with controlling and handling hazardous materials are discussed in Appendix B.

Personal protection and safety are of utmost importance in approaching the spill site. These are outlined in Appendix A.

5.3 SECURE THE SOURCE

Once the product has been identified and the dangers and hazards to the response team and the public have been assessed, further risk may be minimized by preventing additional loss of material. If the entire contents are already lost, the immediate action is to contain the spill on site.

Time is of critical importance in securing a leaking source. The response team should be prepared, upon arrival on site, to quickly assess the situation and be prepared with the necessary tools and equipment to secure the source.

5.3.1 Specific Actions for Securing the Source

The reasons and causes of spills in the Northwest Territories are discussed in Section 2. Human error is a significant factor for many of the spills reported.

The first assessment to be made in proceeding to secure the source is to identify the leak. Potential routes of leakage are:

* open valves;
* overflow;
* orifice leak, (puncture, rupture); or
* vessel failure (fire, explosion).

General procedures for securing the source for various natures of leaks or failures are given in Table 6.

TABLE 6
PROCEDURES FOR SECURING THE SPILL SOURCE

NATURE OF LEAK/FAILURE	SUGGESTED ACTION
Discharge from tank due to overflow	1. Stop flow into tank by closing supply valves or pump. 2. If overflow is from fuel expansion, remove some fuel from the tank by transferring to another vessel.
Discharge from tank due to open valve or pipe.	1. Close valve upstream from discharge point. 2. If no valve is present, transfer contents to another vessel.
Discharge due to orifice leak	1. Transfer contents to another vessel. 2. Patch utilizing techniques described in Figure 6. 3. If leak is from a small vessel (ie. barrel), realign to have level of liquid below leak point.

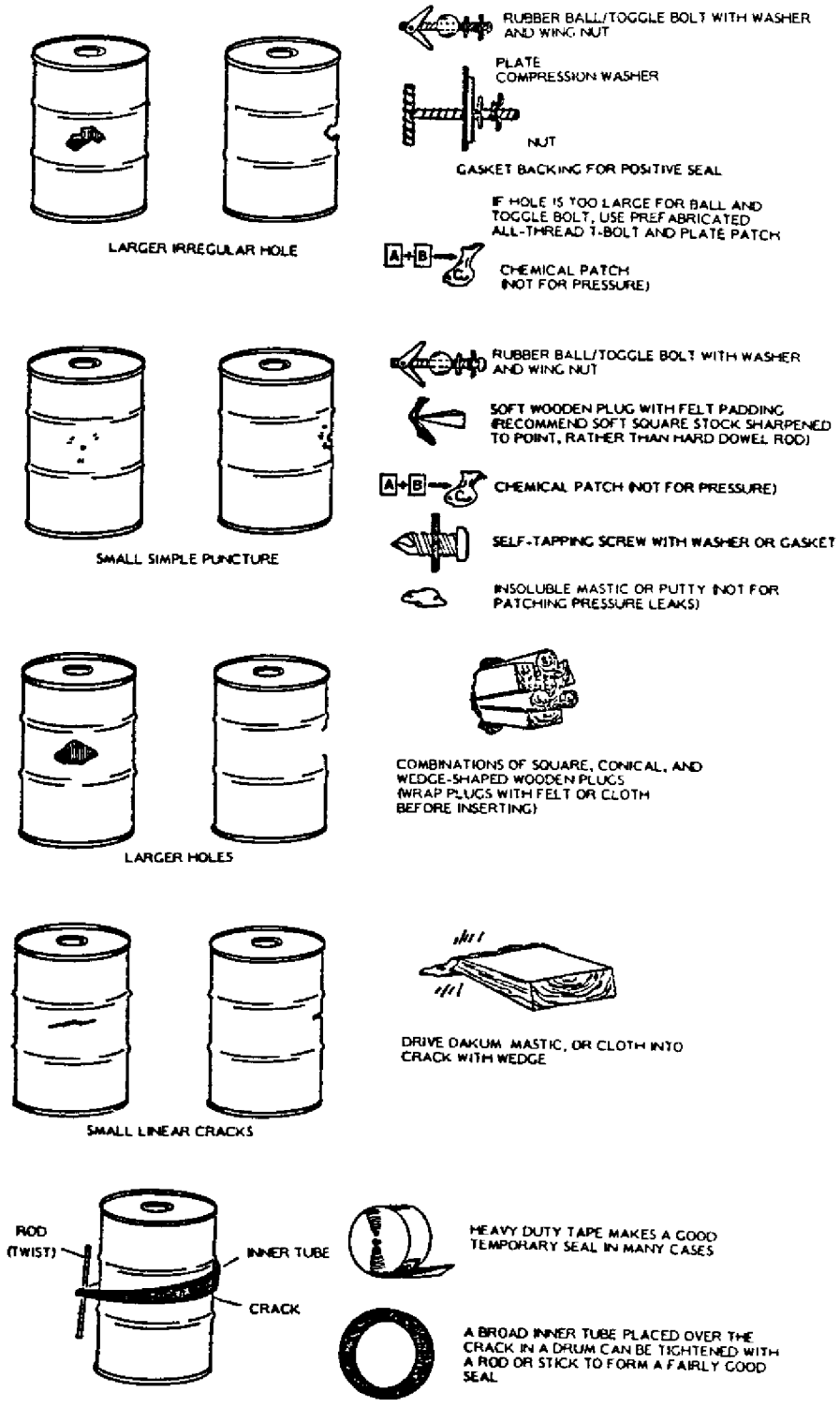


FIGURE 10

TECHNIQUES FOR PATCHING AND STABILIZING LEAKING CONTAINERS

5.4 SPILL REPORTING

In the Northwest Territories, all spills of petroleum products and other hazardous materials must be reported. A telephone line dedicated for this service is maintained in Yellowknife and is known as the

24-HOUR SPILL REPORT LINE: (403) 920-8130

This telephone line was initiated jointly by Indian and Northern Affairs (INAC) and the Government of the Northwest Territories (GNWT) in 1979. The Water Resources Division of INAC maintains the telephone services and GNWT provides for the printing and supply of spill report forms.

The purposes of reporting a spill through this telephone service are:

1. To provide a uniform and consistent approach to spill response in the Northwest Territories.

2. To assist field personnel in responding to the spill, in undertaking proper site assessments, and in identifying recovery and disposal methods.

3. To elicit technical backup from personnel in various government agencies in the Territories and from specialized firms and organizations in Canada.

4. To dispatch (when needed) personnel and equipment to the spill site.

5. To provide technical information on material properties, response and site restoration procedures, as required.

6. To monitor the progress of response and clean-up actions.

7. To provide a central clearing house or command post for progress of spill response actions.

5.4.1 Reporting Procedures and Information Needs

The reporting of spills in the Northwest Territories requires the reporting of specific information on spills of oils and other hazardous materials. A spill report form is available for these purposes and a sample copy is provided in Figure 11. Spill report forms are available from the Government of the Northwest Territories, Department of Renewable Resources. The procedure for reporting is:

1. Fill out spill report form as completely as possible before contacting the 24 hour spill report line. If incomplete information is available, the spill line should be contacted regardless.

2. Report immediately to the 24 hour report line **(403)920-8130.** Collect telephone calls can be made by informing the operator that you wish to report a spill.

3. Where telex is available, follow up immediately by sending a telex copy of the spill report: Telex 034-45623.

4. RCMP or Renewable Resources communications may be used if other means are not available.

The information specifically needed when reporting a spill is:

a) Report Date and Time of Spill

The written report should be prepared as soon as possible after the spill event to ensure completeness. Reporting the time of spill will determine the measures and approaches which may be used for response; the greater the period of time the less that can be done to contain and control the spilled material.

b) Location and Map Coordinates (if known) and Direction of Spill Movement

Be specific and accurate. The potential for the spill discharging to water should be reported.

c) Party Responsible

The party who allowed or caused the spill to occur, be it industry, a government agency or a member of the public. If available the operations supervisor's name should be reported.

d) Product Identification and Quantity Spilled

The material should be positively identified. If the material is not known, assistance should be requested. An estimate of the spill quantity should be made. Identification of container type (tank truck, barge, etc.) will assist in providing an estimate of the magnitude of the spill. Product names should be reported correctly, ensure correct spelling.

e) Cause of Spill

Identify the general incident category (truck overturn, barge grounding, tank overfill, pipeline rupture, etc.) causing the spill.

f) Spill Terminated or Continuing

Is the spilled material continuing to leak from the source? If spill is of a continuing nature, assistance can be provided to identify options for securing the source.

g) Extent of Contaminated Area

Estimate the land or water area covered by the spill. This will assist in determining the potential environmental effects and types of measures needed to contain the spill.

h) Factors Affecting Spill Recovery

Factors such as manpower and equipment availability, temperature, wind, snow, ice, terrain, buildings, etc. will require consideration when undertaking an effective spill response program.

i) Containment Measures

Is containment by natural or artificial means? Provide information on how the spill has been contained so that assessments may be made regarding the need for further actions.

j) Response Actions to Date

Provides information on the actions that have already taken place to contain, recover, clean-up or dispose of spill material.

k) Request for Assistance

Provides information on additional manpower and equipment needs, fire response, medical aid, safety equipment requirements, etc.

l) Hazards and Dangers

Potential hazards and dangers must be identified so that emergency measures may be taken or public warnings made.

m) Comments and Recommendations

Provides for additional comments and information not given in other sections.

"Reported by:"

Self-explanatory

"Reported to:"

Usually the person manning the 24 hour spill report line.

Northwest Territories

SPILL REPORT

(Oil, Gas or Other Materials, i.e. Hazardous Chemicals, etc.)

24-Hour Report Line
Phone (403) 920 8130

A	Report Date	Date and Time of Spill if Known
B	Location and Map Coordinates (if known) and Direction if Moving	
C	Party Responsible	
D	Product Spilled and Estimated Quantities (Provide Metric Volumes/Weights if Possible)	
E	Cause of Spill	
F	Is Spill Terminated or Continuing	
G	Extent of Contaminated Area	
H	Factors Affecting Spill or Recovery - Temperature Wind Snow Ice Terrain, Buildings etc	
I	Containment Naturally Booms Dykes or Other No Containment	
J	Action, if any Taken or Proposed to Contain Recover, Clean-up or Dispose	
K	Do You Require Assistance	If so What Form
L	Hazard to Persons or Property or Environment Fire Drinking Water Threat to Fish or Wildlife	
M	Comments and/or Recommendations	

Reported by	Position Employer, Location	Telephone
Reported to	Position Employer Location	Telephone

FIGURE 11

SPILL REPORT FORM

5.4.2 Follow-up Reporting

During or following actions taken to clean-up a spilled material, follow-up reports should be phoned to the 24-hour spill report line outlining any new information which becomes available. The spill report form should be used to sup ply the follow-up information; supply new information only. Notify the 24-hour spill report line when clean-up has been completed.

5.5 CONTAINMENT

5.5.1 Containment To Minimize Clean-Up Operations

Prompt and effective containment of spill movement is necessary to reduce spill clean-up and site restoration work and to minimize potential environmental and public health risks.

Containment measures may be broadly categorized into two groups: land based and water based. The options available make use of a wide range of materials including straw, chicken wire, and snow fencing to commercial sorbents and booms.

Effective containment will result from prompt action, selection of proper methods, advance planning (prior to spill occurrence) and proper use of equipment.

5.5.2 Land Containment Methods

Land spills are generally more easily dealt with than spills that have reached a waterway. Efforts should be made to prevent or stop spilled product from entering water.

Land containment of spills is generally achieved by minor earthworks such as trenches and earth dams or dykes. Under northern conditions, where earth is frozen for most of the year, snow can be used for temporary containment and can also be used as a sorbent material.

Trenches

Trenches may be used to intercept and hold all types of hazardous materials but are practical only under summer conditions. In areas of continuous permafrost, the depth of excavation will be limited by the depth of the active layer. In

the northern arctic, the thaw depth by the end of summer is about 0.5 - 1.0 metres while in the southern arctic it ranges from 1.0 - 2.0 metres. When water is present in excavated trenches, it should be assumed that contamination will result and will eventually discharge to surface waters. A synthetic membrane liner may be placed on the bottom and sides of the trench. For petroleum products water flooding will separate spilled material from the bottom of the trench and will assist in material recovery.

Trenches may be effective in intercepting subsurface flows (as shown in Figure 12). Under arctic conditions, the flow of contaminants below the ground surface will generally be limited to a 1 - 2 metre depth. Relatively shallow trenches strategically placed downslope of the spill will be effective in intercepting both surface and subsurface migration of spilled materials. This method is effective in preventing subsurface contamination of water and eventual discharge to streams and other water bodies.

The use of this approach may result in permafrost degradation and thermocarsting. Subsequent erosion may complicate site rehabilitation measures.

The materials and equipment needed for trench construction are:

* backhoe, loader, dozer
* shovels, picks
* synthetic membrane liners

Dams/Dykes for Impoundment

Earth or snow dams constructed across ditches or swales may be used to contain a spill and stop its flow. The entire flow of the spilled material and any surface drainage may then be contained.

Construction materials which can be used include earth, wood, sandbags, and snow. The dam or dyke should be lined with plastic sheeting to make it impermeable to the spilled product. In the winter, water may be sprayed on snow dams or dykes forming ice to make it impermeable.

The dam dimensions and location must take into account the volume of material to be retained. Deep ditches or swales require narrow dams. Care should be taken to ensure that dam configuration is adequate to contain the entire spill volume. Insufficient capacity may result in overtopping and failure.

Dams and Weirs for Impoundment and Separation

For ditches or swales with flowing water or for small streams, it may be necessary to allow water flow to continue and to retain the lighter-than-water li quids. These methods apply only to spills of petroleum products which readily separate from water.

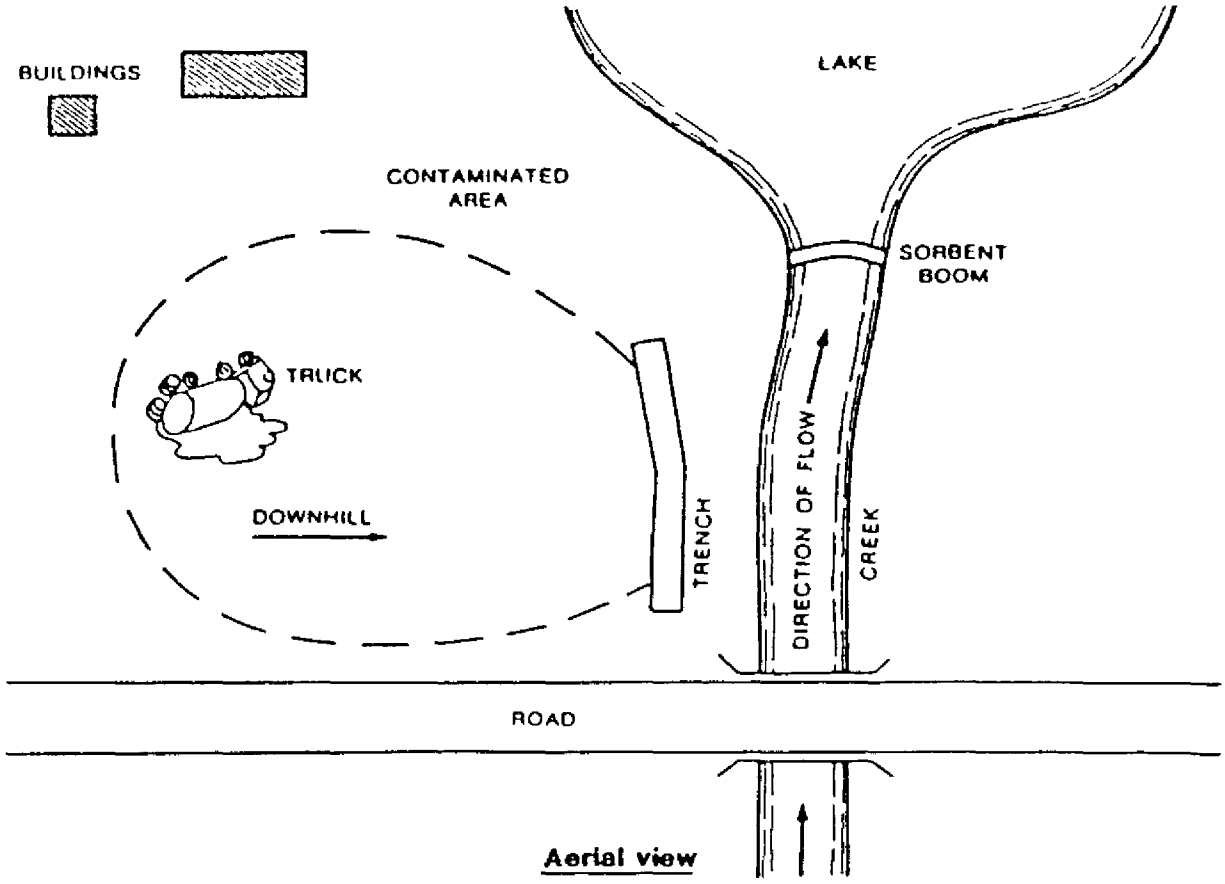
Water bypass or underflow dams may be constructed on small, slow flowing ditches or streams. An earth dyke is constructed stopping the flow of water and spilled products in the ditch. Water is then allowed to continue down the ditch by piping water from below the level of the hazardous liquid as shown in figure 10. It should be noted that the pipe is inclined to prevent the spilled liquid from dropping too far and discharging through the piping. The discharge end should not be inclined above the level of the dam since overtopping and failure will result.

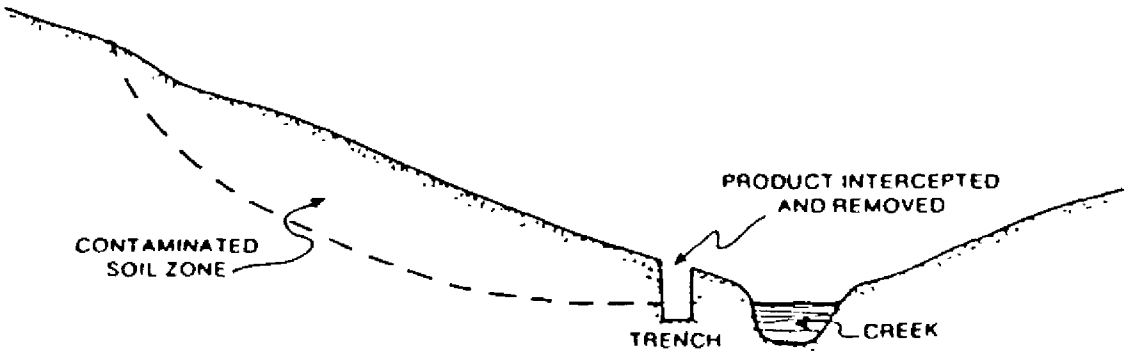
Weirs may be effectively and easily used in ditches and at culverts. Materials commonly used such as plywood, lumber and sheet metal may be placed to completely or partially block culvert entrances. These barriers may be suspended from stakes on either side of culvert openings and raised or lowered to maintain the desired water level while retaining the oil. For fast flowing streams, oil can be entrained in the water and then flow under the weir. Figure 11 illustrates the use of weirs.

Recovery of material collecting behind dams and weirs may be made with the use of solvents, skimmers, or by direct suction. Containment and recovery operations must be monitored to ensure that the system's capacity to retain contained material is not exceeded. Special attention should to be given to positioning the weirs culverts as leakage is a potential problem.

5.5.3 Water Containment Measures

Water containment measures generally include the use of booms or barriers. Unless the entire flow of contaminated water can be stopped by damming, these methods are limited to the containment and recovery of materials that will readily separate from and float on water. For materials which will readily mix with water, efforts should be directed at stopping the material from entering water, ensuring public health and safety (i.e. protection of water intakes, prevention of explosion and fire, etc.), taking quick action in stopping the release at the source, and monitoring the progress and effects of these materials on the environment.





Cross-section

FIGURE 12

TRENCHES TO INTERCEPT OVERLAND/SUBSURFACE FLOW
(DILLON, 1983)

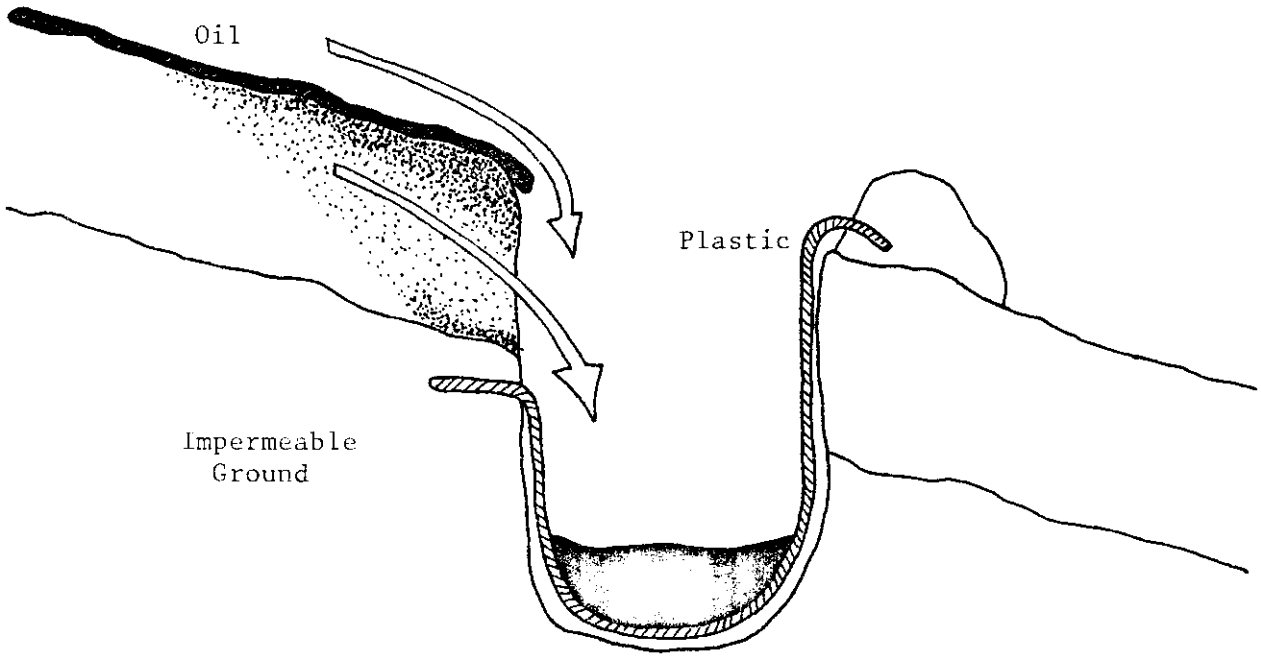


FIGURE 13

DETAIL OF INTERCEPTOR TRENCH

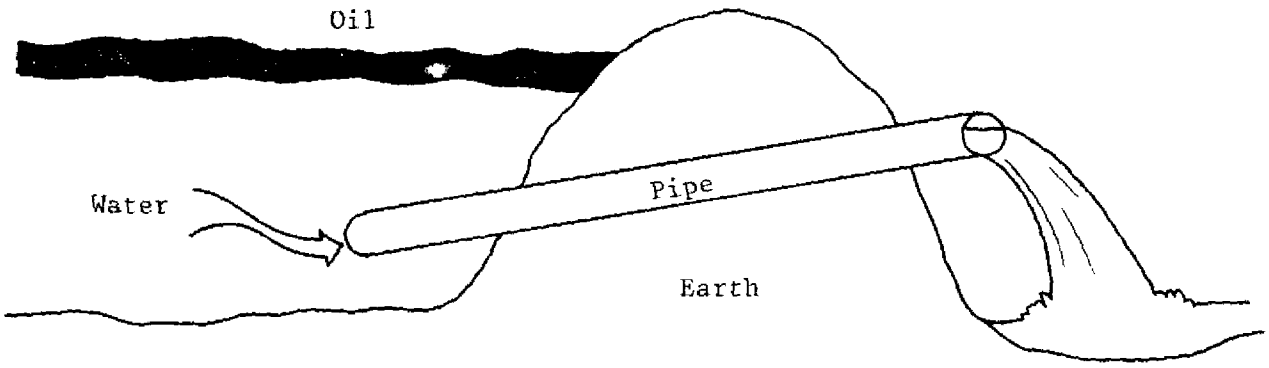
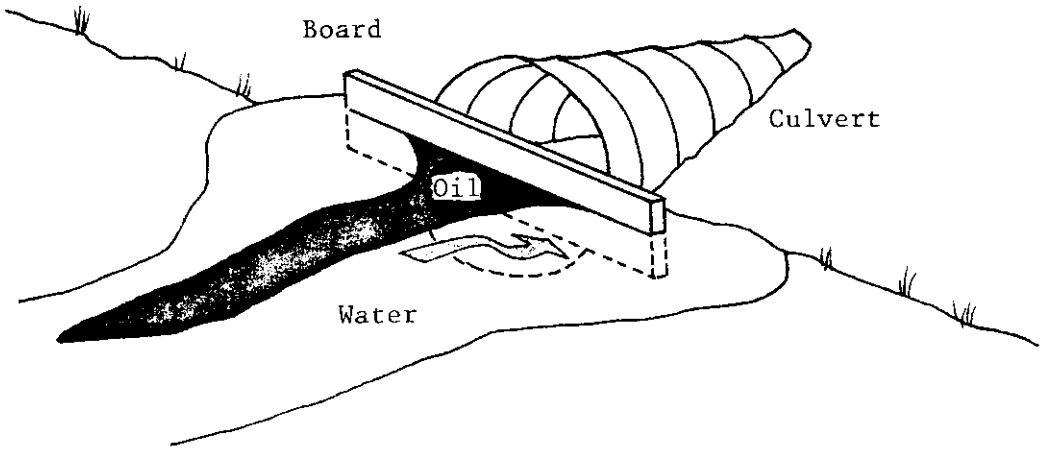


FIGURE 14

WATER BYPASS (UNDERFLOW) DAM



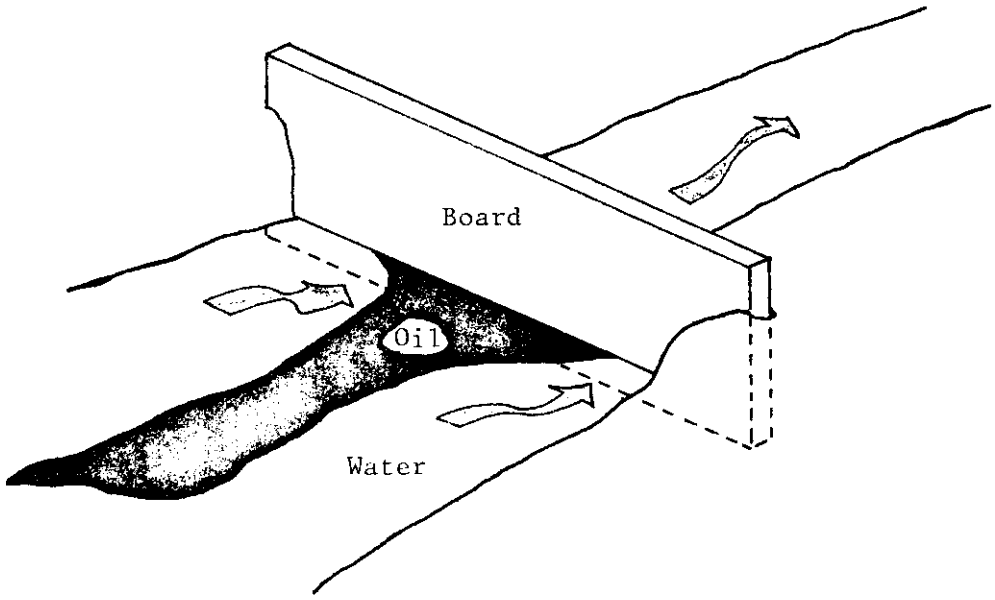


FIGURE 15

CULVERT AND EARTH DAM WEIRS

Areas where there is a high likelihood for accidental spills or which must be protected from contamination should be assessed as part of an advance planning program for spill containment.

The specific locations for water containment measures are dependent on the type of water body (stream, lake, river or pond), climatic conditions, equipment and personnel availability, volume of spill and spill material properties.

Certain materials such as gasoline or other volatile or flammable petroleum products have high risk of fire or explosion. For these materials, containment and evaporation (without recovery) or in-situ burning may be a preferred approach.

Fixed Barriers - Snowfence and Sorbent Barrier

Snowfence and sorbent barriers (Figure 16) may be used in streams with soft beds into which stakes can be driven. These methods are limited to summer conditions.

A snowfence barrier is installed to span the width of a stream less than 1 m deep and anchored at both ends with steel or wooden stakes. Stakes are driven into the stream bottom at 1 to 2 m intervals (supporting braces may be needed for strong currents). Straw bales or commercial sorbents are placed on the upstream side. Sorbent floats against the upstream side but must be replaced before it sinks. The barrier should be angled against the current for shore side collection. Multiple snowfence barriers can provide backup against potential losses from upstream barriers. Net or chicken wire barriers (Figure 17) can be constructed in the same way. For stronger currents, these are more practical since water can flow through more easily.

Floating Booms

a) Commercial Booms

The type and size of boom will depend on the specific location and conditions at which the boom is to be used. The general principles in using a boom are:

* To contain a spill of floating liquid or debris;
* To deflect or divert material to a defined area so that it may be recovered; and
* To protect sensitive areas from contamination.

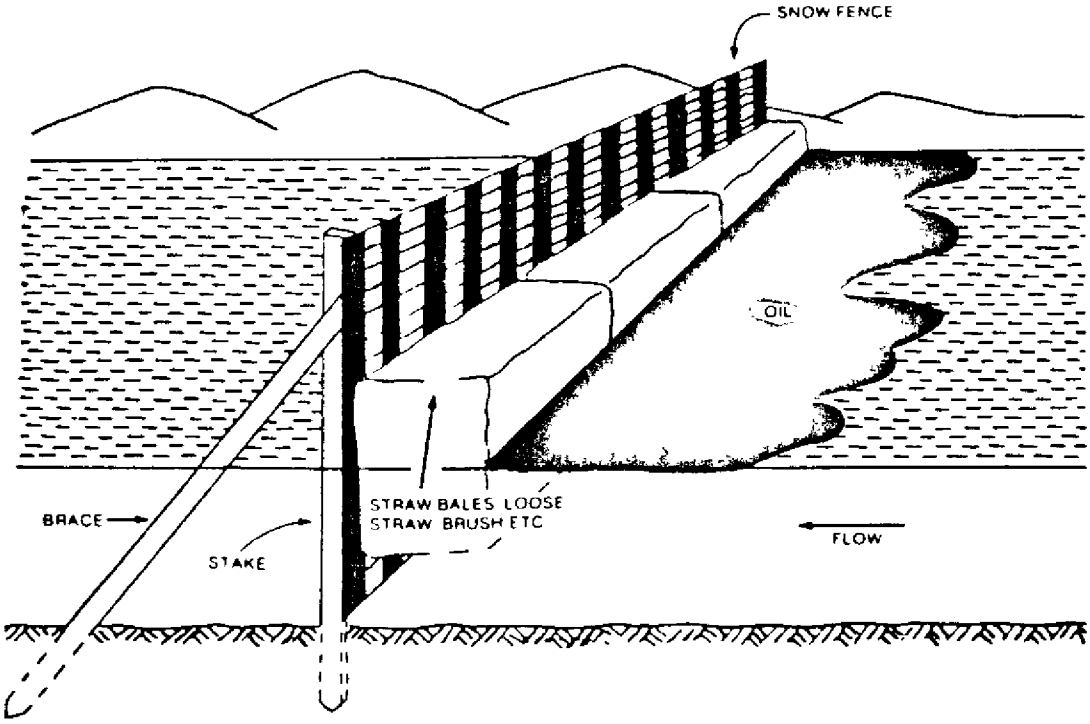


FIGURE 16

SNOWFENCE AND SORBENT BARRIER
(DILLON, 1983)

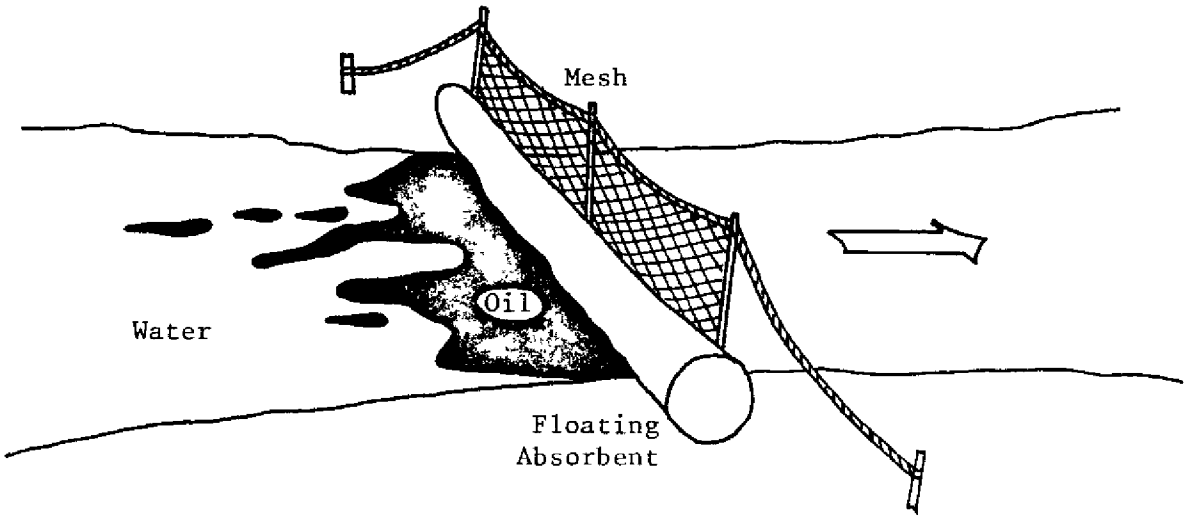


FIGURE 17

NET AND SORBENT BARRIER

The four basic components of commercial booms (Figure 18a) include flotation, skirt, ballast and tension members. Flotation maintains the boom on thesurface of the water; the skirt is designed to prevent contained material from escaping under the boom; the ballast keeps the boom in a vertical position; and a tension member provides directional orientation and holds the boom together. Boom failure can result from high winds, strong currents or large waves. The components of a boom anchoring assembly are shown by Figure 18b.

Boom deployment is a critical consideration. The angle of the boom relative to flow direction must be related to water flow velocity in order to achieve effective containment. This relationship is described by Figure 19.

Several booms arranged in parallel may be necessary to contain all the oil (or other floatable material). These should be spaced to allow for particles which may escape the first boom to float to the surface and be contained by the next boom. In addition, the use of several booms permits the removal of a boom for cleaning. (Figure 20).

b) Improvised Booms

Improvised booms may be constructed from a wide variety of materials readily available in most communities. Basically anything that will float and form a barrier can be used to contain floating spilled product.

Wooden Booms constructed from logs, railroad ties, telephone or power poles, trees or lumber can be used to deflect floating material to shore or to keep floating material within a contained area. Individual sections are connected together by rope, chain or wire. A seal around the joints to prevent leakage can be attempted by wrapping with plastic sheets or burlap. (Figure 21).

Wooden or other floating booms can be used to contain the spilled material itself or the sorbent containing the material. They can also be used upstream of sorbent booms to improve the efficiency and longevity of the sorbent material.

Inflated fire hose or styrofoam can also be used as improvised booms.

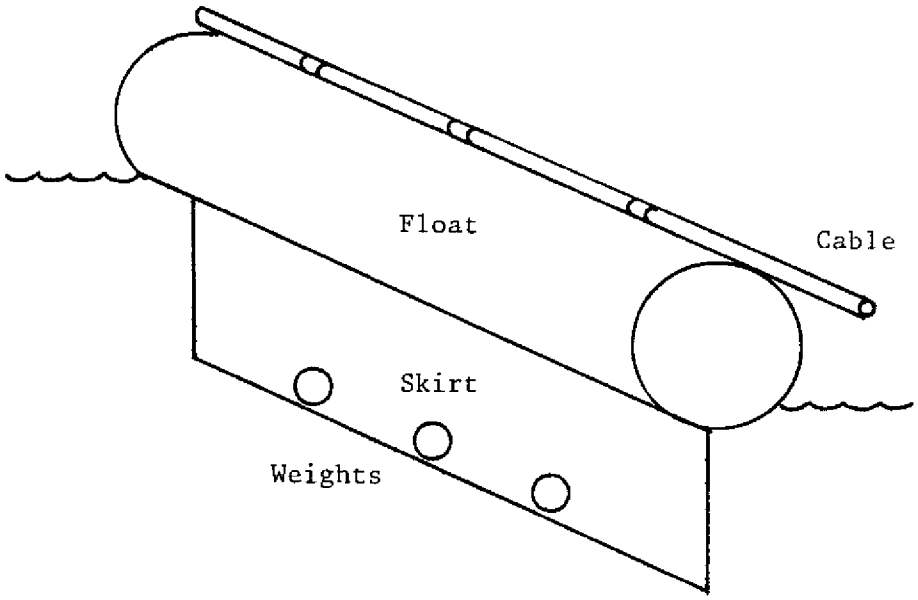


FIGURE 18a

BASIC COMPONENTS OF A COMMERCIAL BOOM

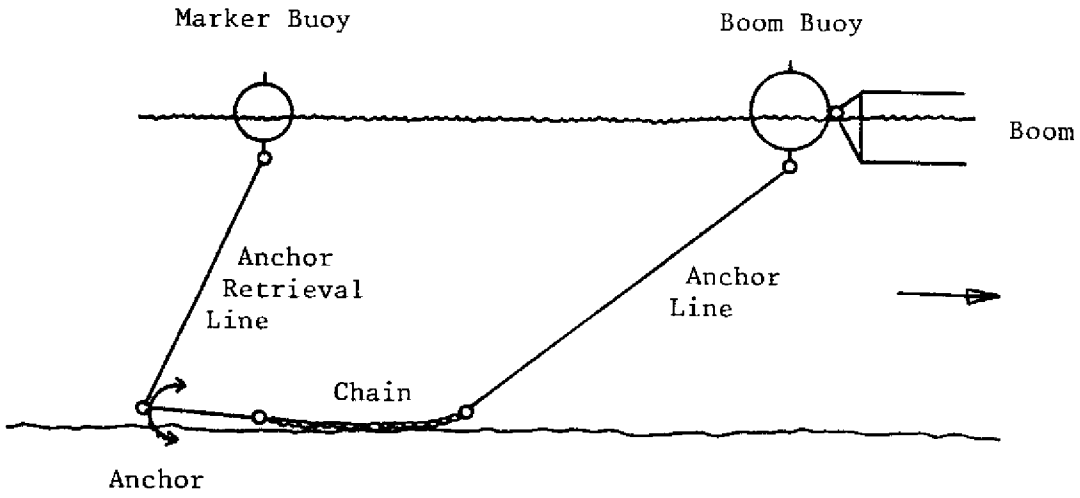


FIGURE 18b

BASIC COMPONENTS OF A BOOM ANCHORING ASSEMBLY

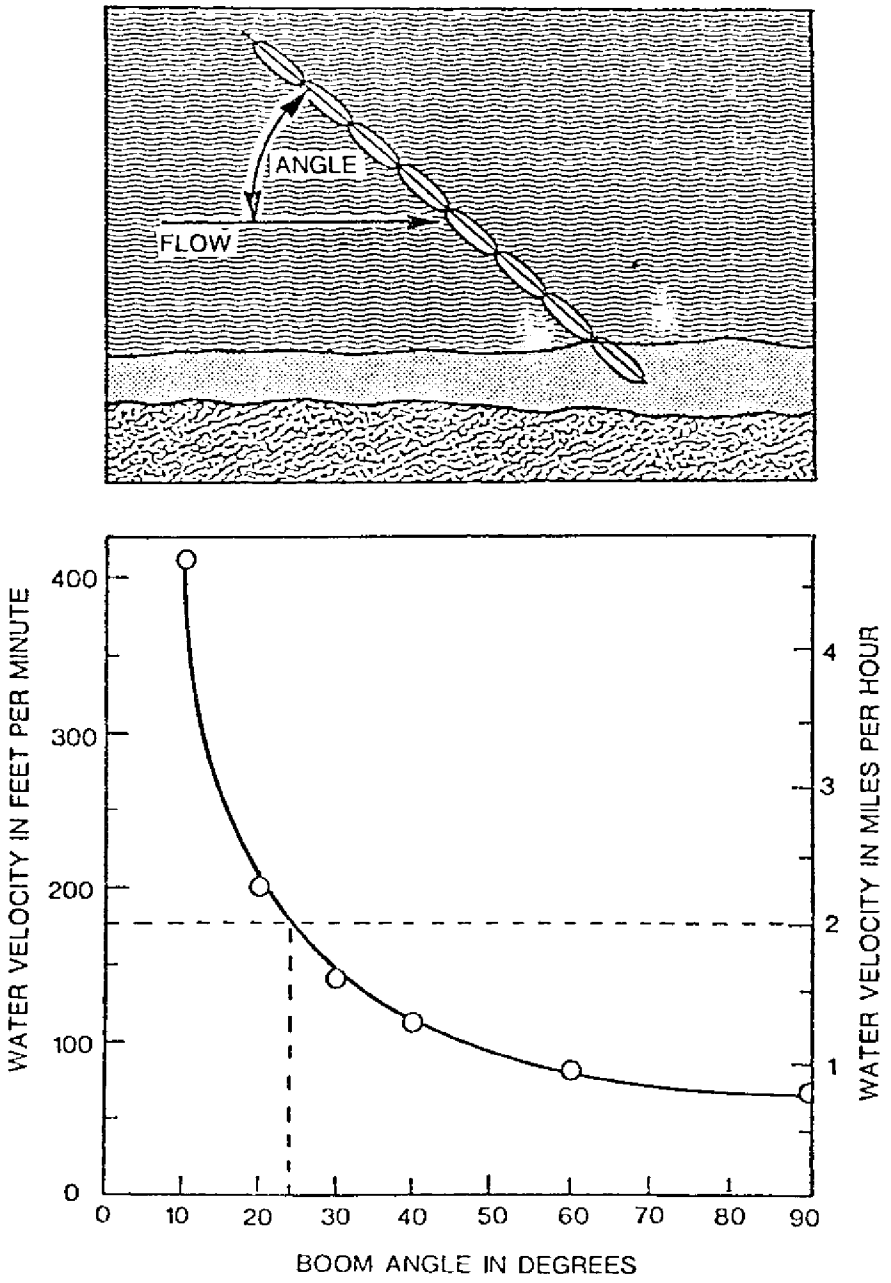


FIGURE 19

BOOM ANGLE DEPLOYMENT VS WATER VELOCITY
(EMO, 1979)

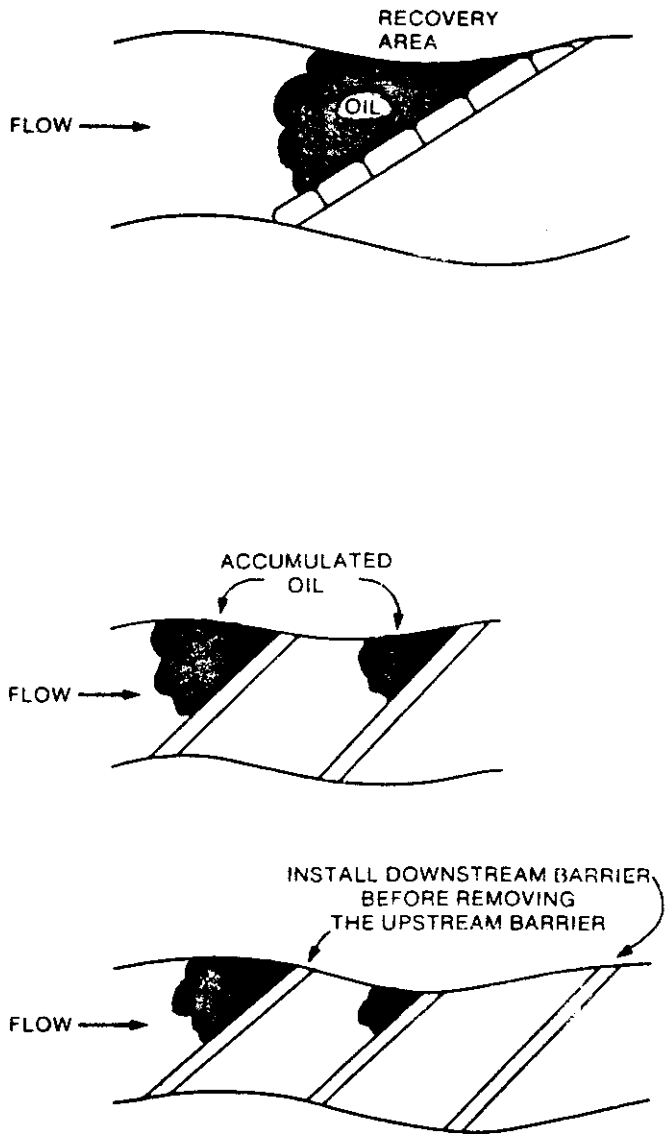
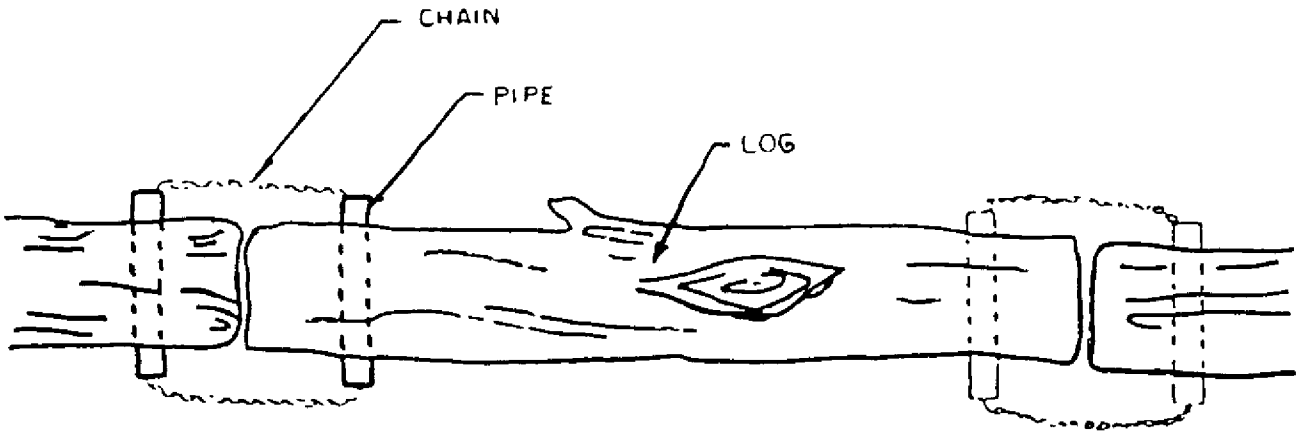
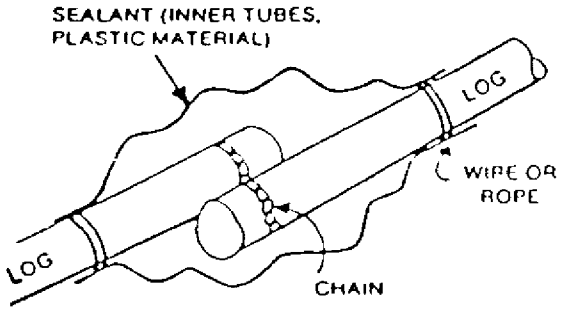
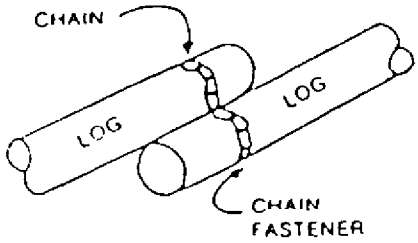


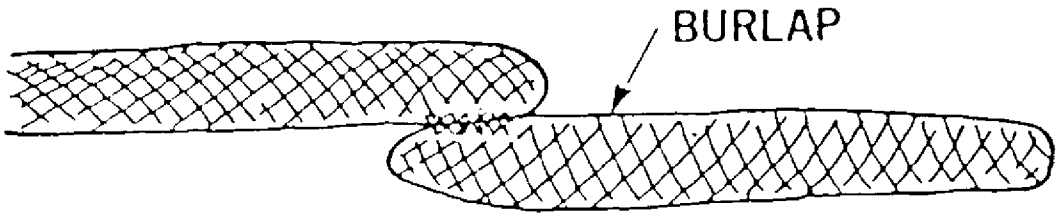
FIGURE 20

MULTIPLE ANGLED BOOMS
(KENNEDY et al, 1981)









STYROFOAM LOGS IN BURLAP

FIGURE 21

VARIOUS MEANS OF CONNECTING WOOD OR STYROFOAM BOOMS
(KENNEDY et al, 1981)

Chicken wire and sorbent booms (figure 22) are applicable to narrow streams with weak currents or still waters. Fishing net can replace chicken wire if the wire is not readily available. This boom is a combination containment and recovery boom. A suitable length and width of chicken wire is rolled up with commercial or natural sorbents in the form of a "jellyroll" or "sausage". Buoyant material should be used within the boom otherwise it will sink after several hours. Rope or wire is used to hold the sections in place. Natural sorbents include straw and evergreen boughs. Commercial sorbents have greater capacity to absorb oil and other petroleum products, they last longer, and they can be re-used. Foam sections have good sorbent capacity and excellent buoyancy.

Several booms can be placed in parallel for more effective containment and to permit the replacement and cleaning of alternate booms. Multiple booms will also reduce the risk of downstream water contamination if an improvised boom rolls over. When removing booms, there exists a potential for the absorbed oil to be expelled back into the watercourse, therefore care is advised in this operation.

Figure 23 illustrates a potential placement of improvised booms. Note the upstream log booms placed for either directing oil or containing debris that might otherwise damage or interfere with the makeshift sorbent boom.

5.5.4 Containment Under Ice

All possible attempts should be made to avoid oil from entering ice covered waters as no easy method exists for containment and recovery of oil under ice.

Ice slotting may be used in rivers or streams when current speeds are slow, less than 0.5 meter/second. A trench is cut into the ice using a chain saw or "ditchwitcher" machine at an angle to the current to deflect and concentrate oil which passes through the area. Because of the thickness of ice cover encountered during northern winters, cutting and removal of ice blocks is often difficult. Loaders or backhoes may be needed to lift blocks out of the slot. Alternately, backhoes may be used to push blocks down. Oil which accumulates in the ice slot may either be pumped out, absorbed or burned in place. Figure 24 demonstrates ice slotting techniques.

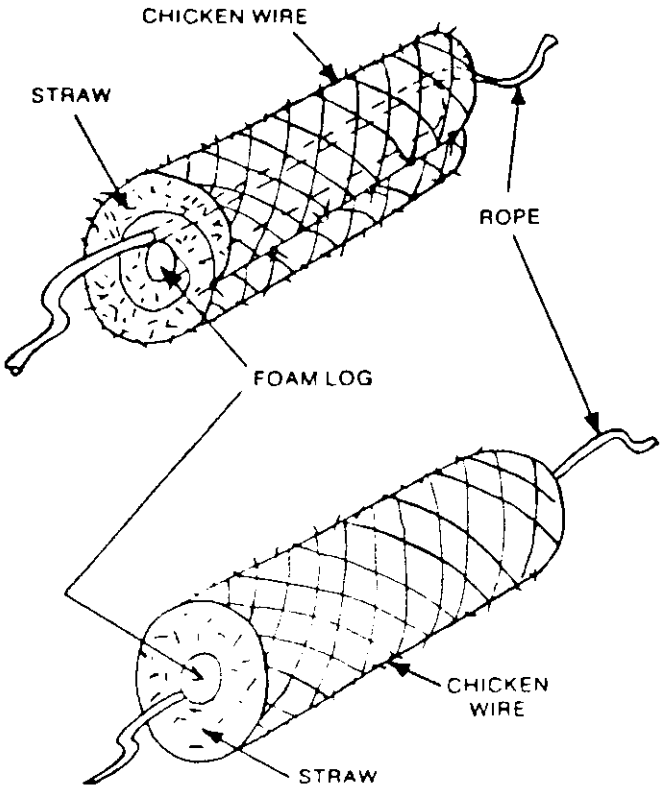


FIGURE 22

JELLYROLL AND SAUSAGE ROLL IMPROVISED SORBENT BARRIERS
(KENNEDY et al, 1981)

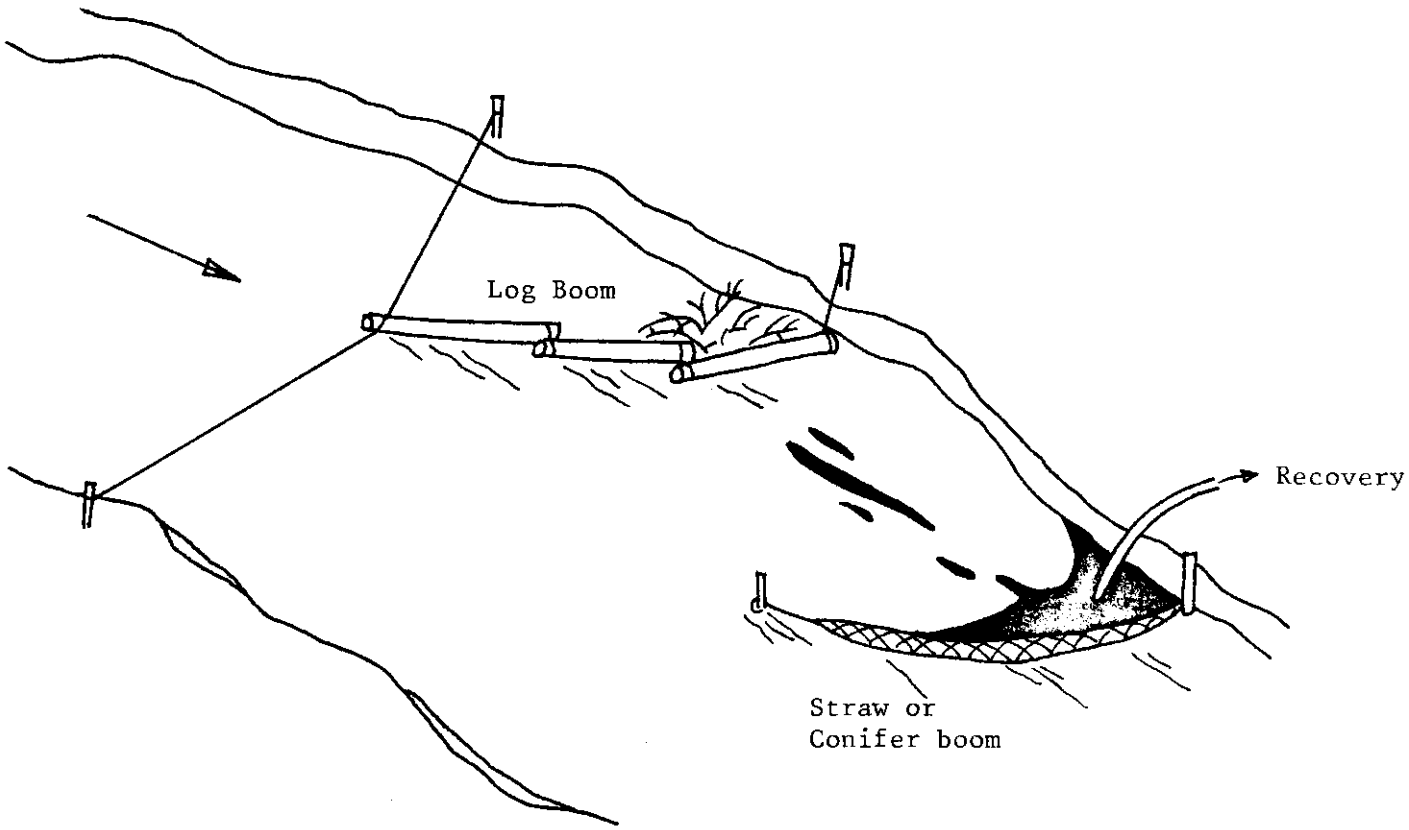


FIGURE 23

POSSIBLE SCHEMES FOR BOOM ATTACHMENT AND DEPLOYMENT
(EMO, 1979)

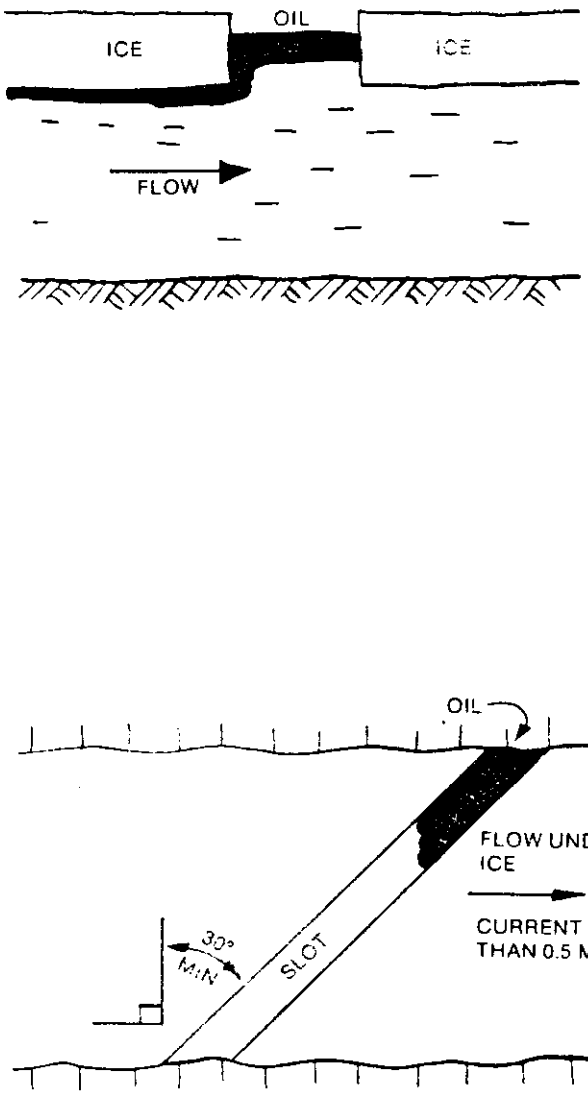


FIGURE 24

ANGLED ICE SLOT FOR OIL DEFLECTION AND RECOVERY
(KENNEDY et al, 1981)

Vertical barriers in ice (example plywood) may be used to deflect oil under ice in slow moving deep waters. Ice conditions must allow support for the necessary personnel and equipment.

Vertical barriers are put in place by cutting trenches in ice at an angle to current flow, inserting the plywood barriers and allowing them to freeze in place. (Figure 25). Chain saws can cut slots into ice up to 0.5 metre thick. The location of the oil slick may be monitored by drilling observation holes with an ice auger.

5.6 RECOVERY

Prompt removal of the spilled material from the spill site is required to reduce and/or eliminate any potential dangers and hazards to the public and to the environment. Recovery methods generally include suction, mechanical removal and the use of sorbent material.

A water spray mist may be used to herd the spilled material to specific areas to assist recovery.

5.6.1 Direct Suction Equipment And Techniques

Direct suction methods include the use of vacuum trucks, portable pumps or shop vacuums.

Vacuum or portable pumps can be used to directly recover materials from damaged containers or from thick slicks on water. Shop vacuums (in particular those of large capacity) are suitable for small spills if a power source is available. Commercial skimmers are available for attachment to vacuum sources. These skimmers serve to "skim" floating product from the water surface while reducing the amount of water recovered.

Suction screens may be required to prevent hose plugging by floating debris and to prevent pump damage.

Care should also be taken to prevent the uptake of water in order to minimize the final volume of material which requires disposal and to prevent emulsification of oil and water. Once removed from the water body, however, water and oil can be separated using gravity separation. Valving on vacuum trucks can be used for water/oil separation or a drum separator may be readily constructed using a 45 gallon drum and hardware as shown in figure 26.

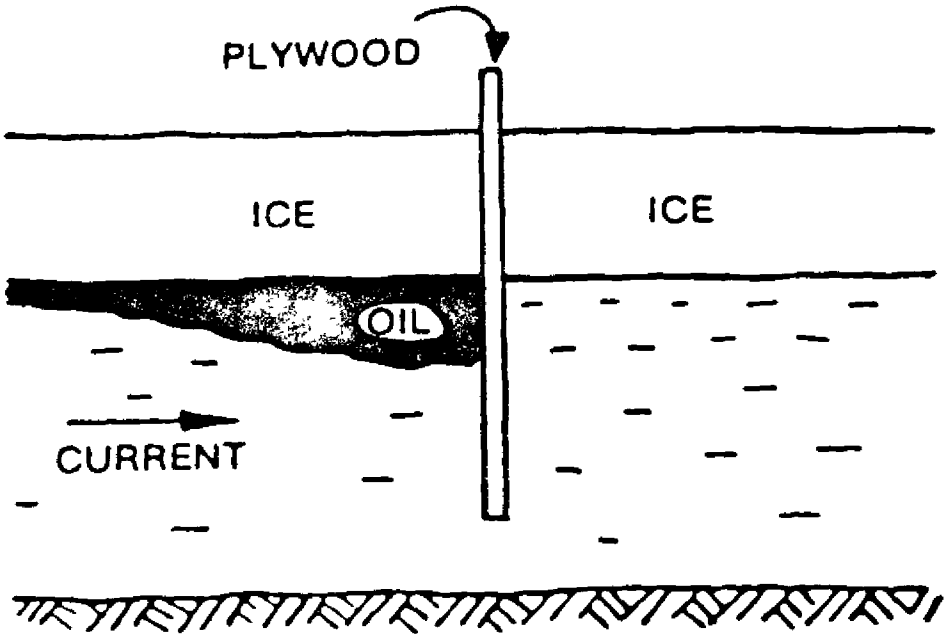


FIGURE 25

PLYWOOD BARRIER IN ICE
(KENNEDY et al, 1981)

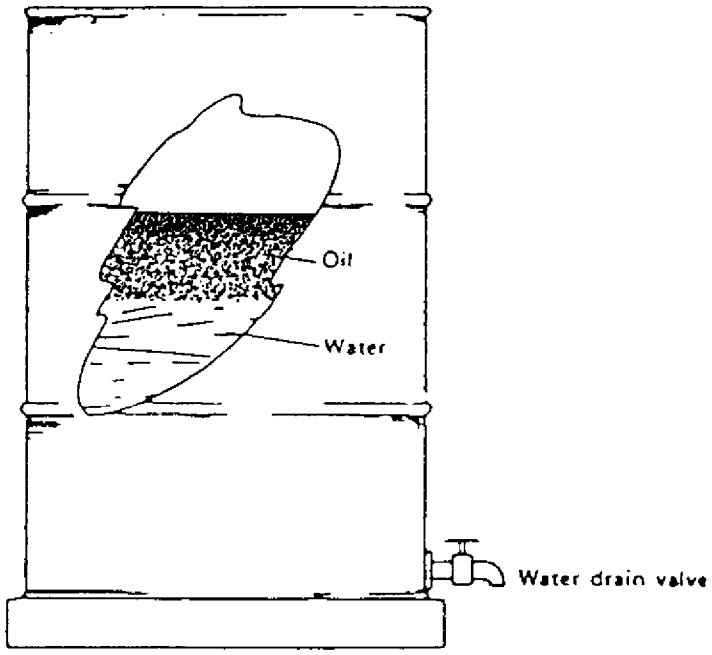


FIGURE 26

IMPROVISED OIL-WATER SEPARATOR DRUM

CAUTION: **All containers used for the recovery of flammable materials must be grounded because of the potential for static-electricity buildup.**

5.6.2 Manual and Mechanical Recovery

Manual recovery by use of handtools (cans, buckets, shovels, rakes) is an effective means of recovering spilled product from small spills or from areas that are inaccessible to larger equipment. Though labour intensive and time consuming, it is often the only method of recovery available and in some cases, is the preferred method as it causes the least damage to the area.

Mechanical recovery using heavy construction equipment can be used in some cases for recovery and loading of material for disposal. Caution must be used when operating such equipment around a spill site. In some instances, more damage could be produced from the operation of the equipment than from the spilled product. Escaping petroleum vapours may be present and pose the danger of explosion and fire.

5.6.3 Use of Sorbent Material

Sorbents are materials that soak up oil either by absorption or adsorption. They are commonly used for final cleanup and recovery of small amounts of oil or to remove oil in places which are inaccessible to other means of recovery. They are effective in recovering thin as well as thick layers of oil; however, large volumes of material is often required.

Snow and soil can be used as effective sorbent materials for a variety of oils. When mixed, the oil in snow or oil in soil mixture can be shovelled or picked up using construction equipment and taken to a suitable disposal site.

5.7 STORAGE

The destruction or disposal of materials from a spill site may not be immediately practical. Storage is required if a suitable location for disposal cannot be found, if climatic conditions do not permit disposal at the time of cleanup, if the selection of a disposal option requires further assessment, or if transportation to a disposal/destruction facility is dependent on the availability of a suitable transportation vehicle.

Storage options generally consist of containers, barrels, drums, tanks or pits. The specific type of storage unit needed is dependent on the volume of recovered

material, the degree of contamination with water or soil, the properties of the spill material, and the duration of storage required.

5.7.1 Vehicle Storage

Vehicles generally suited for the storage of recovered materials and which are available at many locations in the NWT include:

* tank trucks and vacuum trucks
* dump trucks
* flat bed trucks
* sled-mounted tanks
* transport trailers

Many communities in the Northwest Territories depend on the use of water trucks and vacuum trucks for the supply of water and the removal of sewage. Due to the severe climatic conditions and frequent and regular use of this equipment, the service life of these vehicles is generally limited to five years, or less. These vehicles are replaced on a regular basis and used vehicles are stored at sites designated near the communities. These vehicles are no longer useful for their original purpose. The tanks on these unused vehicles may be useable for the storage of liquids from spills.

Tank trucks typically have capacities ranging from 7.8 to 24.6 m^3 while vacuum trucks typically hold 3.8 to 17.0 m^3. Tank trucks have the potential for separating oil and water mixtures by drawing off a bottom layer through valving.

Flat bed trucks and transport trailers are suitable for carrying 45-gallon drums and barrels.

5.7.2 Open-Topped Tanks

Open-topped portable tanks such as plastic lined swimming pools may be quickly assembled on firm, level ground. The capacities range from 1 m^3 to 20 m^3. They may be fed by several hoses at once and can store liquids and solid debris. These should be used only for short-term storage when storing oils and other petroleum products.

The majority of spills in the Northwest Territories are petroleum products and container corrosion will not be a concern in most cases; however, consideration should be given to flammability, explosiveness and security.

5.7.3 Pits and Other Land Dependent Storage

These methods employ terrain and earth works to contain recovered liquid and may be upgraded using synthetic or natural liners to avoid soil and site contamination. Because of the requirement to alter topography, these are limited to sum mer conditions when the active layer is sufficiently deep to provide excavation volume and material for berming. The methods most commonly used include natural land features, ditches, pits, lagoons, and trenches.

Temporary storage sites should be prepared and selected to minimize groundwater contamination. Sites should not be located next to gullies, streams or on the sides of hills, but rather in flat areas. Highly porous or water saturated soils should be avoided for use as temporary storage sites.

Although natural clays may provide an adequate barrier to subsurface migration, these materials are scarce in the Northwest Territories. Synthetic membrane liners such as plastic sheeting may be used for lining storage facilities; however, when storing petroleum products, consideration should be given to liner degradation and the potential for failure.

5.7.4 Drums and Barrels

Temporary storage of liquid may be accomplished using tanks, drums and barrels which are available in all communities.

5.8 DISPOSAL

Disposal or destruction of recovered materials is ultimately needed to eliminate the risk of further contamination from recovered material.

A wide range of materials are recovered from spill sites in the NWT and a wide range of disposal methods may be considered. Disposal does not mean merely relocating the problem. **No decision, except under emergency conditions, should be made until approval has been obtained from appropriate government agencies.** The 24-hour spill report line should be used to initiate such requests and a followup report should describe the disposal method used.

Techniques for the disposal of recovered oil and debris vary widely, but can be categorized into four basic options;

* salvage and recycle,

* mechanical incineration,

* on-site burning and

* natural recovery (biodegradation) [last option].

Factors that determine the most suitable technique for disposal are equipment availability, properties of the recovered product, spill volume, amount and type of debris and impact of disposal techniques on the environment.

Disposal techniques cannot always be pre-planned. The response team should, however, be familiar with the available disposal alternatives in the event that a spill occurs. Companies and/or communities should be encouraged to prepare a proper disposal site.

Whatever the disposal method employed, groundwater must not be polluted -- either by the material being disposed of, or by its decomposition products.

5.8.1 Salvage and Recycle

Salvage and recycling is the desirable disposal technique whenever local conditions permit. Techniques include direct reuse or injection into a pipeline.

Recovered diesel and lubricating oil may be reused directly as a low-grade heating fuel. Unpaved roads may be oiled to reduce traffic dust; however, authorization from appropriate regulatory authorities must be received prior to this being undertaken.

Pipeline injection may be used under certain circumstances for disposal of oil discharged from a pipeline. For example, discharged oil that has pooled along the pipeline may be reinjected at a nearby pump station, pipeline valve assembly, or directly at the spill site, with the field installation of a "T". Techniques for heating the oil to reduce its viscosity may be required before reinjection. Heating may be achieved by transferring the viscous oil into a warming tank.

Another problem to be considered with pipeline reinjection is that of separating the oil from water that may have been collected with it. An effective approach for dealing with this problem involves the use of an oil/water separator. The remaining oil could then be reinjected directly into the pipeline (assuming it is free of debris). A mechanical separation technique can be used to separate the debris from the oil. The oil could be contained in a storage tank before being reinjected into the pipe.

5.8.2 Mechanical Incineration

Mechanical incineration is a good method of eliminating recovered oil. If burning can be controlled, smoke and ash are reduced since oil will burn at a high temperature. The residue left after incineration can be disposed at a landfill site.

Several types of incinerators have been designed for disposal of recovered oil and debris including flare burners, open-pit incinerators, rotary kilns and stoker-type incinerators. These are specialized equipment, however, and few are presently operating in the Northwest Territories.

5.8.3 On-Site Burning

In some remote areas, on-site burning of oil and contaminated debris may be a practical and acceptable disposal technique. In unpopulated areas, the smoke resulting from such burns may cause less environmental damage than the disturbance of the area from conventional recovery methods. Conventional recovery equipment may also not be readily available in remote locations.

On-site burning of oil and contaminated debris requires **prior approval** and advice from appropriate regulatory agencies.

On-site burning should only be carried out in open, unpopulated areas where there is no possible danger of the fire spreading. Also, oil must not be ignited unless all personnel and equipment are a safe distance from the area.

There are benefits and risks associated with on-site burning which must be considered when making the disposal technique decision. An advantage of on-site burning is that it:

Removes the last small quantities of surface oil that cannot be picked up.

Disadvantages include:

* Increases probability of root death by heating;
* Increases the movement of toxic elements of the oil;
* Increases the possibility of forest fires;
* Can cause smoke damage to nearby buildings and property; and
* May encourage oil spreading and kill above-ground vegetation.

Oil on frozen water bodies can be burned using mass burning techniques. The residue and oil not burned can then be scooped up using scrapers, dozers, dump trucks, and finally with brooms and shovels and loaded into trucks.

Burning can also be considered when oil penetration has been prevented due to low permeability of the soil surface (frozen or compacted mineral soil) or when the water table is at the surface. Residue can be removed the same way as on ice but great care must be taken to protect area vegetation.

The worst areas to consider burning is where islands of vegetation exist or where the surface has a moss cover into which the oil has penetrated to more than eight or ten centimetres.

5.9 FINAL CLEAN-UP AND RESTORATION

Every reasonable effort must be made to clean-up a spill site to pre-spill conditions. To effect final clean-up and restoration, activities may include:

* Natural Assimilation or Revegetation
* Replacement of Soil.

5.9.1 Natural Assimilation (Biodegradation) and Revegetation

Oil can be degraded naturally by microorganisms under proper conditions of temperature and nutrients. The biodegradation of oil spilled onto soils may be enhanced with the application of fertilizers. Tilling the affected soil to increase the exposure of the soil organisms and oil to oxygen can also be beneficial. Before considering leaving oil in place, the following factors should be considered;

* The oil should remain in the upper 15 cm soil layer;
* The oil must not affect groundwater;
* Proximity to drinking water, surface water supplies;
* Short or long-term health hazards;
* Disturbance to vegetation or permafrost from clean-up activities versus disturbance from no actions taken;
* The oil will not interfere with property use; and
* The oil will not spread or otherwise contaminate the environment further.

The utilization of natural assimilation to treat, in whole or in part, soils affected by spilled oils requires prior concurrence of environmental authorities.

A considerable amount of natural assimilation also takes place on oil spilled on surface water. Thin sheens of oil left after oil recovery operations may disappear naturally within days. Warm temperatures, wind and wave action will accelerate oil degradation and natural assimilation on water.

Research has found that many plant communities will naturally regenerate. For instance, various willows and birches are tolerant to spilled oil if the oil does not penetrate the soil surface and kill the root systems. In one study, total plant recovery was found to be between 20% and 55% after the first season in an arctic willow-birch plant community. There is merit in leaving the spilled oil and preventing additional disturbance through clean-up activities.

5.9.2 Replacement of Soil

The grass on the upper layer of soil may have to be removed if these have been contaminated with oil or chemicals. Reasons for removal of this material may include:

* soil restoration and prevention of groundwater contamination;
* elimination of odours or hazardous fumes; and
* aesthetic reasons.

When contaminated material is being removed, **regulatory agencies should be contacted in regard to acceptable disposal sites.** In some instances, it will be necessary to replace contaminated soil with clean soil. Sensitive areas in the tundra should be left untouched.

TABLE 7
DISPOSAL ALTERNATIVES

METHOD	APPLICATION
Salvage and Recycle	The preferred fate of any material that can be recovered.
Mechanical Incineration	A practical method of disposal. Can achieve close to 100% combustion, does not leave undesirable residues. Transportable units are available which can burn 50-50 water-oil mixtures. Transportable unit can burn 50 to $80m^3$/day.
On-Site Burning	Best for oil on ice. Can achieve about 70% combustion. To be most effective, spill should be less than 24 hours old, 0.5 cm thick, and winds 1 1/2 to 2 km/h. Residue must be scraped up immediately after burn. Burning on land increases depth of spill penetration and combustion is difficult. Caution is needed to keep fire under control. Can cause crusting where oil has penetrated a moss cover or wet areas. Kills all above-ground vegetation. On water, it is best if the slick is fresh and thick. Wicking agents may be used to help support combustion. Utmost care must be exercised in preventing hazards to life and property. Government supervision, consultation, or approval is necessary for any on-site burning.
Natural Recovery (biodegradation)	Rate and extent of microbial degradation is limited by temperatures and lack of nutrients. Application of nitrogen and phosphorus fertilizers can assist. May be considered for sensitive areas, such as muskeg, where disturbance from clean-up activities could cause more harm than the spilled oil. Government agencies should be consulted before decision to allow natural recovery is made. (IPL Spill Contingency Plan, December 1984)

Equipment for the removal of contaminated soil includes front-end loaders and small dozers.

The primary concern of any restoration is the prevention of environmental deterioration through accelerated erosion. In cold regions, where permafrost is pre sent, minimizing alterations to soil thermal regimes and the melting of permafrost are important objectives of restoration.