A CASE STUDY IN PUBLIC HEALTH RISK ASSESSMENT AND COMMUNICATION DURING THE *NEW CARISSA IN SITU* BURNING

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ABSTRACT: *The cargo vessel* New Carissa *ran aground in February 1999 in Coos Bay, Oregon, only a few miles from nearby towns with a total population of 26,000. When the ship began leaking oil,* in situ *burning remained the only viable option to minimize a potentially major spill. Experts at the local, state, and federal levels cooperated in using modeling, previously done research, and monitoring, to conduct a public health risk assessment of the smoke plume on residents in the nearby communities, which were found to be very low. Risk communication was done to provide this information to the public and the media. Easily accessible information on* in situ *burning and improved communication between the Unified Command and local public health officials are recommended for similar future incidents.*

Background

On February 4, 1999 in a gale-force wind, the wood chip freighter *New Carissa* became stranded on the Oregon coast, 4.3 km north of the entrance to Coos Bay. The ship was empty of cargo, but carried on board an estimated 359,000 gallons of heavy fuel oil, and 37,400 gallons of diesel fuel (Hall, 1999). The stormy weather prevented tugboats from coming to the rescue, and logistical constraints prohibited pumping the fuel out of the ship. After several days of battering by high waves, the ship began leaking oil on February 8, and 2 days later the engine room flooded with water, rendering the ship a total structural loss. The Unified Command had to act quickly to minimize the possibility that the remaining fuel aboard the vessel would spill into a pristine and protected environment. A decision was made on February 10 to burn the fuel aboard the ship.

A burn of this magnitude typically generates copious black smoke, a possible concern to public health. Since the nearest towns with a total population of 26,000 were only a few miles away, the Unified Command conducted an initial risk analysis using the guidelines of the Northwest Area Contingency Plan (NWACP) and the weather forecast, and concluded that burning the fuel on the ship under the conditions predicted would impose only a minimal risk. To further address concerns for public health raised by Oregon Department of Environmental Quality (ODEQ), Oregon Health Division (OHD), and Coos County Health Department (CCHD), federal, state, and local spill responders and public health officials formed a team on February 10. This team conducted a public health risk assessment and assisted with risk communication to convey this information to public health officials, the public, and the media.

Risk assessment

The process of risk assessment includes identifying the hazard, evaluating the exposure that may cause adverse effects, determining the conditions under which such exposure is possible, and estimating the likelihood that such conditions will occur (NRC, 1983). When it became apparent that a large burn might take place near population centers, the team conducted a risk assessment concentrating on the elements below.

Identifying the hazard and potential exposure. Smoke plumes generated from burning oil *in situ* has been studied quite extensively in the lab and in numerous burns (Buist *et al*., 1994; Evans *et al.*, 1992; Ferek *et al.*, 1992; Fingas *et al.*, 1994). It was found that the smoke from *in situ* burning is similar to the smoke generated from burning hydrocarbon fuel in cars, home, and industry—most of the emissions are carbon dioxide and water. Other gaseous products in the smoke plume include carbon monoxide, sulfur oxides, nitrogen dioxide, and some ketones and aldehydes. These gases, however, are generated in minute quantities, and dilute to below their respective level of concern close to the fire.

The primary human health concern is the particulate matter in the smoke plume. Particulates are generated because the burn is inefficient and oxygen-starved, and the carbon in the fuel does not oxidize fully with the oxygen in the air, resulting in generation of up to 15% of the carbon mass in the fuel into particulates. These particulates are made mostly of inert elemental carbon (soot). Because of their small size the particulates are not affected much by gravity, are carried downwind over long distance, and may stay in the plume at concentrations above the level of concern for 10–20 miles downwind. Of specific concern are the very small particles 10 microns or less in diameter (a micron equals one-millionth of a meter, or 0.0004 of an inch). These particles are commonly referred to as "PM 10" and are small enough to lodge in human lungs. Most of the *in situ* burn (ISB) smoke particulates fall under this category.

For most people, exposure to respirable particulates may become a problem only at high concentrations (several milligrams of particulates per cubic meter of air.) However, some evidence suggests that people with respiratory diseases and heart problems may be susceptible to levels much below that (Dockery *et al.*, 1989; Pope, 1991; Schwartz, 1992). The controversy over what level of particulates is safe still rages in the scientific and regulatory communities.

For people living several miles from the site of the burn, the only significant potential exposure route from *in situ* burning is through inhalation of small smoke particulates. When the potential emissions are compared to more familiar smoke sources such as forest fires or slash burns, ISB generation of toxic constituents is modest . A table comparing ISB emissions from the Newfoundland Offshore Burn Experiment (NOBE), a large test burn conducted off the coast of Newfoundland in 1993, was provided to public health officials to assist in putting the proposed burn in perspective (Table 1).

Weather forecast. The weather on scene, especially wind direction and speed, played a crucial role in the risk assessment process because the smoke goes where the wind takes it. The National Oceanic and Atmospheric Administration (NOAA) provided the weather forecast several times a day. In addition, the National Weather Service in Portland was contacted for up-to-date conditions in the area. At first, the forecast predicted gusty winds from the south, but as the storm stalled, the forecast was modified to winds from the south-southeast at 10 to 15 knots, blowing the smoke parallel to and away from the shoreline, greatly reducing the risk that nearby population centers would be exposed to the smoke.

Plume behavior. Based on experience with previous burns, the smoke plume was expected to loft to several hundred feet, stabilize at this elevation, and then be carried away by the prevailing wind while dispersing over distance (Evans *et al.*, 1992). How high the plume lofts depends on the size of the burn and on wind speed. In stable atmospheric conditions, the plume may remain overhead and not reach down to ground levels for many miles downwind, as was evident in numerous test burns and in Kuwait during the Gulf War, when the smoke plume from the huge oil fires created by the retreating Iraqi armies completely covered the sky, but visibility at ground level in many cases was clear for miles around.

Modeling. Several trajectory models were developed to predict the direction and shape of the smoke plume from an in situ burn, as well as the particulate concentrations gradient in the plume. The National Institute of Standards and Technologies (NIST) ALOFT FT model, which provides a multi dimensional characterization of the smoke plume and includes concentration gradients, was used to provide an estimate of plume trajectory and particulate concentration.NIST prepared modeling runs for wind speeds of 15 and 30 knots, and fire areas of 250- and 1,000-meter squares. No ground impact was predicted for the 15-knot wind speed scenario that best suited the weather forecast for the burn (Figure 1) and only minor impacts were predicted for the higher wind speed cases. The NOAA model, while not as detailed in its output, predicted similar results.

Level of concern. The level of concern (LOC) adopted for this operation was 150 $\mu g/m^3$ of particulates smaller than 10 micrometer in diameter (PM-10) averaged over a 1-hour period. Recommended by the National Response Team (NRT) for ISB operations, this LOC was adopted by the Region X Regional Response Team, of which Oregon is a member (NRT, 1995). This LOC is more health-protective than the National Ambient Air Quality Standard (NAAQS), which calls for a LOC of 150 $\mu g/m^3$ averaged over 24 hours.

Monitoring. While risk assessment is geared toward predicting future risks, it greatly benefits from timely feedback on its predictions. Air monitoring for particulates was conducted before and during the burn using the Special Monitoring of Applied Response Technologies (SMART) program. SMART calls for deployment of small, mobile teams using rugged, real-time

Table 1. Comparison of the emissions from NOBE, a 10,000-bbl crude oil burn to other sources of emission.

Substance	Average emission factor for NOBE (g/kg fuel burned)	Emission rate (kg/hr)	Comparable emissions from other known factors
CO_2	2,800	75,600	~2-acre slash burn
CO	17.5	470	~0.1-acre slash burn or 1,400 woodstoves
SO_2	~15	405	7,400 kg/hr. (avg. coal-fired power plant)
Total smoke particle	150	4,050	~9-acre slash burn or ~58,000 woodstoves
Sub-3.5-µm smoke particle	113	3,050	~9-acre slash burn
Sub-3.5-µm soot	55	1,480	~38-acre slash burn
PAHs	0.04	1.1	~7-acre slash burn or ~1,800 woodstoves

Note: From Ferek *et al.* (1996).

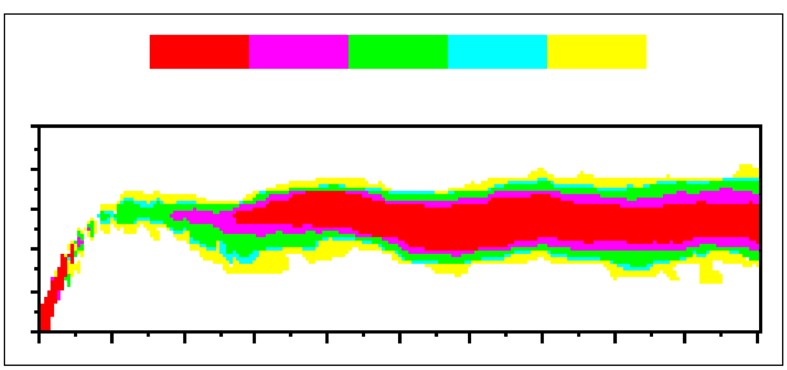

Figure 1. Part of the model output from ALOFT FT for the *New Carissa* burn.

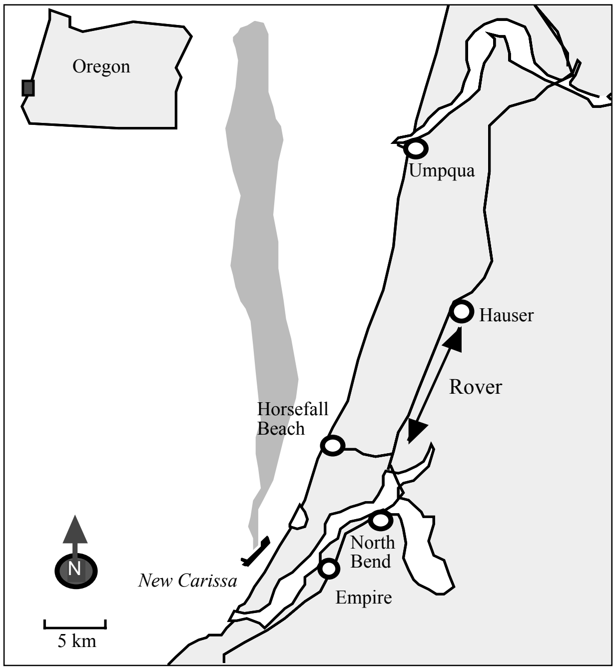

Figure 2. Monitoring locations on February 11, with estimated smoke plume trajectory at the initial stage of the burn.

particulate monitoring instruments at population centers near the burn to provide the Unified Command with field data on particulate concentrations (Barnea and Laferriere, 1999). The SMART teams deployed at several locations (Figure 2) and provided data throughout the burn duration. The monitoring operation provides the tangible confirmation that overexposure does not occur, or if it does, then to what extent and whether or not it is a problem that needs to be addressed in the risk communication to public health officials, the public, and the media. During the *New Carissa* burn, higher concentrations of particulates were detected on several occasions, but none approached the level of concern (Table 2). This strongly validated the other elements of the risk assessment process.

Risk communication

The population. The towns near the grounding site of the *New Carissa* are home to approximately 26,000 people, who share the appreciation for the fragility and natural beauty of the shoreline near their communities. They did not want to see their shoreline contaminated, both because they care about their environment and because of concern for loss of tourism and shellfish industry income. While concerned about the grounding and potential spill, and later concerned to some degree about the smoke plume from *in situ* burning, the residents of the area shared the Unified Command notion that any method that would minimize the risk of an oil spill and shoreline contamination would be worth a try.

Communicating the risk. The CCHD and the Coos County Emergency Management made several attempts to assist the Unified Command from the time of the initial grounding of the ship on February 4, but were not included in the Incident Command System (ICS) until February 10. In the morning of that day, CCHD was contacted by the OHD, and informed of the plan for an *in situ* burning of the fuel aboard the ship. The CCHD was told that a burn is planned for that afternoon, 3 hours hence, and that because the smoke might drift inland, a health advisory should be given by direct telephone contact (time was of an essence) to schools, hospitals, and nursing homes, while the OHD was planning to release a written advisory through the Unified Command.

CCHD proceeded to contact these institutions by phone, and provided this succinct advisory:

- Smoke from the burn does not present acute or health threatening hazards to healthy individuals, but could aggravate symptoms and breathing difficulties in persons with asthma, emphysema, hay fever, allergies, or other predisposed respiratory conditions.
- People at risk are advised to stay indoors as much as possible during the burn, especially when smoke is visible in the air. Any irritation, breathing difficulties, or other symptoms are expected to resolve shortly after exposure ceased.
- Those with existing condition of breathing difficulties who can easily leave the immediate area during the burn are advised to consider it.
- In the event that a heavy visible smoke comes directly in contact with a building, it is advised to temporarily shut off air intakes, and close windows and other outdoor entry points. Fresh air supply is to be restored as soon as the smoke clears.

People were told that if they experienced abnormal symptoms, they were to contact their physicians. Schools were advised to dismiss students prior to the burn as it was expected to continue through the afternoon.

Around noon on February 10, the CCHD, as well as the emergency management representative, were asked to participate in the ICS and together with federal and state personnel form a group to monitor public health concerns during the burn. From that time on adequate communication and information flow were achieved: the federal representatives provided the state and the CCHD with information on *in situ* burning in general and details on this specific burn. The county assisted the group by addressing concerns from local residents, advising on best monitoring locations, and in general interfacing with the local population whom they work with year around and know well.

Table 2. Monitoring results, February 11, 1400–2200.

Location	Ambient readings	Elevated readings due to smoke	Comments
Empire	10–20 μg/m^3	None	
North Bend	10–20 μg/m^3	None	
Horsefall Beach	10–20 μg/m^3	1900–1930, TWA of 50 μg/m^3, 1930–2000 TWA of 40 μg/m^3, then back to ambient level	Smelled smoke
Hauser	10–20 μg/m^3	1855–1935, peaks of 70–80 μg/m^3, TWA rose from 12 to 20 μg/m^3	Readings taken near highway, elevated readings probably caused by traffic
Shutter Creek	10–20 μg/m^3	None	
Umpqua	10–20 μg/m^3	None	

The Unified Command released a written health advisory from OHD the next day (February 11) by as Press Release #16 (Hall, 1999). This advisory, in essence similar to the verbal advisory given by CCHD, explained that the smoke was black because of the nature of the oil being burned. Those with asthma, allergies, or other lung disease might experience aggravation of their symptoms. Those who used medications or inhalers were to use them if needed as they would under normal conditions. The OHD advised them to consult a physician only if symptoms became severe, or were not controlled. It was explained that the smoke may leave a sooty residue similar to that from a "slash burn," and because this was a logging community, it was expected that everybody would understand what a slash burn was. The soot could be washed with a mild detergent. The OHD did not anticipate any permanent impacts to soil, plant, food, or drinking water because of soot contamination, but advised people not to consume food and water that had been contaminated. CCHD personnel answered all other health questions about the burn.

Prior to the burn, the monitoring teams deployed to nearby towns. Particulates readings would be conveyed to the monitoring group coordinator, and if elevated readings were detected, the CCHD would be notified and would provide to the public additional advisories as appropriate.

At 5:45 that evening, a second attempt to ignite the fuel was successful, and the smoke plume from the burn, which lasted throughout the night, drifted north away from population centers and was not detected to any significant degree by monitoring. Additional risk communication or public health advisory was not required.

On Friday, February 13, the burn gradually diminished, and by Friday evening, it was mostly out. Through the media, the ODEQ conveyed that no significant exposure to the smoke plume occurred, and CCHD handled calls from concerned citizens. On Friday night, the fire was out, monitoring was placed on standby, and risk communication on the smoke plume was no longer needed.

Population response. The CCHD received numerous calls from local residents inquiring about the burn and its possible implications. In general, the public need for information about the spill and salvage operations exceeded what had been provided. However, on Saturday, February 13 during a town hall meeting, local residents showed support for the decision to conduct the burn and gratitude that a major spill was averted.

Summary and lessons learned

The risk assessment for this burn worked adequately. Potential public health risks associated with *in situ* burning are well known after years of research, and were communicated along with supporting data (e.g., table comparing *in situ* burning to other burns that was faxed quickly to the command post). Rapid, on-location access to more data would have been beneficial. A few months later this data became available on-line at the NOAA-Office of Response and Restoration (OR&R) Web site (*http://response.restoration.noaa.gov/oilaids/ISB/ISB.html*), which is available for anyone to access and use.

The risk assessment was accurate in describing the risk as low, helping to emphasize an important point: *In situ* burning, under some circumstances, may be done near population centers with little or no risk to public health. In the future when the choice is between a potential major oil spill, and a burn that may generate a smoke plume that will not impact public health to any significant degree, the positive experience of the *New Carissa* burn should be kept in mind.

The SMART real-time monitoring played an important role. In addition to providing the Unified Command with real-time input on particulate concentrations in the field, it provided public health officials with the data they needed to either advise the population of protective measures, or assure the public (and the media) that all is well, that exposure was monitored and did not occur, as was the case. It was a validation of the risk assessment process.

The initial stage of the risk communication to the local population encountered some difficulties, which can be attributed to lack of accurate communication. Inadequate communication during the early days of the incident lead to release of information that caused a certain amount of confusion and anxiety in the local community.

It is critical for local public health officials to be part of the ICS if the spill or the response to it may, even remotely, risk public health. With regards to the Coos County Health Department, this did not happen until after the decision to burn the oil took place. Once the CCHD was participating in the response and was included into the workgroup with federal and state experts, information flow between the locals and the response organization was no longer a problem. Accurate, timely, dependable information from those in charge of the response helped local public health officials to support the population under their jurisdiction and responsibility, and enabled them to provide useful information to the ICS. Cooperation among local, state, and federal teams greatly increases the efficacy and efficiency of the risk assessment process, risk communication before and during the burn, and conducting *in situ* burning safely even near population centers.

The authors recommend that in future spills local public health officials be offered to participate in the ICS as soon as a potential public health-related problem is identified. This will facilitate smooth and efficient flow of information between the different entities, and make them available as a resource both for conducting risk assessment and for communicating risk to the local population.

In memory

This paper is in memory of Lisa Wampole, a sheriff deputy and Coos County Emergency Management Coordinator at the Command Post during the *New Carissa* incident. Her dedication, wit, and calm presence were an inspiration to all of us. She died in a car accident on July 20, 1999.

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