U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Response and Restoration
Emergency Response Division
1305 East West Highway
Silver Spring, Maryland 20910

Diluted Bitumen Oil Spills: Responder Guidance

Frank Csulak, Scientific Support Coordinator, NOAA

Dr. Jacqui Michel, Research Planning, Inc

Summary:

- Diluted bitumen products (aka dilbits) are crude oils created by mixing bitumen, which is a highly viscous form of petroleum with a density close to 1 g/cm^3, with a lighter hydrocarbon to meet the minimum requirements for transport in pipelines (viscosity <350 cSt and density <0.94 g/cm^3).
- The final oil is a true mixture; the diluent will not separate out as a liquid, though it will be lost by normal volatilization processes. Table 1 list the different types of bitumen products.
- It is very important to know right away if the spilled oil is a diluted bitumen product. So, obtain proper paperwork with details from the pipeline operator as quickly as possible.
- Shortly after a spill, the environmental behavior of diluted bitumen will be similar to medium crude oils, thus booming and recovery tactics will be same as for medium crude oil.
- Studies have shown that diluted bitumen spills are expected to pose air quality concerns similar to medium crude oil spills. BTEX concentrations (average of 0.84% by volume) and H_2S concentrations (< 25 ppm) are lower than many other crude oils.
- In most cases, in situ burning of diluted bitumen spills to water can be effective only for the first 24 hours after release due to evaporative loss of the light fractions.
- After loss of the light fractions, diluted bitumen spills have a greater potential to submerge and form aggregates with suspended particulates in freshwater, compared to seawater, particularly in freshwater environments with turbulent flow and suspended sediments.
- These oil particulate aggregates can be heavier than water and sink in low-flow areas, which can be many miles downstream of the release site.
- As it weathers, the oil becomes very viscous (more viscous than peanut butter) and very sticky, so it can thickly coat and adhere to solid surfaces, birds, aquatic turtles, etc.
- Spills of diluted bitumen crude oil will be very persistent because the bitumen is already highly weathered, so natural degradation rates will be very slow, meaning that there may be a need for more aggressive removal of the remaining oil under certain conditions.
- Because of all these behaviors of spilled bitumen, it is very important to contain a spill quickly, before the oil can reach a water body.

Table 1. Different types of bitumen products.

Product	Description
Bitumen, Neatbit	Undiluted extremely heavy oil extracted from oil sands. Must be heated to be shipped.
Diluent	Any light petroleum used to dilute bitumen for transportation by pipeline or rail; traditionally a condensate or ultralight crude oil but now often a refinery cut such as naphtha.
Synthetic crude	A liquid product made by partial upgrading or refining of bitumen; used as a diluent in synbit
Dilbit	Bitumen diluted with ~30% diluent, such as condensate or naphtha, for transportation.
Railbit	Bitumen diluted with ~15% diluent (i.e., half as much diluent as dilbit), typically for transport by rail car.
Synbit	Bitumen diluted ~50% with synthetic crude.
Dilsynbit	Bitumen diluted with synthetic crude plus another diluent, usually a condensate (as of 2015 Albian Heavy Synthetic is the only dilsynbit transported).
Lightened Dilbit or C_4/C_5 enhanced Dilbit	Bitumen blended with a diluent supplemented with low molecular weight alkanes such as C_4 (butane) and C_5 (pentane).

Responder guidance is provided for the following spill conditions:

1. Release on LAND
2. Release that reaches WATER

For a release of diluted bitumen crude oil **on LAND:**

Secure the perimeter
• Establish and secure a safety zone. • Evacuate non-essential personnel or public based on area affected. • Eliminate ignition sources. • Conduct air monitoring to identify hazards and assist in establishing hot, warm, and cold zones and required PPE for responder safety (see Table 2).
Stop the source
• Close valves, plug holes if this can be done safely and using non-sparking tools. • However, only pipeline staff should attempt to open or close pipeline valves.
Minimize spread of oil on land
• Construct berms, trenches, etc. but only at safe distances as determined by continuous air quality monitoring. Add water and maintain a water layer to oil that is contained behind barriers to reduce penetration into porous substrates. • Install silt fencing, flow control structures, etc. for storm water management at work areas. • Monitor air quality at all areas where the oil is contained.
Minimize spread of oil into a water body
• Construct dams, dikes, diversions, etc., but only at safe distances as determined by continuous air quality monitoring. • Be aware of vapor ignition hazards in areas where the oil has been contained, or in sewers and other confined space where the oil has spread.
Implement protection strategies at sensitive areas
• If oil is present, monitor for VOCs and benzene to determine responder PPE before implementing the protection strategy.

• If no oil is present, proceed with implementing the protection strategy.
Oiled substrate cleaning
• Residues can be very adhesive so that low-pressure flushing (<50 psi) may not be effective at removing weathered diluted bitumen crude oil from substrates composed of man-made structures or vegetation. • Surface washing agents can increase removal rates; however, diluted bitumen crude oils that have been exposed to the sun for days can only be scrapped off or removed with high- pressure and high-temperature flushing or dry ice blasting. • In forested wetlands, with large amounts of organic debris, diluted bitumen can adhere to the debris and sediments, and might necessitate aggressive removal or capping to control chronic sheening.

For a release of diluted bitumen crude oil that reaches **WATER:**

Secure the perimeter
• Establish and secure a safety zone around the release site. • Consider community evacuation based on area affected. • Conduct air monitoring to identify hazards and required PPE for responder safety (see Table 2).
Stop the source
• Close valves, plug holes if this can be done safely and using non-sparking tools. • However, only pipeline staff should attempt to open or close pipeline valves.
Quickly deploy containment and recovery strategies for floating oil
• Early containment and recovery is key to preventing the oil from submerging[1] or sinking in fresh water as it loses the diluent by evaporation and can adhere to particulates in the water under turbulent conditions. • Deploy booms, underflow dams, filter fences, etc. at locations with sufficient access to conduct both containment and recovery operations. • Take advantage of natural low-flow areas for containment and recovery.
Implement protection strategies at sensitive areas
• For floating oil, traditional booms may be effective. • If the oil has submerged, deploy barriers that extend into the water column at the appropriate depth, such as air curtains or nets or curtains attached to the bottom or suspended from the surface.
Vary skimmer type depending on oil viscosity
• Fresh diluted bitumen crude oil has low viscosity, so drum and disk skimmers would be more effective early in the response. • As the oil weathers and becomes more viscous, it may be necessary to shift to brush skimmers.
Consider in situ burning
• In situ burning of diluted bitumen spills to water will be effective only for the first 24 hours or so after release due to evaporative loss of the lighter components, so it must be conducted very quickly. • Expect to have higher amounts of burn residue even for effective burns.
Prepare for submerged or sunken oil assessment
• Mobilize equipment and experts for submerged or sunken oil containment and recovery as soon as there is any indication that the oil could submerge or sink. • If some of the diluted bitumen mixed with particulates and sank, be aware that, as the water warms, the oil can separate from the particulates and refloat, resulting in chronic release of oil droplets and sheens on the water surface.
Submerged oil containment and recovery
• For small streams, filter fences or gabion baskets stuffed with sorbents can be placed across the

stream channel where flows are less than 1 ft/sec. Where flows are higher, these devices can be deployed at an angle, to direct the oil to low-flow areas for recovery. • In wetlands, with large amounts of organic debris, diluted bitumen will adhere to the debris and sediments, and may require aggressive removal or capping to control chronic sheening. • Spills in larger streams/rivers/lakes will require specialized and site-specific tactics. Refer to the 2016 American Petroleum Institute Technical Report on Options for Minimizing Environmental Impacts of Inland Spill Response (API, 2016).
Sunken oil containment and recovery
• Refer to the 2016 American Petroleum Institute Technical Report and Operations Guide on Sunken Oil Detection and Recovery, Report 1154.
Substrate cleaning
• Low-pressure flushing (<50 psi) will not be effective at removing weathered diluted bitumen crude oil from substrates such as seawalls, riprap, or gravel. • Surface washing agents can increase removal rates; however, diluted bitumen crude oil that has been exposed to the sun for days can only be scrapped off or removed with high pressure and temperature flushing. • Oiled vegetation and debris will usually have to be removed

[1] **Submerged oil** is spilled oil that is in the water column, below the water surface, including oil that is in temporary suspension due to turbulence and will refloat to the surface or sink to the bottom in the absence of turbulence. **Sunken oil** is spilled oil that is on the bottom of the water body.

Table 2. Recommended air monitoring at spill sites for responder safety. LEL and H_2S pose acute risks of ignition and death, so they are highest in the order.

Parameter*	Measurement/Action
NO FIRE	
LEL	<10% – proceed to measure other parameters 10-25% – proceed to measure other parameters but with care >25% – stand back until measurement is <25% LEL (Note that USEPA and USCG responders do not enter an atmosphere that exceeds 10% LEL. Industry also can have their own criteria.)
H_2S	<1 ppm – proceed to measure other parameters >1 ppm – select appropriate respiratory protection for responders
VOCs	<100 ppm – proceed to measure other parameters >100 ppm – select appropriate respiratory protection and PPE for responders
Benzene**	<0.5 ppm – proceed with operations >0.5 ppm – select appropriate respiratory protection and PPE for responders
FIRE (additional parameters to those above)	
Particulates	<150 µg of $PM_{2.5}$ per m^3, averaged over 1 hr – proceed with operations >150 µg of $PM_{2.5}$ per m^3, averaged over 1 hr – select appropriate respiratory protection and PPE for responders
SO_2	<75 ppb averaged over 1 hr; <0.5 ppm averaged over 3 hr – meets NAAQS**
NO_2	<100 ppb averaged over 1 hr – meets NAAQS
CO	<9 ppm averaged over 8 hr; <35 ppm averaged over 1 hr – meets NAAQS**

***** LEL = Lower Explosive Limit: the LEL for Bakken crude oil is estimated to be 0.4-0.8%

H_2S = Hydrogen sulfide

VOCs = Volatile organic compounds

SO_2 = Sulfur dioxide

NO_2 = Nitrogen dioxide

CO = Carbon monoxide

** Most first responders have limited or no ability to monitor benzene levels. Specialized resources will likely be needed to determine benzene levels

*** National Ambient Air Quality Standards

Additional Resources:

American Petroleum Institute (API). 2016. Options for Minimizing Environmental Impacts of Inland Spill Response. Available at: http://www.oilspillprevention.org/oil-spill-research-and-development-cente

NOAA ADIOS ((Automated Data Inquiry for Oil Spills) oil weathering model. http://response.restoration.noaa.gov/adios

National Research Council. Effects of Diluted Bitumen on Crude Oil Transmission Pipelines. The National Academies Press: Washington, DC, 2013. http://www.nap.edu/catalog/18381/trb-special-report-311-effects-of-diluted-bitumen-on-crude-oil-transmission-pipelines

National Research Council. Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response. The National Academies Press: Washington, DC, 2015. http://www.nap.edu/catalog/21834/spills-of-diluted-bitumen-from-pipelines-a-comparative-study-of

Consensus Ecological Risk Assessment of Potential Transportation-related Bakken and Dilbit Crude Oil Spills in the Delaware Bay Area: Comparative Evaluation of Response Actions. 2015. https://www.uscg.mil/d5/sectDelawareBay/Planning/Final_ERA_report_093015%20REV.pdf

Though each spill will be different, below shows NOAA oil weathering model results for a release of 100,000 gallons of Cold Lake Blend (a diluted bitumen) from 4 rail cars into a tributary of the Delaware River at 60°F with winds of 3 knots.

Solve | Density | Viscosity | Water | Benzene | Budget | Evap | Disperse | Remain | Burn | Skim | Beach

- **Oil Type**
  - COLD LAKE BLEND
  - Location = ALBERTA, CANADA
  - Synonyms = COLD LAKE DILBIT
  - Product Type = crude
  - API = 22.6
  - Pour Point = -45 deg C
  - Flash Point = -35 deg C
  - Density = 0.920 g/cc at 50 deg F
  - Viscosity = 294.5 cSt at 50 deg F
  - Adhesion = unknown
  - Aromatics = unknown
- **Emulsification**
  - Mousse begins to form when 6% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 2 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 0 ppt
  - Sediment Load = 50 g/m3 (avg. river/estuary)
  - Current = 0.2 mph towards 0 degrees
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = January 15, 0500 hours
    - Amount Spilled = 100000 bbl