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ENVIRONMENTAL CONSERVATION

U.S. COAST GUARD
SEVENTEENTH DISTRICT

U.S. EPA, REGION 10
ALASKA OPERATIONS OFFICE

In Situ Burning Guidelines for Alaska

Revision 1

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Glossary and Acronyms

AAC: Alaska Administrative Code.

ADEC: Alaska Department of Environmental Conservation, also referred to as "DEC"

ALOFT-FT: A Large Outdoor Fire plume Trajectory-Flat Terrain

ARRT: Alaska Regional Response Team.

ASTM: American Society for Testing and Materials.

BBL: Barrel of oil.

Burning Agents: Those additives that, through physical or chemical means, improve the combustibility of the materials to which they are applied

CFR: Code of Federal Regulations.

Controlled burn: Combustion that is started and stopped by human intervention.

Complex terrain: Land that rises more than 10 percent of the atmospheric mixing layer height, which is where the smoke plume becomes level, as predicted by the National Weather Service or reported by smoke observers.

DOC: U.S. Department of Commerce.

DOI: U.S. Department of the Interior.

DOI-_FWS:_ U.S. Department of the Interior-Fish and Wildlife Service

DOI-_NPS:_ U.S. Department of the Interior-National Park Service

EPA: U.S. Environmental Protection Agency.

ESA: Endangered Species Act

Flat terrain: Waterbodies and land that rises less than 10 percent of the mixing layer height which is where the smoke plume becomes level, as predicted by the National Weather Service or reported by smoke observers.

FOSC: Federal On-Scene Coordinator.

IC: Incident Commander

ICS: Incident Command System

Green Zone: Safe Air Quality. Predicted concentrations of particulates will not exceed established air quality standards.

In situ burning: Combustion of oil on the surface where it spilled. "In situ" is Latin for "in place." Excludes well control, waste disposal, burning of oily vegetation, and adding a burning agent.

MOA: Memorandum of Agreement

NAAQS: National Ambient Air Quality Standard

NCP: National Oil and Hazardous Substances Pollution Contingency Plan

NOAA: National Oceanic and Atmospheric Administration.

NRT: National Response Team.

PAH: Polynuclear Aromatic Hydrocarbon.

$PM_{2.5}$: Particulate matter with diameter of 2.5 microns or less.

PM_{10}: Particulate matter with diameter of 10 microns or less.

Populated Area: One or more persons physically present who are not spill responders under the control of the Unified Command and a spill-specific worker safety plan.

Red Zone: Unsafe Air Quality. Predicted concentrates of particulates will exceed established air quality standards.

Safe distance: Downwind from a fire, the greatest radius at which $PM_{2.5}$ emissions near ground level diminish to 1-hour concentrations equal to their National Ambient Air Quality Standard concentrations averaged for 24 hours or less.

Site safety plan: Incident-specific document for response worker protection that addresses the in situ burning operation, follows 29 CFR 1910.120 OSHA regulations, and is signed by the responsible party or the response action contractor. May also follow the National Response Team Science and Technology Committee's 1997 "Guidance for Developing and Site Safety Plan for Marine In Situ Burn Operations," and a plan in compliance with 18 AAC 75.425 (e)(1)(c), Alaska regulations for oil spill contingency plans' safety plans.

SMART: Special Monitoring of Applied Response Technologies

SOSC: State On-Scene Coordinator

Unpopulated Area: An area where people are not present within three miles of the burn operation.

Yellow Zone: Marginal Air Quality. Predicted concentration of particulates may exceed established air quality standards.

How to Use *In Situ Burning Guidelines for Alaska*

The Alaska in situ burning guidelines are used by the Alaska Department of Environmental Conservation, United States Coast Guard, and U.S. Environmental Protection Agency on-scene coordinators to authorize an emergency in situ burn of oil. They may authorize burning when: mechanical containment and recovery by themselves are incapable of controlling the oil spill, burning is feasible, and the burn will lie a safe distance from populated areas. To receive authorization, an applicant completes the "Application and Burn Plan" form (found in Appendix 1) and submits it to the on-scene coordinators in the Unified Command. The on-scene coordinators then complete the FOSC/SOSC Review Checklist in Appendix 2. The checklist includes the following six steps: review of the completed Application to Burn Plan (Step 1); determine feasibility of burning (Step 2); determine whether burn may be conducted at a safe distance from population areas (Step 3); determine whether environmental and other considerations will be adequately addressed (Step 4); review consultations and requests for authorization (Step 5); and make decision on whether to authorize burn (Step 6).

NOTE: These guidelines were initially updated to meet the National Ambient Air Quality Standard (NAAQS) of $PM_{2.5}$ and 65 $\mu g/m^3$ for public health and safety requirements. In 2006, the standard was revised to 35 $\mu g/m^3$. These guidelines are consistent with the revised national air quality standard. However, air monitoring (in accordance with the SMART protocols) must be conducted during the burn operation to ensure the standard is not exceeded for populated areas, and to validate predictive models used in this document.

Note: The Unified Command can proceed with approving the burn operation as long as SMART resources are en route or available within a reasonable timeframe.

Among the guidelines are distances that should separate populated areas from the burn to protect the public health. The "safe distances" are designed to meet the most recent state and federal air quality public safety regulatory standards in populated areas. Air monitoring must be conducted (whenever there is a potential of impacting populated areas) to verify that safe distances and public health and safety standards are maintained at all times during the burning operation. In uninhabited areas, the safe separation distances are not necessary for burn authorization.

The guidelines include the following sections and appendices:

- Overall background information is described in Section 1.
- Technical background that supports the guidelines is included in Sections 2, 3 and 4.
- The general guidelines for safe distances are described in Section 3 and Table 4.
- Cook Inlet and North Slope alternative guidelines for safe distances are described in Section 3 and Table 5.
- Public notification levels are described at the end of Section 3 and in Table 7.
- Information on environmental considerations is included in Section 4.

- The Application and Burn Plan is provided in Appendix 1.
- The FOSC/SOSC Review Checklist is provided in Appendix 2.
- A sample FOSC/SOSC Decision Document is provided in Appendix 3.
- Class I Areas in Alaska are identified in Appendix 4.
- A list of air quality monitoring equipment in Alaska is provided in Appendix 5.
- Definitions of Fire Danger Ratings for Inland Areas are included in Appendix 6.

SMART Protocols for in situ burning can be accessed at:
http://response.restoration.noaa.gov/book_shelf/648_SMART.pdf

Background and Technical Information

1. INTRODUCTION

Purpose and Scope

The guidelines identify (1) the Alaska Regional Response Team's (ARRT's) policy on the use of in situ burning as a response tool; (2) the process to be used by the FOSC/SOSC through the Unified Command to determine whether in situ burning is appropriate following an oil discharge; and (3) entities to be consulted by the FOSC/SOSC to obtain input on a request to conduct an in situ burn.

The guidelines serve the following purposes:

- Provide the FOSC/SOSC with a process that will help expedite in situ burning decision-making.
- Ensure that stakeholders and other technical experts are consulted as appropriate.
- Protect public health from smoke emitted from emergency burns.
- Transfer the state open burn permit authorization role under 18 AAC 50.035 from the state air quality regulators to the SOSC.
- Incorporate most recent available criteria for human health protection.
- Provide information on environmental considerations.
- Provide a resource document for preparing in situ burning plans as part of the contingency plan process, regulated under 18 AAC 75.425(e)(3)(G)(iii), (iv), and (v).
- Provide a background for determining when to use the tool of in situ burning.
- The guideline document is neither an operational nor a tactical manual. It does not provide a contingency plan for an optional response tool, a site safety plan, nor an exhaustive literature review.

Applicability

These guidelines apply to in situ burning of petroleum discharges during emergency response anywhere in Alaska. This includes marine waters and inland areas and waters.

Background

In March 1989, the ARRT adopted the "Oil Spill Response Checklist: In Situ Burning" for use by a party responding to a spill. The checklist was subsequently revised and approved by the ARRT in July 1992. In February 1991, the ARRT approved the "Alaska Regional Response Team In Situ

Burning Memorandum of Agreement: Beaufort and Chukchi Seas and Selected North Slope Areas." In 1994, the ARRT incorporated the *In Situ Burning Guidelines for Alaska* into its *Unified Plan*; the *In Situ Burning Guidelines for Alaska* superseded both the checklist and the memorandum of agreement. This version (Revision 1) updates the 1994 guidelines, but is not a pre-approval under the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP). Consultation, as required by the NCP, is necessary.

In certain circumstances, the effectiveness of mechanical containment and removal is limited. In these circumstances, the use of in situ burning, alone or in conjunction with mechanical and/or chemical countermeasures, may minimize threats to public health and the environment.

Under the NCP, the FOSC can authorize the use of burning agents on a case-by-case basis after obtaining concurrence from the U.S. Environmental Protection Agency and state representatives to the regional response team and in consultation with the U.S. Department of the Interior (DOI) and U.S. Department of Commerce (DOC) natural resource trustees when practicable. In Alaska, the DOI and DOC ARRT representatives are the DOI and DOC natural resource trustee representatives, respectively. From a federal perspective, "burning agents" must be authorized according to the provisions of the NCP, 40 CFR Part 300.910. The use of in situ burning is regulated by Subpart J of the NCP, the Clean Air Act, the Federal Water Pollution Control Act as amended by the Oil Pollution Act of 1990, and State of Alaska law.

From a state perspective, in situ burning constitutes an open burn for which approval is required under Alaska air quality regulations (18 AAC 50.065). By following these guidelines, the SOSC can approve in situ burning. The state's air quality regulations incorporate this document by reference in 18 AAC 50.035.

In Alaska, federal and state agencies consider applications for in situ burning under the *Unified Plan* and a unified command system that join the FOSC and SOSC in decision-making. The *Unified Plan* states that "whenever there is an incident involving more than one agency with jurisdiction, the Unified Command is implemented."

Updates in this Revision

This is Revision 1 of the *In Situ Burning Guidelines for Alaska.* It updates the original guidelines that were incorporated into the Unified Plan in 1994. Revision 1 includes the following changes:

- Revision 1 is not a pre-approval under the NCP. Rather it provides for case-by-case consideration of the use of in situ burning of petroleum discharges.
- The safe distances recommended between an in situ burn and populated areas are refined. See Section 3.
- The "ISB Review Checklist" and "Application for ISB" in the 1994 guidelines are streamlined. The new forms are "Application and Burn Plan" and "FOSC/SOSC Review Checklist."
- The new safe distance guidelines are based on the smoke plume's predicted concentrations of $PM_{2.5}$. The 1994 guidelines were based on PM_{10} concentrations. The change takes into account the new National Ambient Air Quality Standards for $PM_{2.5}$ that became effective in

1997. See Section 3. These guidelines are consistent with the revised national air quality standards (35 $\mu g/m^3$ for $PM_{2.5}$).

- Revision 1 assumes that maintaining safe distances between populated areas and harmful levels of $PM_{2.5}$ will also provide an adequate buffer to protect populated areas from air toxics and all other byproducts of combustion.

- The new version of the smoke plume trajectory model, ALOFT-FT-Flat Terrain version 3.04 for PC, distinguishes between flat, complex terrain, and water scenarios. This refinement is reflected in the new safe distance guidelines. See Section 3.

- Safe distance prediction uncertainty is expressed in graphs of mixing height and wind speed effects in McGrattan et al. (1997). Predicted distances are no longer multiplied by a factor of 2 to produce safe distance guidelines.

- Revision 1 considers the results of in situ burning studies reported in the proceedings of the International Oil Spill Conferences and the Arctic and Marine Oilspill Program Technical Seminars, in situ burning guidance of other Regional Response Teams, and guidance from the National Response Team.

- Revision 1 includes residue collection as a condition of authorization, when practicable.

- Revision 1 includes, as a condition of authorization, requirements for visual monitoring and/or sampling of the smoke plume (in accordance with the Special Monitoring of Applied Response Technologies (SMART) protocols) during a burn where there is a potential to impact populated areas. See Section 3.

- The process for considering the use of in situ burning in all environments (inland and marine) is addressed.

- Discussions of the importance of in situ burning in Alaska and general issues of smoke, residues, and toxicology are updated.

- Revision 1 incorporates Endangered Species Act compliance in accordance with the "Inter-agency Memorandum of Agreement Regarding Oil Spill Planning and Response Activities Under the Federal Water Pollution Control Act's National Oil and Hazardous Substances Pollution Contingency Plan and the Endangered Species Act (ESA MOA)".

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2. OPERATIONAL CONSIDERATIONS

The in situ burning operations discussion in this section supports Parts 1 and 2 of the Application and Burn Plan and Steps 1 and 2 of the FOSC/SOSC Review Checklist. In Step 1, the FOSC/SOSC decides whether in situ burning is an appropriate response option, when considering mechanical containment and recovery and/or the use of dispersants. In Step 2, the FOSC/SOSC determines whether in situ burning is feasible under the spill circumstances.

In Situ Burning in Relation to Mechanical Recovery

When mechanical recovery is unfeasible, ineffective, and/or insufficient, removing oil from the water or from land by in situ burning may provide increased protection for fish, wildlife, and sensitive environments, as well as commercial, subsistence, historic, archaeological, and recreational resources. In situ burning may (1) prevent the resources from coming into contact with spilled oil; (2) reduce the size of the spill and thus the amount of spilled oil affecting natural resources and/or historic properties; (3) allow the natural resources to recover more quickly; and/or (4) provide the most effective means to remove oil from water prior to shoreline impacts in broken ice conditions, in remote or inaccessible areas, and/or when containment and storage facilities are overwhelmed.

Optimal Conditions for Burning

Table 1 summarizes the optimal conditions for in situ burning. Oil thickness and emulsification have the greatest effects on ignition and burn efficiency. Most types of oil burn readily. However, the difficulty of establishing and maintaining slick thickness of lighter oils and achieving ignition of heavier oils make in situ burning less feasible for some oils, such as diesel and Bunker C.

Oil Thickness and Containment

Thicker layers of oil more readily ignite and sustain a burn. A minimum thickness of 2 to 3 millimeters of oil may be required for ignition (ASTM 2003) regardless of oil type. The thickness necessary for successful ignition increases with weathering and viscosity of oils. For example, minimum ignitable thicknesses for Alaska North Slope crude oil are estimated at 1 millimeter for fresh, volatile crude; (S.L. Ross 1997). Once the slick has been ignited, combustion is sustained as long as the slick maintains some minimum thickness, estimated to be about 1 millimeter (ASTM 2003).

Thicker layers of oil also burn more efficiently. The U.S. Environmental Protection Agency (1991) reported that in a slick of 10 millimeters thickness, approximately 80 to 90 percent of the oil burned. In a slick of 100 millimeters thickness, approximately 98 to 99 percent of the oil burned.

Table 1
Optimal Conditions for Effective Burning of Alaska North Slope Crude Oil

Considerations	Conditions for Effective Burning
Oil thickness	Minimum 2 to 3 mm for ignition. Efficiency (percent of oil in the boom removed by burning) increases with increased thickness.
Emulsification	Less than 25% water content. Efficiency and ease of ignition decrease with increasing water content.
Weathering	Relatively fresh oil (less than 2 to 3 days of exposure) is best for ignition. Difficulty of ignition increases with further weathering. Weathering times may vary among crude oil types and weather conditions.
Wind	Less than 20 knots for ignition.
Waves	Waves impact boom effectiveness and combustion primarily by causing splash-over. Less than 3 ft in choppy, wind-driven seas is optimal (short-period waves, less than 6 seconds). Less than 5-6 ft in large swells is optimal (i.e., long-period waves, greater than 6 seconds).
Currents	Less than 0.75 knots relative velocity between the fire boom and the water is optimal to reduce oil entrainment beneath the boom.
Ice	Variable effects depending upon the nature and concentration of the ice. Where ice contains the oil and prevents it from spreading, the burn can remove a high percentage of the naturally contained slick. Isolated floes may interfere with booming operations by filling collection areas, preventing oil from building up within the collection area, blocking the flow of oil to skimmers, and even damaging containment booms and skimmers. Likewise, ice can build up within fire booms and preclude the effective use of burning within the boom.

Adapted from Alyeska Pipeline Service Company, 1996.

In many situations, spilled oil is concentrated by containment to achieve the optimal thickness level. Fire-resistant boom contains oil best when deployed in a catenary mode and towed at speeds of less than 0.35 m/s (~3/4 knot) (ASTM 2007). At greater speeds, oil is lost under the boom by entrainment.

Ice concentrations of approximately 8 tenths coverage or greater may provide good containment for oil trapped between ice cakes and floes (Industry Task Group 1984). In pack ice conditions in Cook Inlet and on the North Slope, oil can be contained by the reduced area available for spreading, the cold surface waters, and the reduced influence of wind. During field tests conducted by Buist and Dickins (1987), ice cover “dramatically reduced” the spread of oil.

Solid ice on the North Slope can contain oil as follows (Industry Task Group 1984):

- Landfast sea ice provides barriers to the spread of oil spilled on or beneath it.
- During the solid-ice period, cold air temperatures, surface roughness, and snow limit the spread of oil and reduce evaporative losses, thus enhancing in situ burning operations.
- Oil on early spring ice accumulates in melt pools, and subsurface oil slowly migrates to the surface through brine channels and cracks.
- During freezeup, spilled oil becomes contained by new thin or slush ice.

Guenette and Sveum (1995) found that fresh crude and emulsions can be burned uncontained on open water. The wind-herding effect of the burn allows the slick to maintain sufficient thickness to burn at similar efficiencies to contained burns. The burning, uncontained emulsion slicks spread significantly less than the burning, uncontained fresh crude slicks.

Shorelines also sometimes serve as natural containment for oil for in situ burning (ASTM 2003).

Emulsification

Emulsification and water entrainment decreases ignitability, burn rate, and burn efficiency (Buist et al. 1997). In a series of small-scale test burns, Buist (1989) concluded that for a given thickness of oil, ignition times increased only slightly with weathering but increased dramatically with emulsification.

Although not enough data are available to determine the specific water percentage that limits ignition, indications are that oil containing less than about 25 percent water will burn, while emulsions containing 70 percent water cannot be ignited (ASTM 2003).

Alaska Clean Seas conducted test burns on weathered, emulsified crude oil (Buist et al. 1996, 1997). The tests showed that Alaska North Slope crude cannot be ignited at water contents greater than 25 percent, although the results varied widely among oil types (Buist et al. 1995b). Endicott crude containing up to 25 percent water burned well, even with weathered oil. Point McIntyre crude and IFO-30 fuel oil with various water contents, however, were difficult to burn, even with no weathering.

Oil spill models such as the ADIOS model (NOAA 2005) and S.L. Ross (1997) describe emulsification rates of oils.

Weathering

Weathering (i.e., evaporation) decreases the ignitability and efficiency of in situ burns (Buist et al. 1996). Researchers have found that weathering resulted in the loss of volatile compounds, more difficult ignition, and slower combustion, but in some cases, a higher proportion of oil burned (Fingas and Punt, 2000). Weathering up to about 20 percent appeared not to affect the burn efficiency of crude oil. Between 20 and 35 percent, weathering increased burn efficiency, but beyond 35 percent efficiency declined.

Waves

In test burns, wave energy increased the burn rate of thicker unemulsified slicks (10 to 20 millimeters) of fresh and weathered Alaska North Slope crude. However, waves had little effect on the burn rate of thinner slicks (2 to 5 millimeters). Although waves decreased the burn rate of emulsions of 10.3 percent evaporated Alaska North Slope crude, they had little effect on the burn rate for 29.1 percent evaporated oils with high water content (Buist et al. 1997).

Burn Volumes

Burn rate is relatively independent of physical conditions and oil type. Oil burns at a rate of about 0.07 gallons/square foot/minute, or about 100 gallons/square-foot/day (ASTM 2003). This means that a single 500-foot fire boom, positioned in a U configuration to intercept a spill, provides enough burn area to sustain a burn rate of 15,000 barrels per day. Three such U configuration booms working in a collection-relocation-and-burn mode could burn approximately 8,000 barrels of oil during a 12-hour period, with only one U configuration burning at a time (Fingas and Punt, 2000).

Residues

The responsible party or applicant is required to have a plan for residue collection. Section 4 discusses the toxicological aspects of burn residues. The toxicological properties and effects of the residue demonstrate the need and importance of a residue recovery plan which is an operational requirement.

Volume and Chemical Composition. The volume of residues produced by in situ burning is much lower than the original volume of the oil (Table 2), and is altered in chemical composition and physical properties from the oil. During a burn, the lighter, lower-boiling-point hydrocarbons are eliminated, while the heavier, higher-boiling-point hydrocarbons are concentrated in the residue. (Trudel et al., 1996) found that the majority of burn residues are composed of non-volatile compounds with boiling points greater than 538°C. Burn residues from crude oils contained no volatiles with boiling points less than 204°C; all contained some portion of the medium-volatility compounds with boiling points between 204°C and 538°C. Burn residues may be less toxic than the parent oils, because the volatiles such as benzene, naphthalene, and benzopyrenes are nearly absent (S.L. Ross, 1997). Environment Canada carried out several series of burns on heavy oils and characterized the residues fully (Fingas et al., 2005). They found that the PAHs in the residue were pyrogenic – deriving from the fire and there were few residual PAHs from the oil itself. Models were developed to predict the overall composition and density of the residue.

Table 2
Residue Produced During the Newfoundland Offshore Burn Experiment

Variable	Burn 1	Burn 2
Volume of oil discharged (m^3)	48.3	28.9
Residue in fireproof boom after the burn (m^3)	0.2 (max.)	0.1 (max.)
Residue in backup boom after the burn (m^3)	0.2 (max.)	0.3 (max.)
Burn efficiency	>99%	>99%
Density (g/mL at 15°C) (density of sea water is 1.025)	0.9365	

Data from Fingas et al., 1994.

Physical Properties. Burn residues are more dense and viscous than oil. During two test burns with Alaska North Slope crude oil, one with fresh, unweathered oil and the other with weathered, emulsified oil, the residues in both cases sank after the residue had cooled (Buist et al. 1995a and b). Table 3 lists the densities of Alaska North Slope crude oil residues after several test burns.

Table 3
Characterization of Residues from Laboratory Test Burns of Alaska North Slope Crude

Variable	Thickness of Oil Slick		
	5 cm	10 cm	15 cm
Burn efficiency	84.9%	91.6%	90.9%
Density (in g/cm^3) at 15°C (density of normal sea water is 1.025)	1.025	1.075	1.045

Adapted from Tables 4 and 5, Buist et al., 1995.

Residues from in situ burns vary greatly in consistency. Tests on Alaska North Slope crude oil produced residues ranging in consistency from a “semi-solid not unlike cold roofing tar” for fresh, unweathered oil, to residue in the form of a “brittle solid” for weathered, emulsified oil (Buist et al. 1995a and b). The 15,000- to 30,000-gallon test burn during the *Exxon Valdez* spill produced about 300 gallons of “stiff, taffy-like residue that could be picked up easily” (Allen 1990). Emulsion residues can be less viscous and more difficult to recover than residues from fresh crude. Burns from heavy oils resulted in residues that were often solid and glassy (Fingas et al., 2005). Floating, tar-like residue can be removed manually with sorbents, nets, or other similar equipment. However, recovering the less-burned residue from emulsion burns, which can include unburned oil and emulsions, may require special equipment (Guenette and Sveum 1995). Residues of some oils, including Alaska North Slope crude, may sink as they cool, even in sea water. It should be noted that the cooling rate of the residue is slow and this may allow a few hours to recover the residue before it sinks (Fingas et al., 2005).

Monitoring, Sampling, and Trial Burns

In situ burn operations should incorporate constant visual monitoring of the smoke plume's behavior. The FOSC/SOSC will jointly ensure the monitoring of smoke plumes for all in situ burns. Burn monitoring teams will be quickly organized, and if possible, deployed prior to conducting any trial or operational burn. If practicable, this will include, for all burns, visual monitoring of the smoke plume's behavior. In addition, air monitoring will be conducted during the burn operation whenever there is a potential to impact populated areas.

The Unified Command should consider additional safeguards when appropriate such as use of the NRT's SMART protocols for monitoring burns.
(See http://response.restoration.noaa.gov/book_shelf/648_SMART.pdf)

Information from burn monitoring will be continuously evaluated to ensure the burn is being conducted safely. Weather and sea conditions will also be continuously monitored. In the event burning conditions become unfavorable and/or if it poses a threat to safety or public health, the burn will be extinguished.

A trial burn should be conducted (if practicable) to verify predicted plume direction and dispersion distance downwind before authorizing continued burning operations. When performing inland burn operations the FOSC and SOSC will utilize the Incident Command System / Unified Command System to coordinate with appropriate land managers and other stakeholders (e.g., borough and city officials).

Federal and/or State natural resource trustees may request, on case-by-case basis, that natural resource trustee representative(s) be included on the in situ burn monitoring team (e.g., if threatened or endangered species are, or may be, present in the area; if burning is conducted on Federal or State-managed lands; or if in situ burning is conducted near a migratory bird colony). See Appendix 5 for a list of air quality monitoring equipment in Alaska.

Safety of Personnel

A site safety plan for in situ burning is required. Occupational Safety and Health Act regulations (29 CFR 1910.120) specify that employers are responsible for the health and safety of employees in response situations. Generally, the in situ site safety plan is an appendix to an umbrella site safety plan covering the entire spill response (NRT 1997b). The combination of the general site safety plan and the appendix site safety plan for in situ burning must include the elements listed in 29 CFR 1910.120(b)(4).

Incorporated here by reference for guidance is "Guidance for Developing a Site Safety Plan for Marine In Situ Burn Operations," written by the National Response Team's Science & Technology Committee (1997a). Alyeska Pipeline Service Company's "Supplemental Information Document: Burning as a Response Tool" (1996) also provides suggestions. There are a number of other, excellent resource documents available to assist with decision-making.

Safety concerns associated with in situ burning include the following:

- **Fire hazard.** In situ burns are monitored to ensure that fire does not spread to adjacent combustible material. Care is taken to control the fire and to prevent secondary fires. Personnel and equipment managing the process are protected.

- **Ignition hazard.** Ignition of the oil slick receives careful consideration. Involvement of aircraft for aerial ignition with gel or other ignition methods is coordinated. Weather and water conditions are kept in mind, and safety distances are set and adhered to.

- **Extinguishing and controlling the burn.** An in situ burn on water may be extinguished by increasing the tow speed so that oil is entrained in the water, by slowing down to reduce the rate at which the boom encounters oil, or by releasing one side of the oil containment boom. In the test burn during the *Exxon Valdez* spill, Allen (1990) noted that the area of the burning oil was easily controlled by adjusting the speed of the towing vessels.

- **Vessel safety.** In situ burning at sea involves several vessels working in relatively close proximity to each other. Vessels and crews working in these conditions should have practiced the techniques involved with in situ burning.

- **Other hazards.** Training and safety guidelines are a part of all in situ burning operations. Working under time constraints may impair judgment or increase the tendency to attempt costly shortcuts. In Alaska, personnel may be exposed to extreme cold. Personnel may also be exposed to extreme heat from the fire.

Wildlife

In accordance with the Endangered Species Act (ESA) Memorandum of Agreement (MOA) emergency consultation process, when a threatened or endangered species and/or their critical habitat(s) are, or could be present, in the area affected by a proposed in situ burn, U.S. Department of Commerce-National Marine Fisheries Service and/or DOI-Fish and Wildlife Service representatives will provide the FOSC with timely recommendations to avoid and/or minimize impacts to listed species and/or their critical habitat. These recommendations may include horizontal and vertical separation distances between (1) in situ burning-related aircraft/motorized vessels and concentrations of listed species and/or portions of their critical habitat (e.g., sea lion haul outs); and/or (2) the in situ burn and concentrations of listed species and/or portions of listed species' critical habitat (e.g., sea lion rookeries). [Note: When a threatened or endangered species and/or their critical habitat(s) are, or could be present in an area affected by incident-related response activities, the FOSC needs to initiate emergency consultation by contacting the NOAA and/or the DOI ARRT contacts to request endangered species expertise.] These recommendations may also be made where non-listed species are present in, or adjacent to, the area where an in situ burn is proposed.

In addition, depending on the circumstances of an incident, Federal and State natural resource trustees may recommend that, where possible, wildlife that are present in, or adjacent to, the area where an in situ burn is proposed, be deterred away from the area.

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3. SAFE DISTANCE

The safe distance discussion in this section supports Part 3 of the Application and Burn Plan and Step 3 of the FOSC/SOSC Review Checklist. In Step 3, of the decision-making process, the FOSC/SOSC determine whether the burn may be conducted at a safe distance from populated areas. In situ burning is not authorized if it does not meet public health regulatory standards. The FOSC/SOSC may use Table 4 for general safe distance guidance. They may use Table 5 in place of Table 4 in Cook Inlet and on the North Slope. In Step 6 of the FOSC/SOSC Review Checklist, the FOSC/SOSC determine whether to conduct an in situ burn. A decision to conduct an in situ burn may include conditions to protect human health.

The "safe distances" are designed to meet the most recent state and federal air quality public health regulatory standards in populated areas. Air monitoring (in accordance with the SMART protocols) must be conducted during the burn operation whenever there is a potential of impacting populated areas to ensure the public health and safety standard is not exceeded.

In unpopulated areas, the safe separation distances are not necessary for burn authorization. For populated areas on flat land and on water within 3 miles of shore, the FOSC/SOSC, working within the Unified Command, may authorize burning 3 miles or more upwind. The FOSC/SOSC may also authorize burning on marine water that is 3 miles or more from shore and 1 mile or more upwind from populated areas.

A computer model has predicted the greatest downwind distance at which the smoke plume's particulate matter of 2.5 microns or less in diameter ($PM_{2.5}$) diminishes to 65 micrograms per cubic meter averaged over one hour at ground level in flat terrain. At that distance, concentrations of soot and chemicals in the smoke are well below the National Ambient Air Quality Standards. In **unpopulated** areas, the safe separation distances are not necessary for burn authorization. To help determine whether an area that could be affected by an in situ burn smoke plume is unpopulated, the Unified Command will consult with land managers and (to the extent practical) land owners of the area to help determine whether there may be individuals using the area for activities including, but not limited to, fishing, hunting, berry picking, camping, boating, backpacking, and/or conducting research. The Unified Command may require further verification by aerial reconnaissance or some similar means.

Note: Another alternative to using computer models is to use predictors based on actual fires. Such a system is presented in Environment Canada's handbook on in situ burning (Fingas and Punt, 2000). The advantages of this system are that it is based on actual burns and factors in many conditions. The disadvantage of this system is that exact weather conditions or terrain cannot be factored in. On the other hand, the weather conditions prevalent at the time of the actual burns represent the typical conditions under which one might burn.

In some conditions in populated areas, the FOSC/SOSC may authorize in situ burns without relying on computer predictions. The predictions apply only to distances beyond 1 kilometer and to flat terrain. However, the FOSC/SOSC may authorize in situ burns closer to populated areas and in hilly terrain, if their best professional judgment is that the smoke will not expose populated areas to emissions exceeding the National Ambient Air Quality Standard concentrations averaged over one hour.

The Public Safety Criterion

The safe distance separating populated areas from in situ oil burns is the downwind radius from the fire at which smoke $PM_{2.5}$ concentrations at the ground diminish to 35 micrograms per cubic meter averaged over one hour. The safe distance guidelines are based on the predictions of a computer model, ALOFT-FT-Flat Terrain model 3.04. The safe distance meets the National Ambient Air Quality Standards for particulate matter in flat terrain and is also used as the indicator that populated areas will not be exposed to unsafe levels of all other smoke components.

As noted previously, these guidelines were initially updated to meet the National Ambient Air Quality Standard (NAAQS) of $PM_{2.5}$ and 65 $\mu g/m^3$ for public health and safety requirements. The standard was subsequently revised to 35 $\mu g/m^3$. These guidelines are consistent with the revised national air quality standard. However, when practicable air monitoring (in accordance with the SMART protocols) must be conducted during the burn operation whenever there is a potential of impacting populated areas. This action is necessary to ensure the standard is not exceeded for populated areas, and to validate predictive models used in this document.

Computer modeling was used so that real-time air sampling of the smoke plume is not necessary during an in situ burn. However, visual monitoring of the plume is required. Fifty-six scenarios in Cook Inlet and the North Slope were modeled by the program, and the worst-case predictions were used to develop the safe distances. Incorporated here by reference is “In Situ Burning Safe Distance Predictions with ALOFT-FT Model” (Bronson 1998), which explains how the safe distances were predicted.

$PM_{2.5}$ reflects the size of particulates that pose the greatest human health hazard. The National Response Team noted that if the particulate matter standard is “exceeded substantially, human exposure to particulates may be elevated to a degree that justifies terminating the burn. If particulate levels are generally below the limit, with only minor transitory incursions to high concentrations, there is no reason to believe that the population is unacceptably exposed above the accepted National Ambient Air Quality Standard for the burn” (NRT 1995). Furthermore, safe $PM_{2.5}$ concentrations indicate safe concentrations of other emissions (Bronson 1998).

The factor of 2 that was applied to the downwind distance predictions in the 1994 in situ burning guidelines (ARRT 1994) is replaced as the means to incorporate uncertainty in the safe distances. Uncertainty in the predictions is now shown in the diagrams introduced by McGrattan et al. (1997) and discussed by Bronson (1998).

Safe Distance in Populated, Flat Terrain

The FOSC/SOSC determines whether the flat terrain safe distance guidelines apply through the use of topographic maps and on-scene weather information. Among the conditions of authorization is that the in situ burn lies a safe distance from populated areas.

Table 4 lists the general safe distances separating an in situ burn and downwind, populated areas on flat terrain using the computer model. Figures 1 through 4 show bird's-eye and cross-sectional views of the safe distances.

Table 4: Safe Distances Between In Situ Burns and Downwind Populated areas in Flat Terrain

(see Table 5 for Cook Inlet and North Slope Safe Distances)

<table>
<tr><th>Location of Fire</th><th>Green Zone</th><th>Yellow Zone</th><th>Red Zone</th></tr>
<tr><td>Flat terrain on land</td><td rowspan="2">>3 miles</td><td rowspan="2">1 to 3 miles</td><td rowspan="2"><1 mile</td></tr>
<tr><td>Water <3 miles from shore</td></tr>
<tr><td>Water >3 miles from shore</td><td>>1 mile</td><td>not applicable</td><td><1 mile</td></tr>
</table>

The **green zone safe distance** on water more than 3 miles from shore, is 1 mile from populated areas. In these circumstances, the green zone originates immediately after the red zone without a buffering yellow zone. Yellow zones are used only in populated areas where there is potential exposure.

The green zone safe distance on land or on water less than 3 miles from shore is 3 miles from populated areas. Burning at a green zone safe distance from populated areas is acceptable following Level 1 public notification as outlined under "Notification Levels".

The **yellow zone distance** extends from 1 to 3 miles downwind of an in situ burn, and within 45 degrees of the smoke plume, when the burn is on land or on water within 3 miles of shore. The quadrant shape of the zone protects populated areas from smoke subjected to minor wind shifts. The FOSC/SOSC may authorize burning following Level 2 and Level 3 public notifications, warning, and sheltering in place or evacuation as outlined under "Notification Levels".

The **red zone distance** is within 1 mile of any in situ burn and within 45 degrees of the smoke plume. The FOSC/SOSC may authorize burning in the red zone following public notifications, warnings, and sheltering in place or evacuation, and if the FOSC/SOSC's best professional judgment supports the expectation of $PM_{2.5}$ less than 35 micrograms per cubic meter, 1-hour average in populated areas. (See "Notification Levels")

The red zone radius takes into account that the risk of smoke exposure becomes greater close to the fire. In addition, the ALOFT-FT model does not predict the behavior of smoke close to the fire before it lofts. The red zone downwind boundary also lies downwind of the expected in situ burn operations site safety area. For example, a 1,000-foot radius around an in situ burn of oil in a fire boom may be designated as the worker site safety zone by the site safety officer.

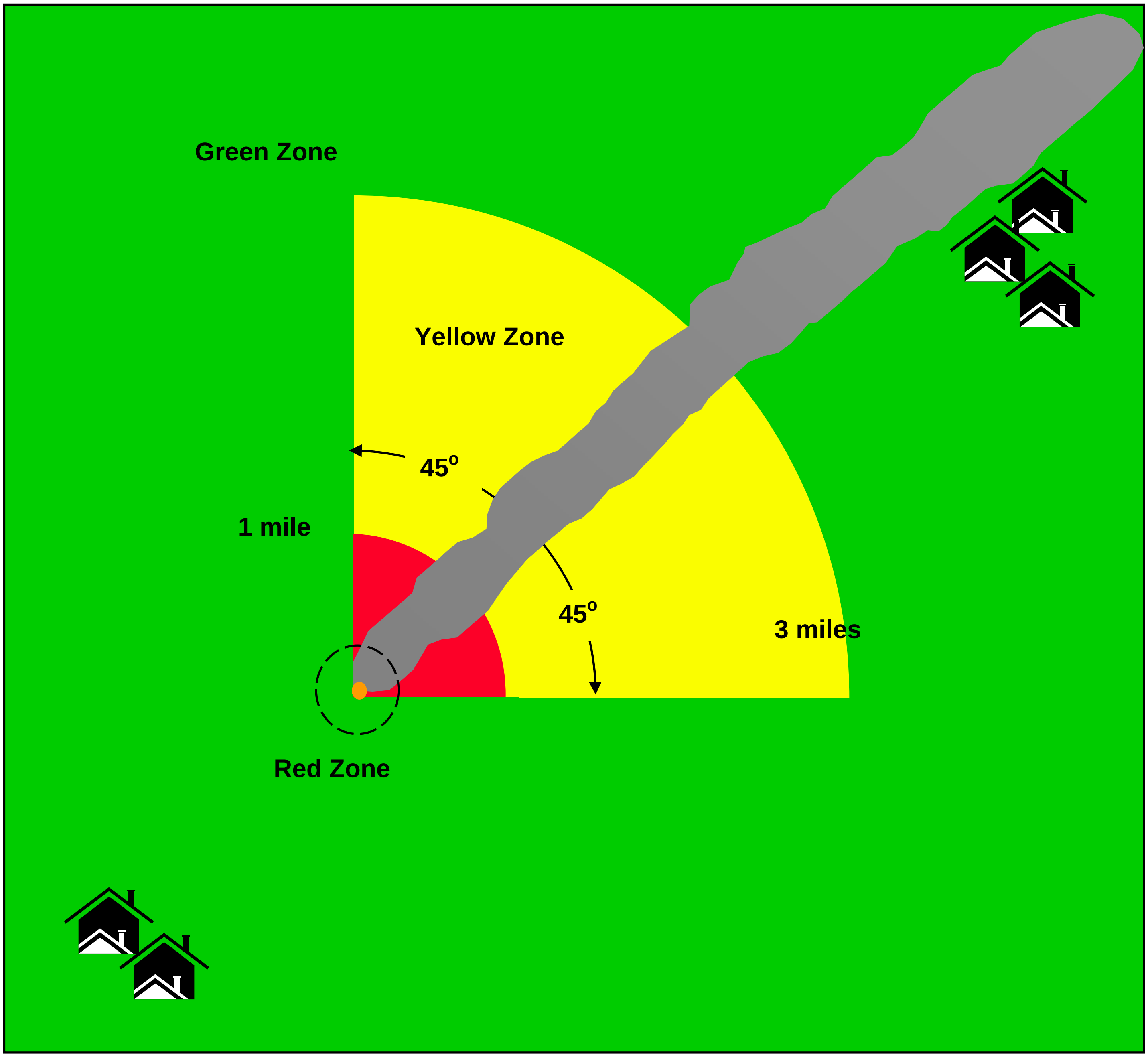
The Table 4 rules apply only in the following situations:

- In the vicinity of populated areas
- For a burn of any size from a single source
- For simultaneous burns less than 100 yards apart

The Table 4 rules do not apply in the following situations:

- In unpopulated areas
- In situ burns less than 3 miles upwind of terrain that rises more than 10 percent of the mixing layer height
- For simultaneous burns more than 100 yards apart

Figure 1: Zones for In Situ Burns on Populated Flat Land, and on Water Within 3 Miles of Shore



The dashed circle shows an example of a 1,000-ft radius site safety zone for workers, determined under a separate site safety plan.

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Figure 2. Example of Zones for an In Situ Burn Over Land or on Water Within 3 Miles of Shore

ALOFT-FT model projection for a burn of 5,000 square feet of oil in Cook Inlet during the summer.

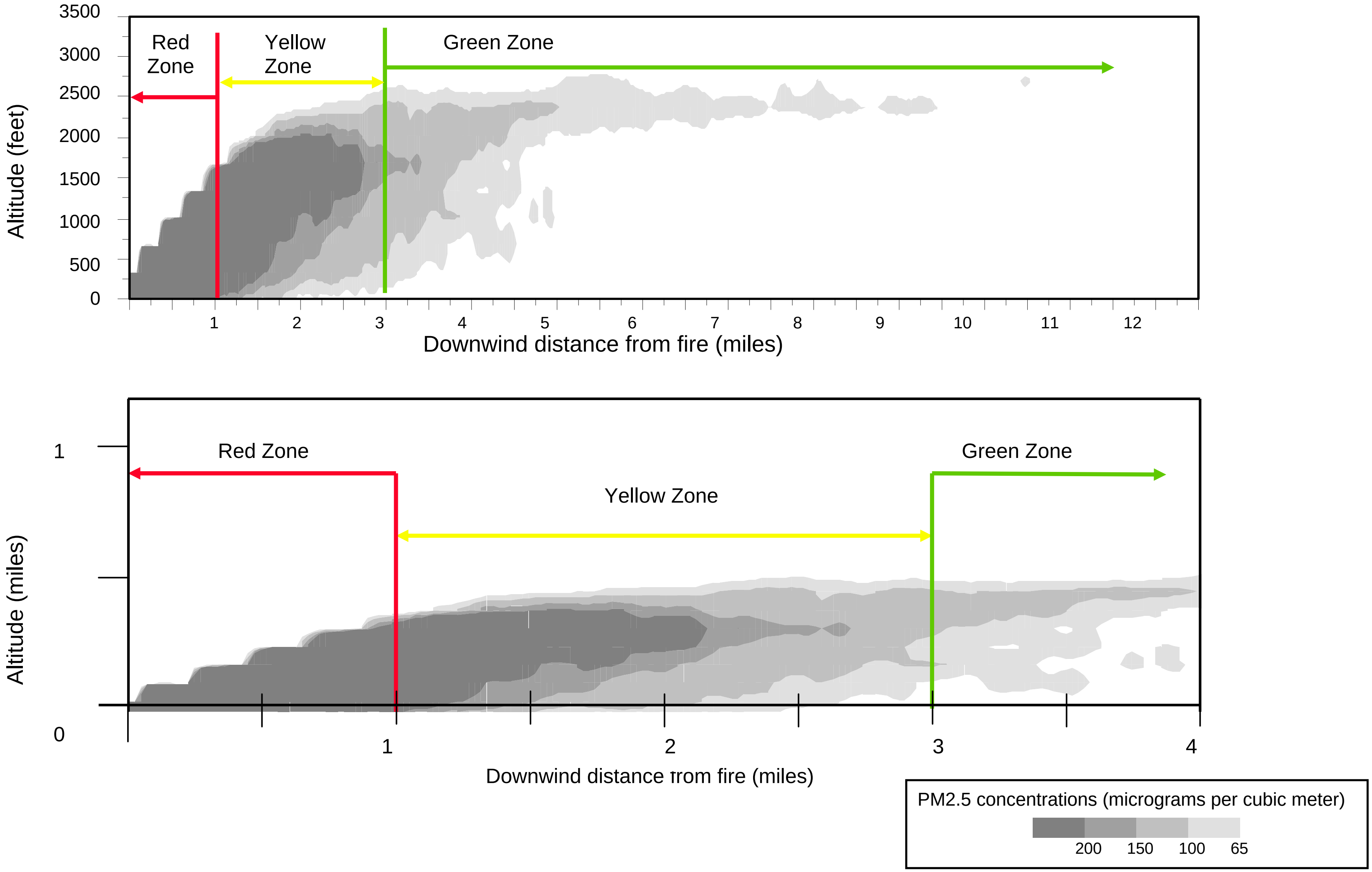

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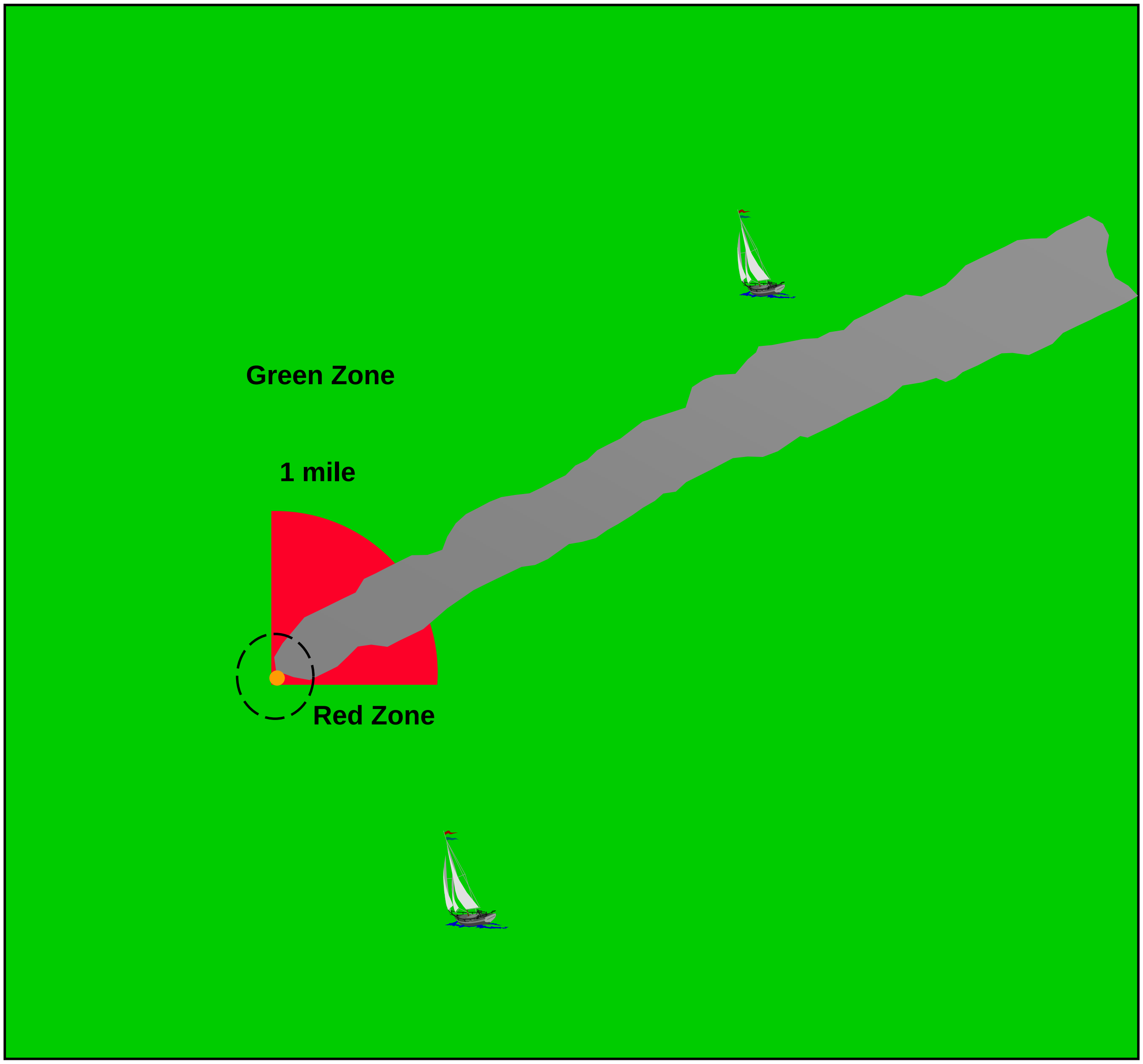
Figure 3: Zones for In Situ Burns on Water more than 3 Miles from Shore



The dashed circle shows an example of a 1,000-ft radius site safety zone for workers, determined under a separate site safety plan.

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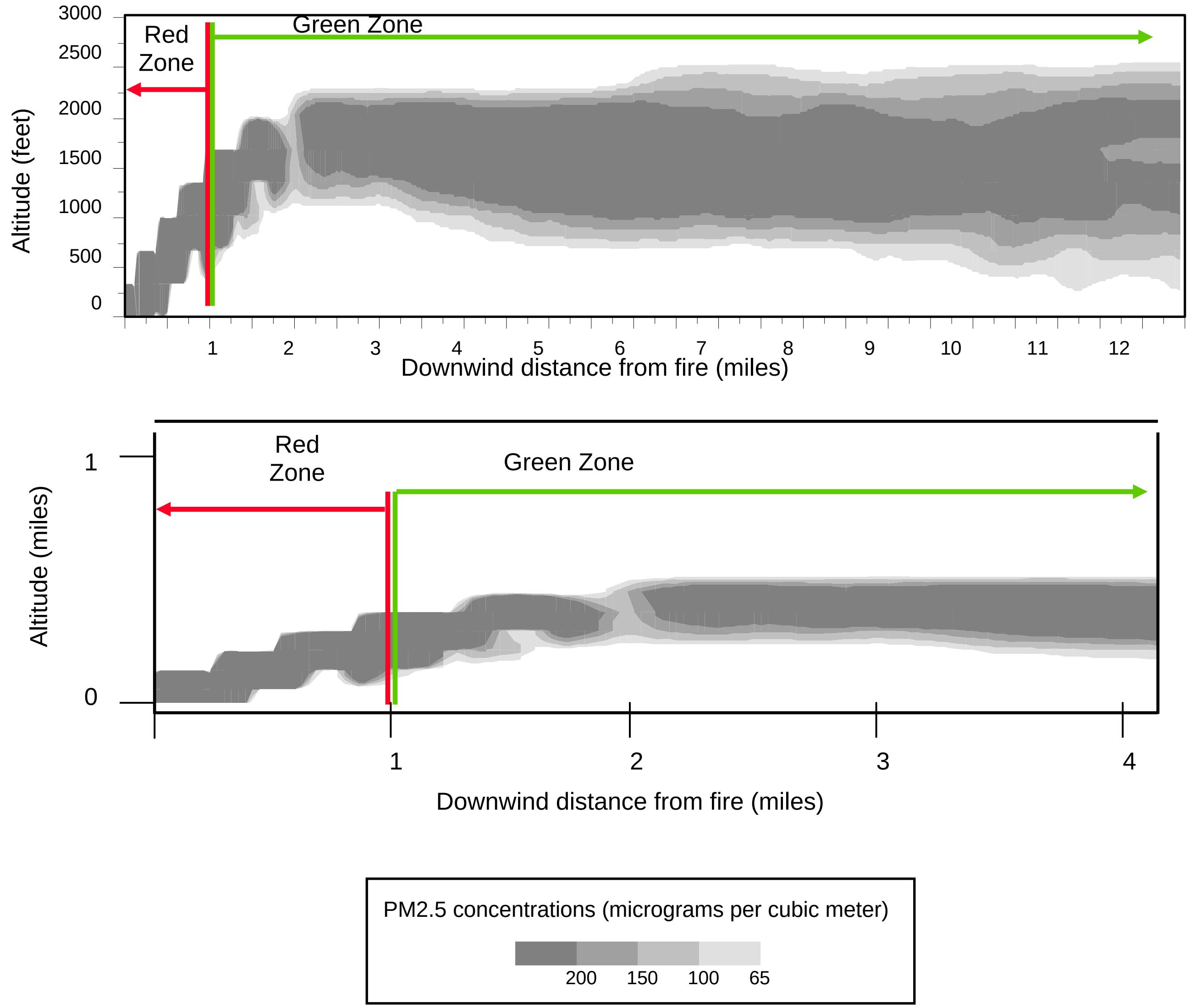
Figure 4. Example of Zones for an In Situ Burn on Water at least 3 miles from Shore

ALOFT-FT model projection for a burn of 5,000 square feet of oil in Cook Inlet during the summer.



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Authorization in Cook Inlet and on the North Slope

Table 5 summarizes the results of computer modeling of in situ crude oil burns involving meteorological conditions typical of Cook Inlet and of the North Slope in flat terrain. The table lists the greatest downwind distances at which concentrations of $PM_{2.5}$ are expected to reach 65 micrograms per cubic meter at ground level. The FOSC/SOSC may use the predictions in Table 5 as safe distances for burns over flat terrain in Cook Inlet and on the North Slope instead of the green zone distances in Table 4.

$PM_{2.5}$ National Ambient Air Quality Standard

The $PM_{2.5}$ safe distance criteria in these guidelines were revised in the late 1990s to reflect the National Ambient Air Quality Standards' 65 microgram per cubic meter threshold. The standard was subsequently revised to 35 $\mu g/m^3$ in 2006. These guidelines are consistent with the latest revision of the fine particulate standard. To enhance the FOSC/SOSC's understanding of fine particulate levels downstream of a burn, air monitoring (in accordance with the SMART protocols) must be conducted during the burn operation whenever there is a potential of impacting populated areas to ensure the standard is not exceeded.

The 1-hour period follows the recommendations of the National Response Team Science & Technology Committee (1995) and reflects the lack of a formal short-term exposure limit for particulate matter.

The national primary and secondary ambient air quality standards for particulate matter now include the standard of 35 micrograms per cubic meter 24-hour average concentration measured in the ambient air as $PM_{2.5}$. The $PM_{2.5}$ 24-hour standard is met when the 3-year average of the annual 98th percentile concentration values of measurements over 24-hour periods at monitoring sites is less than or equal to 35 micrograms per cubic meter.

Table 5
ALOFT-FT Predictions of Downwind Safe Distances for Ground-Level $PM_{2.5}$ Concentrations of 65 Micrograms per Cubic Meter over Flat Terrain.
Simulations are based on atmospheric conditions typical of Cook Inlet and the North Slope.

<table>
<tr><th rowspan="2">Burning Area</th><th rowspan="2">Season</th><th rowspan="2">Regional Source of Meteorological Data</th><th rowspan="2">Wind Speed (knots)</th><th colspan="2">Downwind Distance (miles)</th></tr>
<tr><th>Land</th><th>Water</th></tr>
<tr><td rowspan="6">2,500 square feet</td><td rowspan="4">Summer</td><td rowspan="3">Cook Inlet</td><td>8</td><td><0.6</td><td><0.6</td></tr>
<tr><td>16</td><td>1.5</td><td><0.6</td></tr>
<tr><td>23</td><td>1.8</td><td><0.6</td></tr>
<tr><td>North Slope</td><td>8, 16, 23</td><td><0.6</td><td><0.6</td></tr>
<tr><td rowspan="2">Winter</td><td rowspan="2">Cook Inlet and North Slope</td><td>8, 16</td><td><0.6</td><td><0.6</td></tr>
<tr><td>23</td><td>0.9</td><td><0.6</td></tr>
<tr><td rowspan="5">5,000 square feet</td><td rowspan="4">Summer</td><td rowspan="3">Cook Inlet</td><td>8</td><td><0.6</td><td><0.6</td></tr>
<tr><td>16</td><td>1.2</td><td><0.6</td></tr>
<tr><td>23</td><td>2.4</td><td><0.6</td></tr>
<tr><td>North Slope</td><td rowspan="2">8, 16, 23</td><td rowspan="2"><0.6</td><td rowspan="2"><0.6</td></tr>
<tr><td>Winter</td><td>Cook Inlet and North Slope</td></tr>
<tr><td>10,000 square feet</td><td>Summer and Winter</td><td>Cook Inlet and North Slope</td><td>16</td><td><0.6</td><td><0.6</td></tr>
</table>

Adapted from Bronson, 1998.

Consideration of Moving Source

The FOSC/SOSC may consider that a moving in situ burn may expose populated areas to less smoke than a stationary fire. Even in a yellow zone, populated areas may not become exposed to smoke for very long if the smoke plume is transiting over a population.

For example, the smoke from a continuous in situ burn in Cook Inlet may blow over the city of Kenai, borne by a wind from the west. Concurrently, the tidal current carries the fire and its smoke plume southward at several knots. The width of the plume passes over a residential area in a matter of 15 or 20 minutes. Thus, at a point in Kenai where the smoke's $PM_{2.5}$ concentration equals 35 micrograms per cubic meter, the plume's short duration there brings the 1-hour average exposure well below 35 micrograms per cubic meter.

Conditions of Authorization

An authorization to conduct an in situ burn as practicable, includes:

1. Visually monitoring the resulting smoke plume.
2. Collecting the resulting burn residue.
3. Notifying and/or warning populated areas in proximity to any of the three safe distance zones.
4. Other conditions, as needed, to protect human health as imposed by the FOSC/SOSC.
5. Air monitoring (in accordance with the SMART protocols) whenever there is a potential of impacting populated areas.

In addition, an authorization to conduct an in situ burn may also include other requirements, such as the inclusion of natural resource trustee representative(s) on the in situ burn monitoring team.

Notification System

The notification system is in place for the possibility that the modeled in situ burn smoke plume does not dissipate as expected. Four warning levels are to be used which correspond to the air quality standards listed in Table 7 below. Methods for notifying populated areas may include, but are not limited to: radio and television broadcasts; aircraft advisories; broadcasts to mariners; road closures; marine safety zones; and use of handheld radios, cell phones, satellite phones, and/or fixed or rotary-wing aircraft.

The notifications may also be used for sheltering in-place or evacuating small numbers of people for a short period of time (e.g., fishermen, hunters, backpackers, recreational boaters, rural residents, offshore platform operators, pump station and/or highway camp personnel).

Notification Levels

Level 1, *general notification*, is public notification/warning to people in populated areas within or near the green, yellow, and red zones that burning is (or will be) occurring and the area is to be avoided for a specific period of time. The FOSC/SOSC will implement Level 1 notification upon their discretion, or when modeled air emission patterns indicate a particulate matter level greater than state air quality alert/warning levels.

Level 2, *alert notification*, is public notification/warning involving a medical alert to persons with existing conditions that put them at risk to air quality degradation. It is used when the ALOFT-FT model predicts airborne $PM_{2.5}$ concentration is anticipated to exceed 35 micrograms per cubic meter 1-hour average in a populated area. The FOSC/SOSC will implement Level 2 notification upon their discretion, or when modeled air emission patterns indicate a particulate matter level greater than state air quality alert/warning levels.

Level 3, *warning notification*, is public notification/warning in the yellow zone for in-place sheltering for a specified period of time. The FOSC/SOSC will implement Level 3 notification upon their discretion, or when modeled air emission patterns indicate a particulate matter level greater than state air quality alert/warning levels.

Level 4, *emergency notification*, is public notification/warning that includes the evacuation/relocation of small numbers of people for a specific period of time from within the yellow and/or red zones. The FOSC/SOSC will implement this emergency notification at their discretion, or when modeled air emission patterns indicate a particulate matter level greater than state air quality alert/warning levels. The authority to order such an evacuation is vested in local government or, if no local government exists, state officials. In the event there are individuals on Federally-managed lands, the FOSC will work with the appropriate land manager(s) to implement temporary evacuation/relocation and closure procedures.

It should be noted that in situ burns authorized in accordance with these guidelines, using a safe distance, should not ordinarily require Level 2, 3, or 4 notifications.

Post-Authorization Requirements

1. A Unified Command decision document will be generated specifying conditions for approval of the in situ burn operation. (See Appendix 3 for a sample decision document)

2. An evaluation of the ISB operations will be included in the Unified Command after action report as required by the NCP.

4. PUBLIC HEALTH AND THE ENVIRONMENT

Information on public health considerations in this section provides background information in support of Part 3 of the Application and Burn Plan and Step 3 of the FOSC/SOSC Review Checklist. In Step 3, the FOSC/SOSC determine whether the burn may be conducted at a safe distance from populated areas. Information on environmental considerations in this section supports of Step 4 of the FOSC/SOSC Review Checklist. In Step 4, the FOSC/SOSC receive input and determine whether potential effects of an in situ burn on environmental (and other) considerations will be adequately addressed.

Public Health Considerations

Smoke from in situ burns contains chemicals and particulates that may be toxic, much like emissions from motor vehicles, power plants, wood stoves, and slash burning.

Table 6 lists the air quality thresholds for many smoke plume components. Table 7 describes the health effects associated with the pollutants.

Table 6
Air Quality Standards

Contaminant (units)	Averaging Periods				
	Annual	24-hour	8-hour	3-hour	1-hour
National Ambient Air Quality Standards and Alaska State Regulatory Standards					
$PM_{2.5}$ (µg/m^3)	15	*35	—	—	—
PM_{10} (µg/m^3)	50	150	—	—	—
CO (µg/m^3)	—	—	10	—	40
SO_2 (µg/m^3)	80	365	—	1,300	—
NO_2 (µg/m^3)	100	—	—	—	—
OSHA Permissible Exposure Limits					
Total particulates (mg/m^3)	—	—	15	—	—
Respirable particulates (mg/m^3)	—	—	5	—	—
CO (ppm)	—	—	50	—	—
**SO_2 (ppm)	—	—	5	—	—
***NO_2 (ppm)	—	—	5	—	—
CO_2 (ppm)	—	—	5,000	—	—
PAH (mg/m^3)	—	—	0.2	—	—
Benzene (in VOC) (ppm)	—	—	1	—	—

Adapted from Table 2, McGrattan et al., 1997, and Annex D, NRT, 1997b.

***NOTE:** These guidelines were initially updated to meet the National Ambient Air Quality Standard (NAAQS) of $PM_{2.5}$ and 65 µg/m^3 for public health and safety requirements. In 2006, the standard was revised to 35 µg/m^3. These guidelines are consistent with the revised national air quality standard. However, air monitoring (in accordance with the SMART protocols) must be conducted during the burn operation whenever there is a potential of impacting populated areas.

**NAAQS has a secondary standard for sulfur dioxide (SO_2) for 3-hour average at 0.5 ppm or 1,300 µg/m^3.

***The OSHA PEL of 5 ppm for nitrogen oxide (NO_2) should not be exceeded at anytime.

Table 7
Air Quality Index Values and Associated Health Effects.

Index Value	Air Quality Level (Public Notification Level)	Pollutant Levels						Health Effect Descriptor	General Health Effects	Cautionary Statements
		$PM_{2.5}$ (24-hour) $\mu g/m^3$	PM_{10} (24-hour) $\mu g/m^3$	SO_2 (24-hour) $\mu g/m^3$	CO (8-hour) ppm	O_3 (1-hour) ppm	NO_2 (1-hour) ppm			
500	Significant Harm	280	600	2620	50	0.6	2.0	Hazardous	Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion.
400	Emergency (Level 4)	210	500	2100	40	0.5	1.6			
300	Warning (Level 3)	140	420	1600	30	0.4	1.2	Very Unhealthy	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
200	Alert (Level 2)	55	350	800	15	0.2	0.6		Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly persons with existing heart or lung diseases should reduce physical activity.
100	[c]NAAQS (Level 1)	35	150	365	9	0.12	a	Unhealthy		
50	50 % of NAAQS	15	50	80[b]	4.5	0.06	a	Moderate	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity.
0		0	0	0	0	0	a	Good		

[a] No index values reported at concentration levels below those specified by "Alert Level" criteria. [b] Annual primary NAAQS. [c] General Notification
Source: Centers for Disease Control

$PM_{2.5}$ pollutant levels are pending with EPA. Proposed AQI revision as of April 2008

Particulates. Oil burns produce soot equal to 0.1 to about 3 percent of the mass of the burned oil (Fingas and Punt, 2000). In most large-scale burns, not enough air is drawn into the fire for complete combustion. The burn continues under "starved combustion," and produces a thick, dense, black plume of smoke composed of partially-burned byproducts in particulate (soot) and gaseous form.

Particulates are small pieces of solid materials (e.g., dust, soot) or liquid material (e.g., mist, fog, spray) that remain suspended in the air long enough to be inhaled. Particulate size plays a crucial role in health effects, because it affects how far the particles travel before they settle out of the air and how deeply they are inhaled into the lungs. Particulates larger than 10 microns in diameter settle 1 foot in less than a minute in still air, so they tend to settle in the environment quickly and generally are not inhaled. Particulates 0.5 micron in diameter, however, take 5-1/2 hours to settle 1 foot. Therefore, the smaller particulates travel farther from the burn site before they settle out of the air (Shigenaka and Barnea 1993).

Particulates 5 to 10 microns in diameter may be inhaled, but most are deposited in the upper respiratory tract and cleared by mucociliary action, which is efficient and relatively rapid. Only particulates smaller than 5 microns in diameter reach the sensitive alveolar portion of the lungs. Clearance of particulates reaching this part of the lungs is much slower and less efficient. The median size of particulates reaching the alveolar portion of the lungs is 0.5 micron. The mean size of particulates produced by an in situ burn is also 0.5 micron.

For most populated areas, exposure to particulates only becomes a concern at high concentrations. Inhaling high doses of particulates can overwhelm the respiratory tract and cause breathing difficulties (Shigenaka and Barnea 1993). However, for the very old and very young, and for people with allergies, respiratory problems, and cardiovascular disease, exposure to particulates can become a concern at much lower concentrations.

Several experiments found high particulate concentrations at ground level only close to the fire. During the Newfoundland Offshore Burn Experiment, particulates were a concern only up to 150 meters downwind of the fire at sea level; particulate levels dropped to background levels at 1 kilometer downwind of the fire (Fingas et al. 1994a). Particulates in the smoke plume were 800 to 1,000 micrograms per cubic meter near the fire. However, the PM_{10} concentrations beneath the plume, even at heights up to 150 to 200 feet above the sea surface and 1 kilometer downwind, never exceeded background levels (30 to 40 micrograms per cubic meter). Ground-level concentrations beneath a plume from an Alaska North Slope crude oil test burn on the North Slope declined from 86 micrograms per cubic meter 0.5 mile downwind to 22 micrograms per cubic meter 2 miles downwind. Measurements of near-ground smoke concentrations under the plume from two diesel fires in Mobile, Alabama, peaked at 25 micrograms per cubic meter 6 miles downwind in one case and 15 micrograms per cubic meter 6 miles downwind in the other (S.L. Ross, 1997 and Fingas et al., 2001)

Polynuclear Aromatic Hydrocarbons. Polynuclear aromatic hydrocarbons (PAHs) are found in oil and oil smoke. Some PAHs are known or suspected toxins or carcinogens. Long-term exposure to the higher molecular weight PAHs is generally the basis for human health concerns.

The PAHs in oil are largely consumed by combustion. During the Newfoundland Offshore Burn Experiment, PAH concentrations were much less in the plume and in particulate precipitation at ground level than they were in the starting oil. The mass of all PAHs, including the larger or multi-ringed PAHs, was reduced by about 6 orders-of-magnitude using combustion (Fingas et al., 2001).

Westphal et al. (1994) estimated an excess cancer risk of 5 in 100,000 from breathing or ingesting PAHs in soil after a hypothetical burn of 10,000 gallons of crude oil. This risk is within U.S. Environmental Protection Agency guidelines for acceptable risk levels. The researchers found no concern for noncarcinogenic effects from the PAHs. They concluded that adverse health effects from exposure to PAHs "may not be a significant factor in making a burn/no burn decision." Similarly, ASTM (2003), in assessing the results of several experimental burns, concluded: "In all cases, the quantity of PAHs is less in the soot and residue than in the originating oil . . . PAHs are not a serious concern in assessing the impact of burning oil."

Gases. Unlike particulate matter, the gases emitted during a burn do not pose a threat to human health, because the concentrations in the smoke plume fall below levels of concern at very short distances downwind of a burn (S.L. Ross 1997, Bronson 1998, and Fingas et al., 2001).

Volatile organic compounds such as benzene, toluene, n-hexane, and naphthalene can contribute to acute health effects, such as nausea and headache, at high concentrations. High concentrations of volatile organic compounds were present within about 50 to 100 meters of experimental fires (Fingas et al., 2000). However, even higher levels of volatile organic compounds are emitted from an evaporating slick that is not burning. Therefore, burning actually results in lower air concentrations of volatile organic compounds than other remedial actions (Westphal et al. 1994).

Carbon monoxide is a common by-product of incomplete combustion. It is acutely toxic because it displaces oxygen from the blood and causes oxygen deprivation in the body's cells. Carbon monoxide was not detected in the smoke plume from the Newfoundland Offshore Burn Experiment (Fingas et al. 1994). During the Kuwait oil pool fires, carbon monoxide levels were much below levels considered to be dangerous (Ferek et al. 1992). Measurements from other experiments show that at ground level 30 meters downwind of an in situ burn, concentrations are at or near background levels or are below detection levels (S.L. Ross, 1997 and Fingas et al., 2001)

Sulfur dioxide is toxic and may severely irritate the eyes and respiratory tract. Sulfur dioxide was not detected in the smoke plume from the Newfoundland Offshore Burn Experiment (Fingas et al. 1994). Measurements from mesoscale burns ranged from below detection limits to peaks of 1.2 ppm 100 feet downwind, well below the regulatory standards (see Table 6) (S.L. Ross, 1997 and Fingas et al., 2001).

Nitrogen oxides are strong irritants to the eyes and respiratory tract. The maximum concentration of nitrogen dioxide found in the plume from the Kuwait oil fires was 0.02 ppm (Ferek et al. 1992), well below the annual National Ambient Air Quality Standard of 0.053 ppm. Levels of nitrogen oxides in mesoscale burns were below levels of detectability and thus below levels of concern (S.L. Ross, 1997 and Fingas et al., 2001).

Environmental Considerations

The potential effects of *in situ* burning in the marine environment and in inland and upland areas are not well known or understood, and will vary depending on the specifics of each incident. Therefore, the potential trade-offs of using *in situ* burning will be considered on an incident-specific basis by Federal and State natural resource trustees who have resources affected, or potentially affected, by an incident. Those resources include, but are not limited to: migratory birds, marine mammals, terrestrial mammals, finfish, archaeological and historic resources, public lands, and species and critical habitat designated under the Endangered Species Act. It should be noted that Federal and State natural resource trustees with responsibility for managing public lands will also provide to OSCs, available incident-specific information on people who may be using their lands for subsistence, recreation, mineral exploration, research, or other purposes.

Marine Waters. The following information taken directly from Shigenaka and Barnea (1993) provides information for Federal and State natural resource trustees when an *in situ* burn is being considered in marine water.

Potential ecological impacts of in situ burning have not been extensively discussed or studied. As a result, the answer to this question is largely speculative and is based on documented physical effects observed in the laboratory and at limited test burns.

The surface area affected by in-situ burning is likely to be small relative to the total surface area and depth of a given body of water. This does not necessarily preclude adverse ecological impacts, particularly if rare or sensitive species use the waters in question. Organisms that may be affected by in-situ burning include those that use the uppermost layers of the water column, those that might come into contact with residual materials, and possibly some benthic (bottom-dwelling) plants and animals.

Direct Temperature Effects. Burning oil on the surface of the water could adversely affect those organisms at or near the interface between oil and water, although the area affected would presumable be relatively small.

Role and importance of the surface microlayer. The surface of the water represents a unique ecological niche called the surface microlayer, which has been the subject of many recent biological and chemical studies. The microlayer, variously defined but often considered to be the upper millimeter or less of the water surface, is a habitat for many sensitive life stages of marine organisms, including eggs and larval stages of fish and crustaceans, and reproductive stages of other plants and animals. It is known that cod, sole, flounder, hake, anchovy, crab, and lobster have egg or larval stages that develop in this layer. Although most studies of the microlayer have been conducted nearshore, some results suggest that even far off the east and west coasts of North America, eggs and larval stages of fish concentrate at the surface at certain times of the year. For example, Kendall and Clark (1982) found that densities of Pacific saury larvae more than 250 miles offshore were equal to, or greater than, densities nearshore.

The surface microlayer frequently contains dense populations of microalgae, with species compositions distinct from the phytoplankton below the microlayer. Hardy (1986) speculated the surface layer phytoplankton may play an important biogeochemical role by cycling large amounts of atmospheric carbon dioxide.

The microlayer also is a substrate for microorganisms and, as such, is often an area of elevated microbial population levels and metabolic activity. Carlucci and Craven (1986) found microlayer organisms play an active role in the metabolism and turnover of amino acids.

Potential effects of burning on the surface microlayer.

The ecological importance of the surface microlayer and the potential impacts to it from burning activities have been discussed in a different but related, context of ocean incineration. The Office of Technology Assessment (1986) noted in an evaluation of the technique, "given the intermittent nature of ocean incineration, the relatively small size of the affected area, and the high renewal rate of the surface microlayer resulting from new growth and replenishment from adjacent areas, the long-term net loss of biomass would probably be small or non-existent."

In large-scale burns, temperature increases in the water do not appear to be a problem. During the Newfoundland Offshore Burn Experiment, the water under the burn showed no increase in temperature, even though the temperatures at the top of the fire containment boom often reached 1000°C (Fingas et al. 1994). The water probably does not heat up because ambient-temperature seawater is continually supplied below the oil layer as the boom is towed (Shigenaka and Barnea 1993)

Toxicological Considerations. Beyond the direct impacts of high temperature, the by-products of in-situ burning may be toxicologically significant. Although analysis of water samples collected from the upper 20 cm of the water column immediately following a burn of crude oil yielded relatively low concentrations of total petroleum hydrocarbons (1.5 ppm), compounds that have low water solubility or that associate with floatable particulate material tend to concentrate at the air-water interface (U.S. EPA, 1986). Strand and Andren (1980) noted that aromatic hydrocarbons in aerosols originate from combustion associated with human activities, and that these compounds accumulate in the surface microlayer until absorption and sedimentation remove them. Higher molecular weight aromatic hydrocarbons, such as those produced by the combustion of petroleum, have been associated with the incidence of tumors and possibly reproductive disorders in populations of marine fish. Some of these heavier aromatic hydrocarbons are known carcinogens in humans and other mammals.

Aquatic toxicity and concentrations of petroleum hydrocarbons in the water in the vicinity of both burned and unburned crude oil slicks in the open sea is very low. No significant differences were found in the measurements of toxicity or petroleum hydrocarbons among water samples associated with unburned oil, burning oil, or post-burn scenarios (Daykin et al. 1994). Burning does not accelerate the release of oil components or combustion by-products to the water column (ASTM 2003)

Serious pathologies like tumors have generally been associated with longer-term, or chronic, exposures to the hydrocarbons. However, exposures attributable to in-situ burning would likely be short-term and might not result in toxicologically-significant exposures.

Burn Residue. Both residue that floats and residue that sinks may pose some risk of toxicity or contamination to organisms in the water column (S.L. Ross 1997). Residue that floats may pose a threat to shorelines and wildlife. The residue may be ingested by fish, birds, and mammals. The residue also may foul gills, feathers, fur, or baleen (Shigenaka and Barnea 1993). Residue that sinks may affect benthic animals. In general, however, the effects are less severe than those from a large, uncontained oil spill, and no specific biological concerns have been identified to date (ASTM 2003). Oil samples and burn residues collected after the Newfoundland Offshore Burn Experiment were tested for toxicity to three aquatic species. Neither the residue nor the oil was toxic, and the burn residue was no more toxic than the oil itself (Blenkinsopp et al. 1997).

Residues of Alaska North Slope crude oil are likely to be sticky semi-solids or non-sticky solids, depending on the weathering of the oil and the efficiency of the burn. Sticky residues pose a greater potential environmental risk. They may adhere to birds' feathers and disrupt the waterproofing of their plumage or be ingested while the bird is preening (S.L. Ross 1997).

Sunken burn residues can affect benthic resources that would not otherwise be significantly impacted by a spill at the surface of the water. For example, during the *Haven* spill in Italy in 1991, approximately 102,000 metric tons of oil burned, and the residues sank. The residue was distributed over approximately 140 square kilometers of seabed. Local trawl fishermen were unwilling to fish in the area for two years after the spill because of the expected danger of contaminating their nets and catch (Martinelli et al. 1995). In 1983, cleanup contractors ignited the main slick of a spill of Arabian heavy crude from the *Honam Jade* in South Korea. The fire burned intensely for about two hours, and the resultant burn residue sank and impacted crabs in nearby pens (Moller 1992).

Contamination is likely to be local in scale when it occurs at the sea surface or results from sinking residues that could affect certain unique populations and organisms that use surface layers of the water column at certain times to spawn or feed. In crafting an effective and protective response strategy, these effects should be weighed against effects resulting from alternative actions.

Potential environmental trade-offs. As is the case with all response methods, the environmental tradeoffs associated with in-situ burning must be considered on a case-by-case basis and weighed with operational tradeoffs. In-situ burning can offer important advantages over other response methods in specific cases, and may not be advisable in other, depending on the overall mix of circumstances.

<u>Pro's</u>

- In-situ burning has the potential for removing large quantities of oil from the surface of the water with a relatively minimal investment of equipment and manpower.
- Burning may offer the only realistic means of removal that will reduce shoreline impacts in areas where mechanical recovery, containment, and storage facilities may be overwhelmed by the sheer size of a spill, areas of heavy ice coverage, or in remote or inaccessible areas where other countermeasures are not practicable.
- If properly planned and implemented, in-situ burning may prevent or significantly reduce the extent of shoreline impacts, including exposure of sensitive natural, recreational, and commercial resources.

- Burning rapidly removes oil from the environment, particularly when compared to shoreline cleanup activities that may take months or even years.

- In-situ burning has the additional attraction of moving products of combustion into the atmosphere, where they are dispersed relatively quickly.

Con's

- In situ burning, when employed in its simplest form, generates a highly-visible black smoke plume that may adversely affect human and other exposed populations downwind.

- Burn residues, though normally a small fraction of the oil burned, may sink, making it harder to recover the residue and to prevent the potential exposure of benthic organisms.

- For onshore and inland burns, plant and animal deaths and other adverse biological impacts may result from the localized temperature elevations at the water body surface. While these could be expected to occur over a relatively small area, in specific bodies of water at specific times of the year, affected populations may be large enough or important enough to represent reasons for not considering burning as a clean-up technique.

- The longer-term effects of burn residues on exposed populations of marine organisms have not been investigated. Additional research is necessary to investigate the long-term effects.

Inland and/or Upland Areas. The remainder of the information in this section was taken directly from Zengel, et al 1999 and provides information for Federal and State natural resource trustees when an in situ burn is being considered in inland and/or upland areas. The information summarizes the results of a study, where the primary objective was to identify the environmental conditions under which burning should be considered as a response option for oil spilled in inland and upland habitats.

> **Fire ecology and prescribed burning.** Applicable information was gathered from the fields of fire ecology and prescription burning (in the absence of oil). Prescribed fires are often used as a forest and range management tool, and are often conducted for the same reasons as *in situ* burning; fire can be less damaging, more effective, and less costly than chemical and intrusive, mechanical methods (Wright and Bailey, 1982). There are many lessons already learned by prescribed fire practitioners and fire ecologists which are directly applicable to the use of *in situ* burning of spilled oil.
>
> In addition to literature sources, the U.S. Department of Agriculture (USDA) Forest Service maintains a Fire Effects Information System (FEIS) which was used as the major source for reviewing and summarizing information on the ecology and effects of fire on specific plant species (Fischer, 1992). This database can be accessed over the World Wide Web at the following address, http://www.fs.fed.us/database/feis/welcome.htm. The FEIS contains literature summaries and case histories from a wide body of sources. Pertinent database fields include the following: fire ecology and adaptations; post-fire regeneration strategy; immediate fire effect; plant response to fire; fire management considerations; and fire case studies.

Such summaries should provide spill responders with better information on the potential response of different habitat types and plant species to *in situ* burning. Major points from the literature review and the FEIS ecoregion species summaries on fire effects (in the absence of oil) are discussed below by major vegetation type.

Trees/forests. Even if they are not killed by fire, trees generally take a long time to recover to pre-fire levels of structure and dominance relative to smaller, faster growing shrubs and grasses. Fire may wound or scar trees, providing entry points for pathogens (fungi, insects, etc.) that could lead to delayed impacts or mortality as a result of fire. *In situ* burning in most forested areas should be discouraged; however, for certain types of settings and communities, *in situ* burning of surface vegetation within forested areas may be reasonable. Burning might be reasonable for open or savanna-like forest communities with tree species that are at least moderately fire tolerant, especially if fire thread to trees is minimal or actively minimized. *In situ* burning might also be reasonable for a special fire-prone or fire-adapted forest species or communities under certain conditions, even if trees will be directly at risk from fire.

Shrubs and Associated Communities. Woody shrubs may be lumped with trees in certain respects, in that they look similar and may thus be perceived as fire sensitive; however, the shrub species examined showed a wide range of fire sensitivity, with many species being very fire tolerant. Several highly fire-tolerant species examined might be good candidates for *in situ* burning. Shrubs are usually top-killed by fire, but many sprout vigorously from below-ground parts and recover quickly from fire. It should be kept in mind that dense shrub thickets can create fire hazards and carry fire to unwanted areas. Also some very fire-adapted shrub species and communities are also highly-flammable, presenting additional fire hazards.

Grasses/grasslands. Many graminoids (grasses, sedges, etc.) are fire tolerant and appear to be good candidates for *in situ* burning. Most of the species examined respond better during dormant season burns, and when soil conditions are moist or wet, so that roots, rhizomes, and organic soils are less likely to be damaged. For native grasslands, natural and prescribed fires are typically low intensity and fast moving; high intensity, slow burning fires such as those that might be produced by *in situ* burning of oil may be more damaging than typical fires. Native grassland species include many warm-season grasses, dormant in cool season months. Many non-native species which occur in prairies, pastures, fallow fields, etc., are cool-season grasses, whose growing season may correspond or overlap with the typical dormant period of warm-season species. The types of grass species present (warm -season, cool-season, or both) could be an important factor when plant dormancy and other seasonal concerns are considered in relation to *in situ* burning. Finally, although many grasses are fire tolerant, some species or growth forms can be much less so. In general, bunchgrass species or forms are often more fire sensitive than low-growing, rhizomatous grasses. Perennial needlegrasses (*Stipa* spp.) are reported to be the least fire tolerant of the bunchgrasses, and may not be good candidates for *in situ* burning.

Conclusions. *In situ* burning can be a valuable oil spill cleanup tool in inland and upland environments, particularly under certain conditions. The *in situ* burning case histories examined, outline the state of the practice concerning where and when *in situ* burning is feasible and environmentally acceptable. *In situ* burning is clearly suited towards use in certain environmental settings and habitats, but not others. The case histories also highlight important operational and post-burn considerations that should be evaluated for each spill.

Given the available case-history information, the overall knowledge and information base concerning *in situ* burning of inland and upland environments is still limited. To help add to this knowledge base, summary information from the fields of fire ecology and prescribed burning (in the absence of oil) is a valuable tool, increasing the information available to oil spill responders concerning the potential responses of different habitat types and plant species to *in situ* burning. The use of information gathered from the fire ecology and effects literature comes with a strong disclaimer, however. Fire-sensitive vegetation types where *in situ* burning should definitely not be used can be clearly identified, however, the appropriateness of burning of oil in plant communities described as fire tolerant or resistant is largely untested. Due to the complexity of fire science and prescribed burning, and fire ecology and environmental effects in particular, we suggest that prescribed-fire practitioners be consulted when *in situ* burning is planned, to provide valuable knowledge and experience not likely possessed by spill responders.

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Appendix 1: Application and Burn Plan

Incident Name: ______________________________

Incident Location: ___________________________

Incident Date: ______________________________

Incident Time: ______________________________

Date Prepared		Operational Period	
		Date	Time
Time Prepared	Start:		
	End:		

Title of Applicant: __________________________ Address: ______________________________

Affiliation: ________________________________ Phone: _______________ Fax: ______________

PART 1

Potential Burn Location____________________
Site Description_________________________
Latitude ______________________________
Longitude _____________________________

Type of Incident (check one):
______ Grounding
______ Transfer Operations
______ Explosion
______ Collision
______ Blowout
______ Other___________________________

Product Released (check one):
______ North Slope Crude
______ Cook Inlet Crude
______ Residual/Bunker Oil
______ Diesel #2
______ JP4
______ Other___________________________

Estimated Volume of Released Product:
________________________ gallons, or
________________________ BBL

Estimated Volume of Product That May Potentially be Released:
________________________ gallons, or
________________________ BBL

Release Status (check one):
______ Continuous
______ Intermittent
______ One time only, now stopped

If Continuous or Intermittent, estimated Rate of Release:
________________________ gallons, or
________________________ BBL

Estimated Surface Area Covered (square miles)
At Time of Application ___________________

If inland, identify/describe:.

- Vegetative cover at burn site (e.g., wetlands, grasslands, shrublands, forest, tundra, non-vegetated)
- Fire danger rating at and near the burn site (see Appendix 6) Whether burn is on permafrost
- Any ignitable vegetation near the burn
- Any structures/buildings near the burn

Why is mechanical recovery alone **<u>inadequate</u>** for spill response?

Consider the spill size, forecasted weather and trajectories, amount of available equipment, time to deploy, and time to recover. ____

____

Will you use mechanical recovery in conjunction with in situ burning? _________________________ yes no

Have you evaluated dispersants? yes no

Will you use dispersants in conjunction with in situ burning? yes no

Why is in situ burning preferred? ______________________

____

____

PART 2

Did source burn? yes no

Is source still burning? yes no

Is product easily emulsified? yes no

Is product already emulsified? (check one)

______ No
______ Light emulsion (0-20%)
______ Moderate emulsion (21-50%)
______ Heavy emulsion (>50%)
______ Unknown

Estimated Percent Oil Naturally Dispersed and Evaporated Within First 24 Hours: ____________________________

Check boxes and enter wind values in the following table:

	Current Conditions	12-hour Forecast	24-hour Forecast
Clear			
Partly cloudy			
Overcast			
Rain			
Snow			
Fog			
Wind Speed (kt)			
Wind Direction (from)			

Percentage Ice Coverage (check one):

______ No ice present
______ <10%
______ 11-30%
______ 31-50%
______ 51-100%

Tidal state at ____________ o'clock (check one):

______ Slack tide
______ Incoming (flood)
______ Outgoing (ebb)

✓ **Attach a graph** with tidal information for three tidal cycles.

Dominant current (not drift):

Speed (knots) __________________________

Direction (to) ___________________________

Current Speed (knots) Relative to the Containment Boom ___________________________________

Note: Current speed relative to the fire boom should be .75 knots or less to minimize entrainment.

Sea State (check one):

______ Calm
______ Choppy
______ Swell

Waves (estimate height in feet) ____________

Does your site safety plan cover this in situ burn plan? yes no

Will response workers be briefed on the site safety plan before burning? yes no

Are the responders trained and equipped with safety gear? yes no

✓ **Attach an ICS 204 form, or similar document**. On it, list the following equipment you will use:

- Vessels
- Aircraft for ignition and aerial observation
- Lengths of fire boom
- Residue containment and removal equipment
- Fire fighting equipment
- Ignition systems
- Burn promoters
- Communications systems
- Air/plume monitoring equipment.

______

Proposed Burn Date and Time ____________

Describe how you intend to carry out the burn.

____

____

Check one:

______ Ignition is away from source after containment and movement of the oil to safe location (i.e., controlled burn).

______ Ignition of uncontained slick(s) is at a safe distance from the source.

______ Ignition is at or near source without controls.

How will you ignite the oil? __________________________

____

Enter the volume of oil you expect to burn:

Fire No.	Oil Volume (BBL__ or Gal__)	Fire Duration (Hrs__ or Min__)
1		
2		
3		
4		
5		
Attach a list for more fires.		
Total Vol.:		

How many simultaneous burns are planned?

____

What distance will separate simultaneous burns?

____

Are you planning sequential or repeat (not simultaneous) burns?
yes no

Estimated area of oil in uncontrolled burn
(square feet)__________________________________

Describe your ability and procedures to extinguish the burn if necessary or directed to do so.

Part 3

✓ **Attach a chart with a distance scale**. Show estimated spill trajectory and landfalls, with time. Show the location and distance of your proposed burns relative to the following features:

1. Source:

Location ____________________________________

Distance from Burn (miles)_______________________

2. Ignitable slicks:

Location ____________________________________

Distance from Burn (miles)_______________________

3. Nearest Land (burns on water) or
Non-Flat Terrain (burns on land):

Location ____________________________________

Distance from burn (miles) _______________________

Nearby Populated Areas (i.e., one or more non-spill-related people present):

Location ______________________________

Distance from Burn (miles)______________

Location ____________________________________

Distance from Burn (miles)_______________________

Location ____________________________________

Distance from Burn (miles)_______________________

For Inland Burns consider

- Ignitable vegetation
- Structures/buildings
- Areas with Fire Danger Rating of extreme, very high, or high
- Nearest airport
- Alaska Class I Area (see Appendix 4)

4. Attach a drawing showing your mechanical recovery and in situ burning equipment configurations.

6. For burns potentially impacting populated areas, provide an air monitoring plan in accordance with the SMART protocols.

7. Identify whether any Class 1 Areas (Appendix 4) will be impacted.

Part 4

How do you plan to collect burned oil residue?

____

____

How do you plan to store and dispose of burned oil residue?

____

____

For inland burns, how do you plan to address post- burn erosion if applicable?

Describe plan for eliminating risk (if any) of accidental (secondary) fires (e.g., structures/buildings and/or vegetation).

____

____

Will the burn affect visibility at downwind airports within 20 miles?

____

Signatures

____

Signature of Applicant

____

Printed name of Applicant

____

Date and Time Submitted to Federal and State On-Scene Coordinators

____

Prepared by: ____________________ ICS Position: ____________________ Phone: ____________

Appendix 2: FOSC/SOSC Review Checklist In Situ Burning Guidelines for Alaska

Note: If an *in situ* burn is being considered, immediately notify the EPA ARRT representative (unless EPA is the FOSC), the DOI and DOC ARRT representatives, and the USCG Strike Team to provide advance notice of this possibility.

STEP 1: Review of the completed Application to Burn Plan

Is burning an appropriate response option, when considering mechanical containment and recovery and/or dispersant use?	yes	no

STEP 2: Determine feasibility of burning

Will the oil become 2 to 3 mm thick?	yes	no
Is the oil relatively fresh (less than 2 or 3 days of exposure)?	yes	no
Does the oil contain less than 25 percent water?	yes	no
Is visibility sufficient to see oil and vessels towing boom, and suitable for aerial overflight for burn observation?	yes	no
If burning may involve darkness or poor visibility, can the burn be completed safely and well away from any populated areas or other sensitive resources?	yes	no
Is wind less than 20 knots?	yes	no
Are currents less than 0.75 knots relative to the boom?	yes	no
Are waves less than 3 feet in choppy, wind-driven seas or less than 5 to 6 feet in large swells?	yes	no
Does the responsible party have a site safety plan for this incident that specifically addresses the proposed burning operations?	yes	no
Will response workers be briefed on this plan before burning starts?	yes	no
Are personnel trained and equipped with safety gear?	yes	no
Is a communications system available and working to communicate with and between aircraft, vessels, and control base?	yes	no
Are operational and environmental conditions feasible for burning?	yes	no
Can the fire be extinguished and are the procedures for addressing this contingency adequate?	yes	no
Will the burn meet the operational criteria for:		
the next 24 hours?	yes	no
the next 48 hours?	yes	no

STEP 3: Determine whether burn may be conducted at a safe distance from populated areas.

Burning Near Unpopulated Areas:

To help determine whether an area that could be affected by an in situ burn smoke plume is unpopulated, the Unified Command will consult with land managers and (to the extent practical) land owners of the area to help determine whether there may be individuals using the area for activities including, but not limited to, fishing, hunting, berry picking, boating, backpacking, or conducting research. The Unified Command may require further verification by aerial reconnaissance or some similar means.

Will the smoke plume pass into populated areas?	yes	no

If no, proceed to Step 4. If yes, consider the following conditions of authorization.

Burning in Flat Terrain Near Populated Areas:

Is the burn in an area near or adjacent to populated areas? yes no

Are local government, land managers, land owners, and/or state emergency service personnel involved in planning for, and if necessary assisting with, public notifications? yes no

On water more than 3 miles from shore, the Green Zone safe distance is 1 mile from populated areas. On land or on water less than 3 miles from shore, the green zone safe distance is 3 miles from populated areas. Burning at a green zone safe distance from populated areas is acceptable. Proceed to Step 4.

The Yellow Zone distance is from 1 to 3 miles downwind of a burn, and within 45 degrees of the smoke plume, when the burn is on land or on water within 3 miles of shore. If the potentially-impacted population can be sheltered in place or evacuated during the burn, proceed to Step 4. If potentially-impacted populated areas cannot be protected, do not authorize burning at this time.

The Red Zone distance is within 1 mile of any burn. Burns within 1 mile of populated areas may be authorized if the potentially-impacted population can be sheltered in place or evacuated during the burn, and if best professional judgment supports the expectation of $PM_{2.5}$ less than 65 micrograms per cubic meter 1-hour average in populated areas. If these conditions can be met, proceed to Step 4. If these conditions cannot be met, do not authorize burning at this time.

Burning when the Safe Distance Is Not Predicted:

The Unified Command determines whether flat terrain exists through the use of topographic maps and on-scene weather information, and input, as appropriate, from the National Weather Service and the Alaska Interagency Coordination Center.

According to best professional judgment, will $PM_{2.5}$ concentrations remain below 65 micrograms per cubic meter 1-hour average in populated areas? yes no

If yes, proceed to Step 4. If no, do not authorize burning at this time.

Notifications and Warnings:

Is it possible to implement Level 1 general notification in the Green Zone? yes no

Is it possible to implement a Level 2 alert notification in the Yellow Zone? yes no

Is it possible to implement a Level 3 warning notification, which includes in-place sheltering?

Is it possible to implement a Level 4 emergency notification, which includes temporary evacuation? yes no

STEP 4: Determine whether environmental and other considerations will be adequately addressed.

Have potentially-affected natural resources and historic properties been identified and adequately addressed? yes no

If no, document rationale in decision memo.

Have potentially-affected other considerations (e.g., structures/buildings) been identified and adequately addressed? yes no

If no, document rationale in decision memo.

STEP 5: Review of consultations and requests for authorization.

NCP Authorization of Use

Concurrence Required:

- EPA (FOSC or EPA ARRT representative) yes no conditional
- State (SOSC in Unified Command) yes no conditional

Consultation as per the NCP (If other than yes, document how addressed)

- DOI ARRT Representative yes no conditional
- DOC ARRT Representative yes no conditional

Other Consultations with Representatives of Potentially Affected Stakeholders:

- Other State and/or Federal natural resource trustees yes no conditional
- Federally-recognized tribes yes no conditional
- Federal, State, and/or local safety and public health agencies yes no conditional
- Land Owners:
  - Local (e.g. borough, municipal governments yes no conditional
  - Private Land owners (e.g. Native corporations) yes no conditional
- Others (e.g., Regional Citizens Advisory Councils, Port Authorities, Area safety/security committees, law enforcement, etc.) yes no conditional
- For a burn that may affect threatened and/or endangered species and/or their critical habitat, DOI-Fish and Wildlife Service* and/or National Marine Fisheries Service ESA Specialists* yes no conditional

- For a burn that may affect historic properties, the FOSC's Historic Properties Specialist. yes no conditional
- For a burn proposed in conjunction with an Outer Continental Shelf Facility, the DOI-MMS Regional Supervisor for Field Operations* yes no conditional

STEP 6. Make decision on whether to authorize burn.

Authorization and Conditions:

The on-scene coordinators' decision based on review (check one):

___ Do not conduct in situ burning.

___ In situ burning may be conducted in limited or selected areas (see attached chart).

___ In situ burning may be conducted over the limited period of ____ day(s).

___ In situ burning may be conducted as requested in the application.

____ Other, as specified: ____

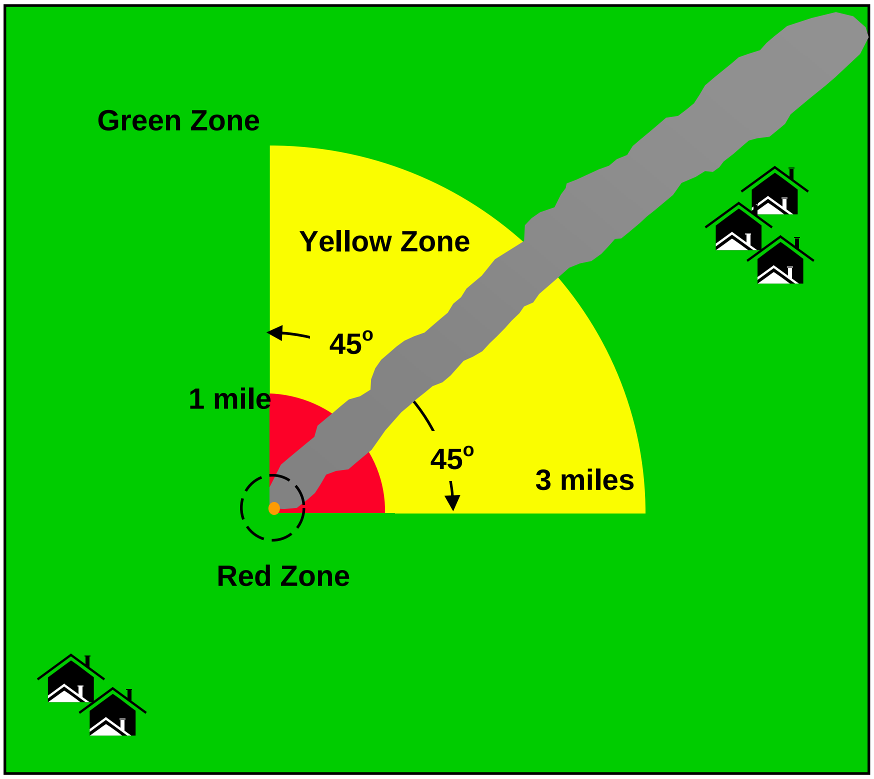
Conditions:

1. The burn operations team will visually monitor the smoke plume in accordance with the monitoring plan.
2. The burn operations team will collect the burn residue in accordance with the burn plan.
3. Public notification/warning to people in populated areas who may be in proximity to any of the three safe distance zones in accordance with the notification.
4. Other incident-specific conditions of authorization (e.g., air monitoring in accordance with the SMART protocols) for a burn with the potential to impact populated areas: _______________

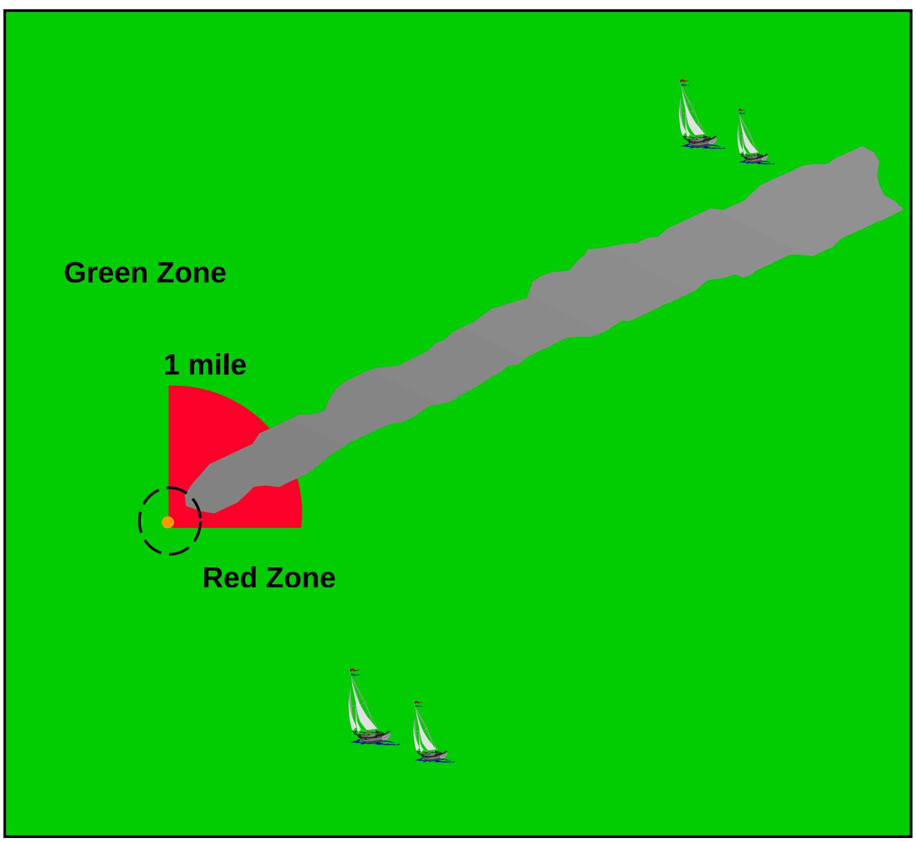
____________________	____________________	____________
Signature of Federal On-Scene Coordinator	Printed Name of Federal On-Scene Coordinator	Date and Time
____________________	____________________	____________
Signature of State On-Scene Coordinator	Printed Name of State On-Scene Coordinator	Date and Time

Prepared By: ____________________ ICS Position: ____________________ Phone: ____________

Figure 5. In Situ Burn Zones



5A: Zones for in situ burns on populated flat terrain, or on water within 3 miles of shore.



5B: Zones for in situ burns on water more than 3 miles from shore.

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APPENDIX 3: SAMPLE UNIFIED COMMAND DECISION DOCUMENT FOR IN SITU BURNING

Unified Command Decision Document	
Authorization to proceed with in situ burning is approved with the following conditions: 1) This approval is for (date). Continued in situ burn operations shall be subject to daily review and approval by the Unified Command. This authorization may be terminated by the Unified Command at any time. 2) The in situ burn operation shall not inhibit or impact on going recovery operations approved by the Unified Command 3) The RP or applicant shall implement a plan to collect residual or unburned oil following the completion of the in situ burn. 4) The applicant shall implement the approved in situ burning site safety plan to provide for the safety of personnel. 5) The Unified Command shall maintain public notification and warning procedures for the duration of the in situ burning operation. 6) The Unified Command shall perform visual monitoring (and air monitoring, where necessary) to ensure the operation and smoke plume is conducted as projected and will not impact either populated areas or the mechanical operations. The applicant shall ensure that the monitoring team includes representatives as determined by the Unified Command to monitor the burn. 7) In situ burn efficacy observations and visual monitoring reports should include the amount of oil burned, the location of the burn, the time and duration of burn, the boom condition, wind direction and plume characteristics. These reports shall be submitted to the Unified Command on a daily basis, no later than 12:00 noon the day following the burn, for consideration in approval for continued burning operations. 8) Following the burn operation, a detailed after-action report will be submitted by the RP denoting the actions taken and the lessons learned from the operation.	
FOSC:	**Date:**
SOSC:	**Date:**
LOSC (if required):	**Date:**
Incident Commander:	**Date:**

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Appendix 4: Class I Areas in Alaska

* This figure shows areas in Alaska, which are identified in accordance with the Clean Air Act and subsequent amendments, as “Class I Areas.” They include one national park and preserve managed by the U.S. Department of the Interior-National Park Service (DOI-NPS) and three national wilderness areas managed by the DOI-Fish and Wildlife Service (DOI-FWS). Class I Areas receive a higher standard of air quality control to protect the visual quality of these scenic areas. In doing so, a higher level of environmental protection from air pollutants is also achieved.

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Appendix 5: Air Quality Monitoring Equipment in Alaska

Monitor Location	Monitor Measurement Capability	Stationary or Portable	Continuous or Manual	Agency Owner	Agency Contact Phone Number
Fairbanks	PM-10, PM-2.5	S	C/M	Alaska Department of Environmental Conservation	907-269-6249
Anchorage	PM-10, PM-2.5	S	C/M		
Juneau	PM-10, PM-2.5	S	C/M		
Butte	PM-10, PM-2.5	S	C/M		
*Wasilla	PM-10, PM-2.5	S	C/M		
*Palmer	PM-10, PM-2.5	S	C/M		
*Soldotna	PM-10, PM-2.5	S	C/M		
Anchorage	PM-2.5 (2 EBAMs)	P	C		
Anchorage	PM-2.5 (2 EBAMs)	P	C	Department of the Interior- Fish and Wildlife Service	907-271-5011
Tuxedni Bay	PM-10, aerosols (IMPROVE)	S	M		
Sand Point	PM-10, aerosols (IMPROVE)	S	M		
Denali National Park	PM-10, aerosols (IMPROVE)	S	M	Department of the Interior-National Park Service	907-271-5011
Trapper Creek	PM-10, aerosols (IMPROVE)	S	M		
*Bettles	PM-10, aerosols (IMPROVE)	S	M		
Fairbanks	PM-2.5 (2 EBAMs)	P	C/M	Department of the Interior-Bureau of Land Management	907-271-5011
Petersburg	PM-10, aerosols	S		U.S. Forest Service	907-772-5865
Anchorage	PM-2.5 (2 DataRAMs)	P	M	Environmental Protection Agency	907-257-1342
Anchorage	PM-.1-10 (2 PDR 1000s)	P	M		
Anchorage	VOC, O_2, CO_2, LEL (3 Area RAEs)	P	C/M		

*These sites are due online in 2008.

Note: “Continuous” monitors run 24 hours a day, 7 days a week and an operator does not have to be present for the sampler to run.

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Appendix 6: Fire Danger Rating for Inland Areas

Extreme

Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash or in conifer strands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

Very High

Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.

High

All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.

Moderate

Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.

Low

Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.

Source: U.S. Forest Service – Wildland Fire Assessment System

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