THE ILWACO, WASHINGTON, TIRE FIRE OIL SPILL

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ABSTRACT: *The Ilwaco tire fire oil spill occurred when oil generated by the pyrolysis of rubber tire chips began seeping from a hillside into an adjacent coastal wetland. The tire chips were used as road fill material to repair a section of State Route 100 damaged by a landslide. This paper discusses not only the complexities of the response to the oil spill, but also the elaborate cofferdam system and containment berm constructed to control and contain the continual flow of oil from the site until mitigation measures could be taken to eliminate the source. Because exposure to oxygen could potentially increase the risk of a tire fire, several in-situ cooling methods were evaluated. The unique properties of this oil, the environmental effects and restoration concerns, the excavation methods, and disposal problems are all discussed. This is one of two sites in the state of Washington where a road fill, constructed of shredded tire chips, has begun burning. A comparison between these two sites, along with some assumptions as to the causes and possible preventative measures, will be briefly discussed.*

In March 1996, during an inspection of a roadway embankment near Ilwaco, Washington, black oil was observed seeping from a hillside and flowing into the waters of Baker Bay, a sensitive intertidal estuary. The embankment was constructed to repair a section of State Route 100 after a landslide had washed out the road. It was rebuilt using shredded tires as a lightweight fill material.

Prior to this, in December 1995, the Washington State Department of Transportation (WSDOT) had begun monitoring the roadway because an unusual longitudinal crack had appeared in the road surface and again in the gravel shoulder. High temperatures were recorded in the vicinity of the cracks. WSDOT closed the road for safety concerns. A month later, when the oil was observed leaking from the fill into the adjacent wetlands, state and federal agencies immediately responded to contain and remediate this unusual situation and restore this site to its original prelandslide condition.

Site description

This site is located within the boundaries of Fort Canby State Park, adjacent to the estuarine intertidal emergent wetlands of Baker Bay at the mouth of the Columbia River in southwestern Washington (Figure 1). The project site is in Pacific County, within the southwest quarter, section 4, township 9 north, range 11 west. In 1994, a landslide occurred along a portion of State Route 100, near Ilwaco, Washington, removing approximately 140 feet of the two-lane roadway. The landslide material and debris slid down the hillside approximately 100 feet and came to rest in this intertidal salt marsh.

Landslide mitigation and possible cause of the oil spill

Because of the relatively unsuitable nature of the foundation soils, geotechnical recommendations for remediation of the landslide and reconstruction of the road included two options: (1) constructing an embankment with a shear key and conventional fill; and (2) constructing an embankment using scrap tires as a lightweight embankment material.

Option 2 was chosen primarily because it was the least costly, would cause the least impact to adjacent wetlands and forestland, and recycling of scrap tires was encouraged by environmental and resource agencies. On the basis of these acceptable arguments, WSDOT proceeded with the reconstruction of the road.

During the reconstruction period, this site experienced above-normal rainfall of 12.4 inches of rain from September 25 to November 2, 1995. Because of the instability of the weathered siltstone and limited site access because of the steep topography, the foundation was prepared using cranes and dragline buckets. The drainage layer was placed in the slide scarp by dumping the material from the existing pavement until sufficient mass was in place to allow access to the floor of the slide with a bulldozer. The shredded tire fill was also placed in the same manner and spread uniformly in 1-foot lifts with a bulldozer and then compacted. Final construction of the shredded tire fill was staged with the placement of a geotextile material for stabilization and covered with soil in approximately 20-foot segments. By the time the hillside was completely reconstructed, WSDOT had used approximately 6000 tons of shredded tires (approximately 700,000 tires).

In December 1995, WSDOT began weekly inspections of the roadway when an unusual longitudinal crack, approximately 70 feet long and several inches wide, was observed in the roadway. Additional cracks began to appear along the gravel shoulder near the guardrail. On January 3, 1996, steam was observed emitting from the cracks, and the ground adjacent to the cracks was dry despite the fact that it was raining and all other surfaces were wet. A thermometer inserted into one of the cracks read 155 degrees Fahrenheit. It was now obvious that some sort of pyrolytic activity was taking place within the tire chip fill. WSDOT began a monitoring program that included not only visual observations of the road, but also settlement surveys, surface temperature monitoring, and air and water quality monitoring. On January 6, 1996, this section of State Route 100 was closed because of concerns over roadway stability and air quality. By mid-February there was evidence that the

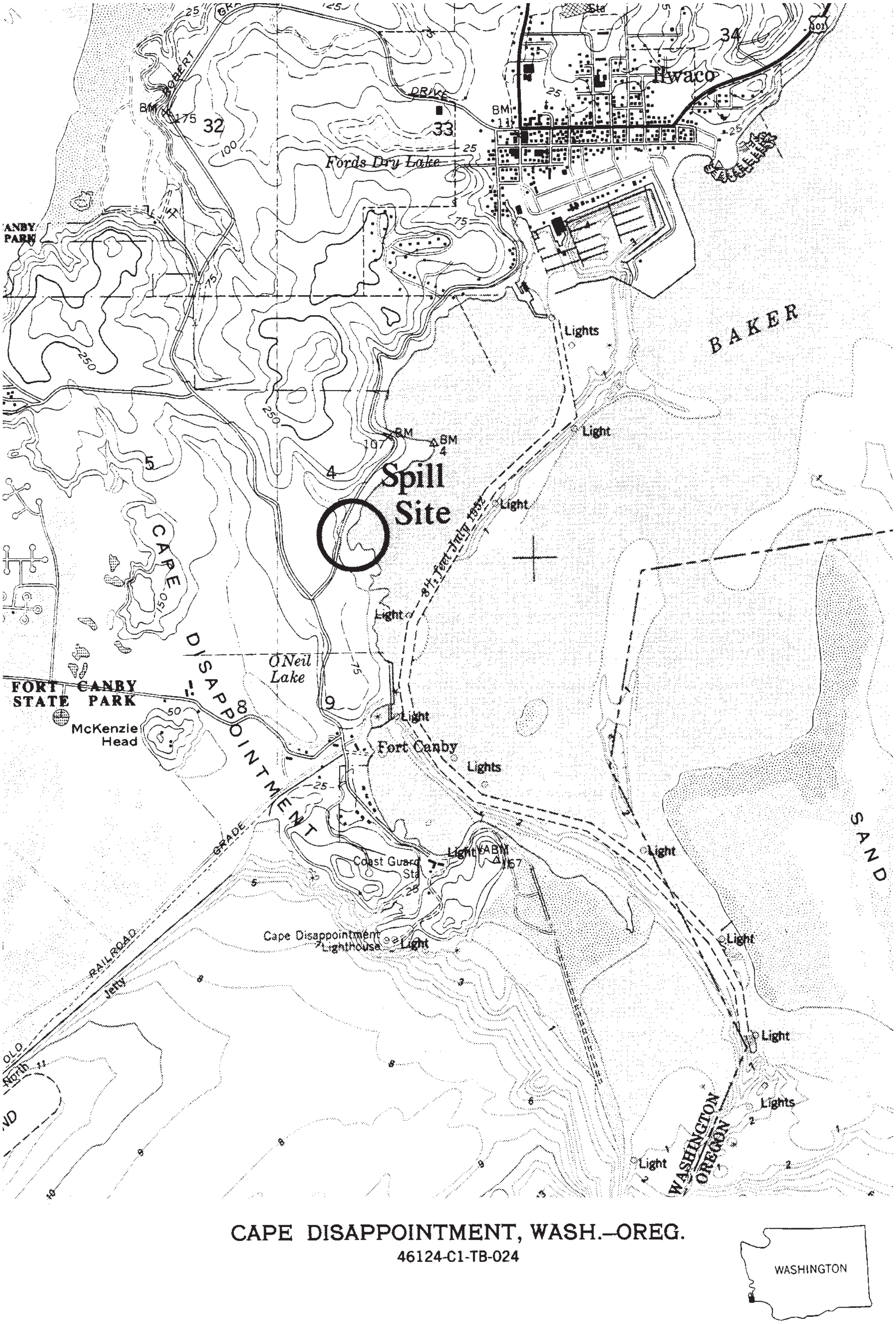

Figure 1. Location of Ilwaco tire fire oil spill

rate of the reaction was increasing, so WSDOT hired a consulting firm to begin evaluating methods for excavating the fill.

Spill response

On March 14, during a site inspection by WSDOT personnel, a heavy black oil was observed seeping out of the hillside at the base of the tire chip fill. The oil flowed from the outflow of the rock drainage blanket, down a narrow erosional ditch, and through a small upland platform, and then entered into the adjacent wetland and intertidal zone of Baker Bay. The Washington State Department of Ecology (Ecology) Spill Response Team was notified of the incident and responded to the site to lend assistance to WSDOT. Following notification of Ecology, WSDOT also notified the USCG and contacted an emergency spill response contractor to mobilize to the site to begin containment and recovery of the oil seeping from the slope.

WSDOT's spill response contractor, Riedel-Smith Environmental Services (RES), immediately deployed oil sorbent booms and oil sweep around the leading edge of the visible sheen in the wetlands and placed sorbent pads onto the largest concentrations of pooled oil. They then proceeded to construct several cofferdams, backing the oily water up into small containment ponds. This system helped to intercept and separate the oily residue from the groundwater discharging from the site.

The cleanup activities were divided into three zones. Zone 1 was the upland area below the bottom of the hill from the point at which the oil was seeping out, down to the outer edge of the upland platform where it drops down to the intertidal zone. This is the area where the cofferdams were constructed. Cleanup protocol for zone 1 was primarily tending the small containment ponds, removing and replacing oily sorbents as necessary. By the second week of the spill, RES crews began constructing a system of three small, lined detention ponds, each designed to act as a weir to collect and separate the oily water. The oil collecting in the first pond was then pumped out with diaphragm pumps into a 6000-gallon poly tank. Oil snares were placed in the lower sumps to collect any remaining sheen that escaped through the weir system.

Zone 2 was the patchy area of heavily contaminated upper intertidal grasses and logs, branches, snags, woody debris, and upper shoreline sea grasses. This zone contained much of the heavier pooled oil trapped primarily by the large concentration of woody debris. Oil recovery in this zone was accomplished through low-intrusive, low-impact manual techniques such as collecting sorbent pads and snares with rakes and boat hooks. With each tide change, oil was refloated from the marsh grass and off the muddy soils, allowing workers to collect it with pads and snare. Foot traffic was kept to a minimum using existing log debris and plywood sheets whenever necessary to ensure against worsening the contamination by trampling the oil into the sediment substrates.

Zone 3 was the area of medium to light oiling in and around the intertidal channel. This was the area initially surrounded by the sorbent booms and sweep. Most of the oiling in this zone occurred within and immediately adjacent to the intertidal channel running into Baker Bay. The sorbent booms remained encircling this area throughout the cleanup and remediation activities. This zone was inspected several times daily, particularly following the low tide. Isolated areas of heavier oiling were cleaned up using sorbent pads and snare.

Three days into the spill, oil began to appear in the sediments within the tidal booms despite the fact that practically all the visible oil on the water surface was removed. Ecology voiced concern that oil might be pooling within the drainage blanket, and that the hydraulic head of such a pool could push oil downward into a deeper water table. Historical data showed that the drainage blanket was on a uniformly graded clay surface, freely draining from the toe of the head scarp to the lower limit of the drainage blanket. However, to alleviate concern over the oil that was showing up in the sediments, WSDOT dug an interceptor trench near the toe of the slope to expose subsurface soils and to check for any leaching of subsurface flows of oil. Fortunately, this excavation did not reveal any oil, ruling out the possibility of a large pooling of oil trapped under the landslide material. As for the oil appearing in the sediments of the wetland, further investigation by Ecology found this occurrence to be localized only within the areas that were most heavily impacted by the oil; they therefore believed that the oil surfacing was previously trapped in the thicker vegetation and litter layer of the ground.

To prevent the occurrence of an unrecoverable oil discharge, and to provide secondary containment for excessive water runoff during the tire chip excavation process, WSDOT designed a semicircular containment berm to be constructed around the oil collection sumps, the oil storage reservoir, and the toe of the embankment. An access road to the base of the hill slope was built to facilitate construction of a containment berm. However, because of restrictions imposed by severe topography and adjacent old growth conifers, the road required a 38% gradient, thus preventing the use of dump trucks for hauling supplies and materials. Fill materials were pushed with a small bulldozer, and other materials were transported by a track excavator and a skiff box.

The berm was constructed approximately 6 feet high and had a maximum holding capacity of approximately 92,000 gallons. Its inward and top surfaces were sealed with a 40-millimeter PVC welded-seam lining to ensure containment of all potential contaminants. A 6-inch PVC pipe with dual valves was placed at the down slope base of the berm to act as a drain and discharge point for water if necessary.

On March 26, 1996, Washington Department of Fish and Wildlife (Fish & Wildlife) biologists discovered dead juvenile fish and invertebrates and requested that water discharge into Baker Bay be suspended. On April 2, water sampling showed elevated levels of toluene and cyanide, resulting in immediate suspension of all water discharge from the project. Baker tanks, with a holding capacity of 21,000 gallons, were mobilized to store groundwater pumped from the lower interceptor trench. Nineteen Baker tanks were needed to contain runoff and/or provide contingency backup for storing runoff from the project, due primarily to heavy rainfall.

A temporary stockpile site was also constructed to store potentially contaminated materials excavated from the fill. The floor of the stockpile area was designed to retain and collect all potential contaminants that might leach from stored materials. It consisted of a uniformly graded and compacted native weathered siltstone base, a cushion layer of fine beach sand, a 40-mm PVC welded seam liner, and another cushion layer of fine beach sand topped with crushed rock for vehicle traction.

Site remediation options

As soon as high temperatures were detected on the roadway, WSDOT began evaluating methods for safely removing the suspected heat source. As soon as the oil and water collection methods were established and under way, the unified command began reviewing these alternatives for remediating the hot spots of burning tires prior to excavation of the tire chips. The following alternatives were discussed:

Alternative 1: Do nothing. This alternative would allow the tire chips to continue burning until all fuel was spent. This implied continued anaerobic pyrolyzation and/or combustion of the materials. This alternative was not chosen because of the following risks: (1) proximity to local residents raised human health concerns; (2) oil would continue to be produced and have to be contained and collected for an undetermined period of time; (3) water management would become significantly daunting; and (4) at least a portion of Fort Canby State Park would have to remain closed through the summer and possibly into the following year.

Alternative 2: Isolate and accelerate hot spot burning. This alternative would excavate and remove material over the tire chips and around the hot spot areas so that the fire could burn aerobically, speeding up the burn. This would result in more complete combustion of tires and gases. Alternative 2 was not selected for the same reasons listed under alternative 1, and for the additional fact that it would increase the fire hazard to nearby virgin old growth trees.

Alternative 3: Quench burning material in place. This alternative would extinguish the fire in situ prior to excavating the cover materials or the tire chips themselves. Holes drilled horizontally into the fill and fitted with perforated casing would provide conduits for the quenching medium. Possible tire-suppressing media included cryogens (liquid carbon dioxide or nitrogen) and water mixed with synthetic fire suppressants. The partially extinguished or quenched material would then be removed from the embankment. This option was not selected because (1) it was not possible to assess the thoroughness of infusion until the embankment was excavated; (2) thorough infusion was not expected, because as the surface of a heated, degraded chip is cooled, it crusts over, preventing contact with the rest of the hot material; (3) surfactants would emulsify oils, rendering the detention ponds useless for oil collection; and (4) many surfactants are highly toxic.

Alternative 4: Expose and quench with chemical surfactant in place. This alternative was similar to alternative 3, and would also expose the hot spot areas by removing the surrounding and overlying material; it would be followed by quenching in situ. This method involved a more direct application of the fire suppressant agent by spraying the liquid onto the tire chips. Although it had the advantage of allowing visual verification of the quenching medium's effectiveness, this alternative was not selected because of the same problems with surfactants described under alternative 3.

Alternative 5: Isolate, remove, and quench with water. This alternative would remove the burning material using conventional excavation equipment. Material would be quenched at the point of removal and loaded into trucks for transport to a temporary holding area. This alternative was selected because (1) the quenching material (water) was the most environmentally sound medium and would not adversely affect the oil collection system; (2) the hazard to workers could be minimized by using large cranes to remove material remotely; (3) visual verification of efficiency was possible; (4) water had the lowest cost of any extinguishing material; and (5) contaminated water collected at the toe of the slope could be applied to the heated tire chips as a quenching medium, thus reducing the amount of contaminated water requiring costly disposal.

Tire chip excavation process

Water and oil collection sumps and trenches were used to collect all quenching and surface runoff, since the existing topography naturally drained to these facilities. Water pumped to Baker tanks was stored and recycled for quenching and for controlling fire outbreaks. A 3-inch-diameter, 650-gallon-per-minute water pump was plumbed to the Baker tanks to provide water for fire fighting. Water monitors (cannons) fitted with 2-inch supply lines were strategically located as primary fire control. The local volunteer fire departments provided backup for tire fire suppression and also furnished protection for the adjacent old growth trees.

During excavation, two distinct hot spots were evident at the approximate locations where they had been predicted through visual observations and infrared imaging. The core of each hot spot was very near the bottom of the shredded tire chip mass, within the deepest section of the fill (approximately 26 feet). At approximately 10:00 p.m., April 7, 1996, fire broke out on the surface of the shredded tire embankment near the north hot spot, in an area approximately 30 feet in diameter, with flames rising approximately 6 feet above the fill surface. The Ilwaco Volunteer Fire Department extinguished the fire with little effort. Several small flare-ups occurred intermittently at the vent locations; these were controlled with minimal misting. These flames were the result of gas emissions and oil (products of pyrolyzation) igniting, rather than tire chip combustion.

Continued flare-ups prevented workers from being able to work safely on the fill surface. All further excavation was performed using a crane equipped with a clam bucket. Chips were excavated, moved to the cooling tray, lightly agitated in water, and removed by a track excavator equipped with a slotted bucket. Once chips were cooled to 87 degrees Fahrenheit and drained, they were loaded into trucks and transported to the staging site.

After the tire chips and drainage blanket had been removed, reddish brown to tan soil colors were observed immediately below the center of both hot spots. The tire fill embankment between the hot spots was entwined with veins of extensively pyrolyzed chips, connecting the primary hot spots with chips pyrolyzing anaerobically. When exposed to oxygen, heated products of pyrolyzation in the veins ignited.

A total of 13,938 tons of shredded tire chips, contaminated soil cover, drainage blanket, and native soils was excavated from this site. Another 402 tons of material was removed from the floor of the stockpile site and disposed of at the designated disposal site, since samples indicated they contained elevated levels of benzo[*a*]pyrene.

Pyrolyzation by product (oil) composition and waste disposal

It was important to have at least a limited understanding of the probable fate and transport of the oily by-product. During the emergency response, the rubber pyrolyzation by-product was subjected to a broad spectrum of analyses and was shown to be composed primarily of a wide range of aromatic compounds, predominantly benzenes, naphthalenes, and other unsaturated compounds. The by-product was similar to a highly aromatic fuel oil, but contained exotic compounds derived from the thermal breakdown of synthetic rubber that are not typically found in petroleum oils. The density of the by-product was approximately 0.935 at 68° Fahrenheit. The product also contained a significant amount of asphaltlike particulates derived from the tire rubber and carbon black used in manufacture.

Water collected at the base of the fill area was analyzed for the following:

- Volatile organic compounds (VOCs) by USEPA Method 8240
- Semivolatile organic compounds (SVOCs) by USEPA Method 8270
- Total and dissolved priority pollutant metals and barium by USEPA 6010/7000 series
- Hardness by USEPA Method 130.2
- Total cyanide by USEPA Method 335.2
- Weak and dissociable (WAD) cyanide by standard method 4500-CN-I
- Total suspended solids by USEPA Method 160.2

The detected concentrations were compared to state marine surface water standards. Seven of the 10 chemicals with marine standards were detected at concentrations above the standards in at least one sample. Contaminants in highest concentration were limited to phenols, acetone, benzene, toluene, cyanide, and mercury. These chemicals did not exceed marine standards in samples collected after April 26, 1996, with the exception of cyanide. Water seeping from the site was collected and contained until the marine standard for cyanide was achieved. All water that was collected was eventually trucked to an industrial treatment facility, treated, and discharged to the Columbia River.

Early samples collected downstream appeared somewhat emulsified. These water samples were analyzed and found to contain low concentrations of alkylated benzenes and a compound tentatively identified as benzonitrile. Since these compounds are slightly water-soluble, it was important to collect as much by-product as possible at the seep location rather than downstream.

The by-product was also a very highly aromatic oil; thus cleanup workers were vigilant in keeping the oil off their skin to avoid skin irritation or possible toxic effects. When working in areas of high concentrations of the product, workers used organic vapor masks as necessary.

Because the oil product was not a hazardous waste, all related materials could be disposed of as solid waste in a sanitary landfill. However, WSDOT examined recycling and recovery options and chose to dispose of oil, contaminated protective clothing, and oiled sorbent pads for energy recovery as hog fuel at a nearby industrial facility incinerator.

As mentioned above, all the water collected on site was either used in the fire-quenching activities or discharged at an industrial treatment facility in Longview, Washington. Options for recycling the tire chips were sought. However, recycling options were very limited, as well as cost-prohibitive. All tire chips and contaminated soils were therefore disposed as solid waste at a landfill and used for daily cover.

Site restoration

Although environmental damage caused by this incident was not rigorously quantified, Fish & Wildlife began raising concerns that the contaminated water and oily residue running off the slope and into the adjacent salt marsh habitats may have adverse effects on the fish and wildlife resources in the area. Despite early efforts to contain the oil with rudimentary oil-water separators, water continued to be discharged from the site into the wetlands. Initial analysis of water samples taken from site runoff indicated elevated levels of potentially toxic compounds, forcing Fish & Wildlife biologists to request that Ecology require WSDOT to contain the water runoff and not let it discharge into Baker Bay (Doty, Hooper, and Divens, 1996).

On March 26, Fish & Wildlife biologists discovered dead juvenile fish and invertebrates at the site. Over the following 15 days, Fish & Wildlife continued to document evidence of fish and invertebrate mortalities at this site. Based on several findings by Fish & Wildlife biologists, it was believed that the dead fish and invertebrates were killed from exposure to toxic substances, specifically those found in the effluent water runoff from the tire fire site (Doty, Hooper, and Divens, 1996).

To address these and other potential damages, WSDOT worked cooperatively with Fish & Wildlife and other resource agencies to develop a restoration plan that would enhance the recovery of the wetland by establishing naturally sustainable communities. The final plan addressed five zones: (1) a wetland restoration zone; (2) a habitat island planting zone; (3) a riparian revegetation zone; (4) an upland buffer revegetation zone; and (5) a freshwater wetland enhancement area. To restore these zones, a portion of the original landslide material will be removed and replanted with native vegetation to restore, to the extent possible, the native wetland plant community. Another portion of the landslide material will be left in place as an island because of the habitat provided by several large trees. Finally, a freshwater wetland located just north of the landslide will be enhanced by directing groundwater discharging from the road fill area to the wetland. This would also enhance the development of brackish and saltwater condition in the wetland restoration zone by directing a significant amount of fresh water away from the restored area (EMCON, 1996).

This reconstruction project will be monitored for a period of 5 years to determine the success rate of such a project and to identify any maintenance needs.

Garfield County, Washington, tire fire comparison

A tire shred fill similar to that used at Ilwaco was used to construct a road embankment near the town of Pomeroy in Garfield County, Washington. This road is gravel-surfaced and is used primarily by farm equipment and local residents. Unlike at Ilwaco, where the fill was a repair to landslide damage, the Garfield site filled a ravine. A culvert was placed at the base of the fill to allow a stream to flow under the road fill.

Some settlement of the road had occurred early after construction but was believed to be time-dependent settlement of the chip fill. However, on October 7, 1995, smoke was reported coming from a fissure in the fill located on the south side slope. This venting continued until January 17, 1996, when open flames were observed on the north side of the slope. The flames were extinguished by the local fire department, but they were again observed 2 days later.

Oil was eventually observed seeping from the hillside. Ecology responded to this oil spill and with the assistance of a contractor was able to control and contain the oil. Shortly after this incident, the Ilwaco tire fire oil spill occurred, and, because of the environmental sensitivities associated with the Ilwaco site, attention was turned from Garfield to Ilwaco to search for an effective solution.

Conclusions and recommendations

Although it is not certain what factors led to the pyrolytic breakdown of the chips in the road fill, it is believed to have been related to a combination of chemical oxidation, pressure, microbial activities, and the presence of water. On the basis of commonalities present in other tire fires that have occurred across the United States, one can say that two factors are related to all: (1) the presence of water seems to be a primary factor, since all have occurred following a significant water event, and (2) the depth of the tire chip fill material is important.

Ilwaco was constructed during periods of above-normal rainfall, and the depth of the tire chip fill material was 27 feet; 6000 tons of tires were used. The Garfield site experienced a flash flood in July 1995 that caused water to build up about 30 feet deep against the upstream side of the embankment. The depth of fill material at this site was approximately 40 feet; 12,000 tons of tire chips were used (Humphrey, 1996).

According to Joe Zelibor, a former advisor to the Scrap Tire Management Council, there are more than 70 other projects in the United States that have used scrap tires as fill material, and only 4 have experienced exothermic reactions. The two sites in Washington are the first to use tire fill to such depths.

Spill response has never been an exact science, and new information is learned with every response. The behavior of the tire by-product in the water and soils at Ilwaco was in some respects different from that of other oils encountered during more typical spills. But what really made this incident unique was the nature of the spill itself. For future spills or emergency responses of this type, the following lessons learned may prove beneficial:

- Exposing the pyrolyzing chips to oxygen may result in open flame events. However, this has the great advantage of greatly reducing oil production volumes.
- Minimal water is effective in dousing flames in a tire chip fire and is unlikely to adversely affect an oil collection system.
- The by-product, with a specific gravity of 0.9, may be extremely difficult or impossible to separate if emulsification is allowed to occur.
- Worker safety considerations include skin contact with the by-product, exposure to carbon monoxide, exposure to benzene fumes, and fire hazards.

The disposition of the millions of tires discarded in the United States each year is a growing problem. Shredding these tires and using them as fill material for highway construction projects appears to be a promising solution to this ever-increasing problem. Despite the fact that many states pondering similar projects using tire chips have postponed or canceled their plans because of Washington's problems, it must be remembered that the majority of project sites have had no problems. If continued use of shredded tire chips as fill material is to be considered, further research into the cause of pyrolysis is needed so that preventative design measures can be developed. Perhaps simply ensuring that these sites are located away from environmentally sensitive locations, such as coastal intertidal wetlands, should be considered until time-tested fills can be evaluated.

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Biography

Eric Heinitz is currently the southwest regional supervisor for the Spill Response and Planning Program at the Washington State Department of Ecology. Prior to joining Ecology, he worked as a project manager for Riedel Environmental and was a marine inspector in the U.S. Coast Guard.

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