INTEGRATION OF RESPONSE, RESTORATION, AND ENHANCEMENT IN A NORTHWEST UNITED STATES SALMONID STREAM FOLLOWING A GASOLINE SPILL

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ABSTRACT: *The gasoline release, explosion, and fire that resulted from the Olympic Pipeline rupture on June 10, 1999 in Bellingham, Washington affected approximately 4 kilometers of the Whatcom Creek system. One component of the response program involved remediation of the affected streambed sections. A combination of mechanical, manual, and hydraulic in situ treatment techniques were used to remove product from the streambed and stream banks. Much of this work involved placement of heavy equipment in the stream and manipulation of unconsolidated substrata. Several kilometers of the streambed being treated had been the subject of historical anthropogenic alterations substantially lowering the suitability of the stream to support salmon spawning and rearing. While the equipment was in the stream, a series of emergency restoration modifications were made to increase the suitability of the stream to support increased viable salmonid populations. Enhancement included: erosion control, provisions for pools, runs, riffles, effective use of groundwater infiltration providing colder water, enhancement of partial passage barriers, and installation of large woody debris. Work was completed by September 1999 prior to the return of spawning adult salmon. Subsequent data collected on the stream used by salmon indicates that the measures were successful. Integration of response, restoration, and enhancement allowed the accomplishment with very little interruption to the anadromous fish cycle following a substantial insult to the stream system.*

Introduction

Approximately 5,500 barrels (bbls) of unleaded gasoline escaped from a ruptured pipeline in Bellingham, Washington in June 1999 (Figure 1). The majority of the product entered Whatcom Creek, affecting approximately 4.8 km (3 miles) of the creek. The product contacted an ignition source burning approximately 2.4 km (1.5 miles) of the Whatcom Creek stream surface and forested shorelines.

The natural resource agencies concluded that few organisms in the affected 3 miles of stream at the time of the incident survived the gasoline toxicity and subsequent fire effects. A water sampling program at 8 stations in Whatcom Creek and 12 stations in Bellingham Bay was implemented approximately 20 hours following the incident. Ultimately, nearly 400 water column samples were analyzed for gasoline range hydrocarbons (GRH), BTEX and MTBE. Samples were collected every 4 hours for the first 5 days, daily for the next 17 days, and 16 of the following 32 days. Within 140 hours of the incident, GRH subsided two orders of magnitude. Instream waters met State of Washington Groundwater Standards in an average of 131 hours from the time of the release for benzene, 127 hours for ethylbenzene, 66 hours for toluene, and 207 hours for xylene. Volatilization of BTEX during transport downstream was evidenced by a consistent gradient of reduced concentrations with distance from the source. Sediment pore water and bulk sediments were also sampled. Initial interstitial water GRH ranged widely from non-detect to 110 mg/l. GRH in bulk sediment samples ranged from non-detect to 447 mg/l.

An agitation program was conducted to release product trapped in the streambed, which reduced contaminants to levels deemed acceptable by a risk-based approach for survival of salmonid fry populations. Heavy equipment and workers using pry bars moved down the stream in sections turning rocks and agitating the substrate to release trapped fuel. The cleanup actions, chemical analyses, and monitoring of the remediation and degradation of the product are described in detail by Owens et al. (2001) and Challenger et al. (2001). The heavy equipment conducting the remediation in the stream during the emergency phase of the incident provided the means to incorporate aggressive restoration in the absence of lengthy permitting processes and Natural Resource Damage Assessment (NRDA). This approach is referred to as Emergency Restoration.

Records indicate anadromous fish did not occur in the creek between the early 1940s and 1978 due to a semi-impassable waterfall at the mouth of the stream, physical habitat destruction, and reduced water quality related to urban and industrial development of the area. Various juvenile fish stocking programs were initiated in Whatcom Creek between 1978 and the early 1980s. In 1980, a fish ladder was built to provide continuous access for returning adults above the lower falls and a fish hatchery began operation at the mouth of the creek. Anadromous fish were reintroduced into the creek for the first time in 1978 after approximately 40 years. Hatchery plants of fall chinook, coho, chum, winter steelhead, sea-run trout, and resident trout have occurred routinely since the reintroduction.

Whatcom Creek and its associated tributaries, despite recent improvements from various restoration efforts, have also been exposed to recurrent patterns of environmental disruption (including chemical spills and elevated water temperatures) followed by subsequent incomplete levels of recovery. Despite the creek's ability to recover and support fish populations in recent years, it continues to harbor detectable levels of numerous toxic substances from a variety of sources due to its proximity and exposure to urban activity (Nahkeeta Northwest, 1995; Huxley College of Environmental Studies, 1995; Cubbage, 1994; Huxley College of Environmental Studies, 1993; Walker et al. 1992; Creahan, 1988).

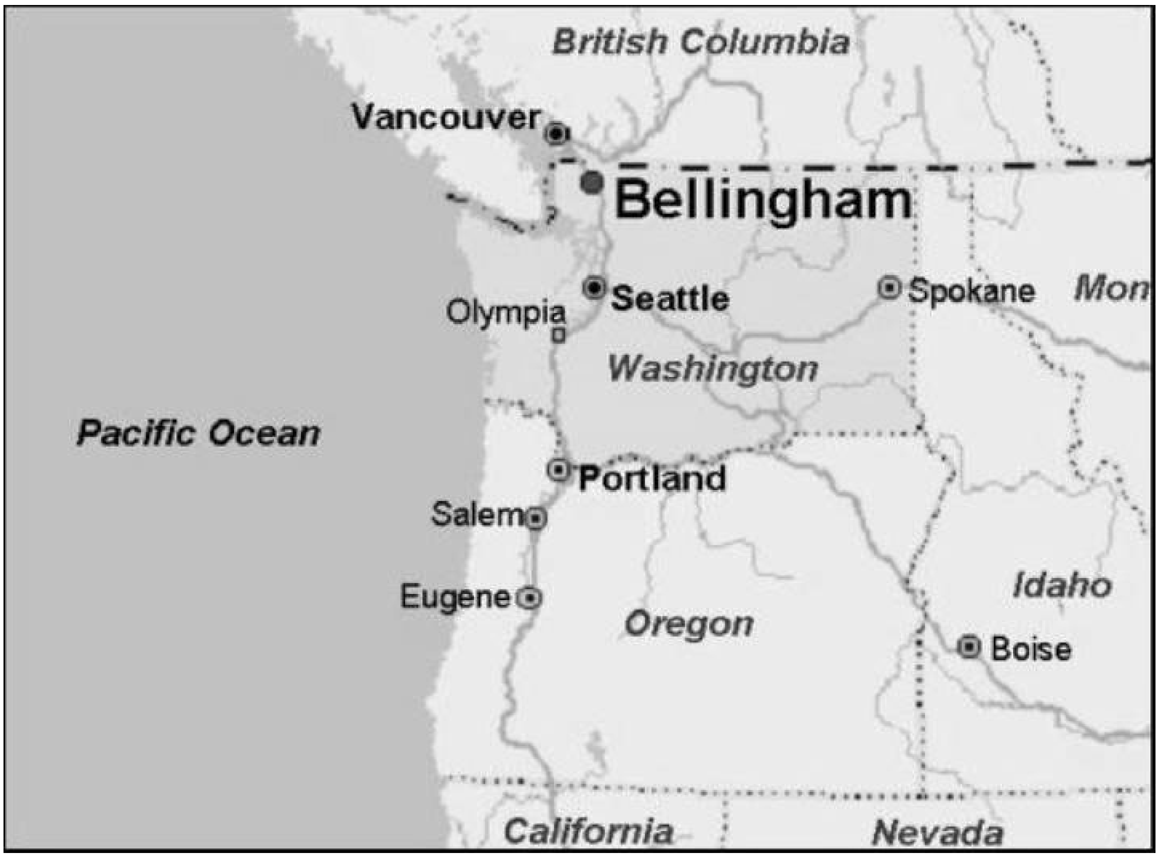

Figure 1. Incident location.

Formation of a restoration committee

When events such as the June 10 release of gasoline to Whatcom Creek occur and result in the injury of publicly held resources, the responsible party(s) (RP) may be held liable for the recovery, restoration, and/or replacement of these resources to public use and environmental health. This responsibility for injuries to natural resources is provided for by the Clean Water Act (CWA) in cases where releases occur into navigable waters, by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), by the Oil Pollution Act of 1990 (OPA), 33 U.S.C. 2706(b), and by the National Contingency Plan, 40 CFR Section 300.600. The assessment of injury and restoration of resources are also provided for under RCW 90.48.366, 90.48.367, and 90.48.368 of the Washington State Water Pollution Control Act.

While a number of models exist under these various laws and regulations for the assessment of damages and the restoration of injured resources, there is the commonality that state, federal, and tribal "trustees" represent the public's interest in assuring the recovery of natural resource damages. The primary federal trustees are the Department of the Interior (including the Fish and Wildlife Service, the National Park Service, and the Bureau of Land Management), National Oceanic and Atmospheric Administration, and the Department of Agriculture's Forest Service. State, tribal, and local trustees commonly include fish and game natural resource, park, and water management authorities.

Through the processes of damage assessment and restoration planning, trustees must provide for the restoration, rehabilitation, replacement, or acquisition of the equivalent of the injured natural resources. These actions, often referred to collectively as "restoration," are principally designed to return injured resources to baseline (i.e., the condition that would have existed if the release or discharge had not occurred). Restoration may also compensate for the public's interim loss of injured resources from the onset of injury until baseline is restored.

Toward these ends, in the case of Whatcom Creek, the trustees agreed that a draft Conceptual Restoration Plan would be prepared by the RP. In an effort to establish a single focus for the processes of injury assessment and restoration planning among all trustees and the RP, the Conceptual Restoration Plan called for the development of a Joint Restoration Committee (JRC). The JRC consists of federal, tribal, state, and City of Bellingham trustees and Olympic Pipe Line Company (OPL). With the exception of the City of Bellingham, the trustee agencies are designated as natural resource trustees under CERCLA, OPA, and the National Contingency Plan. The City of Bellingham, in the person of the mayor, was designated as a natural resource trustee by Washington State Governor Gary Locke in a letter to the President on July 26, 1999.

Both OPA and WAC 173-183 provide for the active and cooperative participation of the responsible party in the development and implementation of natural resource damage assessments and restoration plans. While this participation is not mandated by these acts, it is both allowed and encouraged as a means of achieving timely restoration of the public's resources and resource uses. However, this process can take several months to several years. In an effort to expedite restoration for returning salmon, a process of emergency restoration was proposed by the responsible party. Emergency restoration can occur concurrently with spill cleanup and avoid lengthy permitting and review processes. In this instance, the responsible party felt it was vital to conduct emergency restoration in order for the stream to be suitable for salmon expected to return to the creek within three months of the incident.

Emergency restoration

The main objectives of the emergency restoration were:

- Enhance the Whatcom Creek channel to increase available aquatic habitat, especially adult spawning and juvenile rearing habitat, while facilitating the transport of potential fine sediment through the system.
- Accelerate the recovery of the aquatic invertebrate community.
- Collect baseline, post-incident data for long-term monitoring of the physical and biological characteristics of the stream ecosystem.

Whatcom Creek Channel Enhancements in 1999

Four types of channel enhancement treatments were completed: Pool/Bar, Step Pool, Large Woody Debris (LWD), and Bioengineered Banks in emergency restoration areas. The individual treatments varied from location to location, and some locations received more than one treatment type. Design details of the treatments, such as stone size and details of woody debris placement, were determined based on hydrologic and hydraulic analyses and in consultation with the JRC.

Understanding substrate sizes that move at different flows was important to properly size bank stabilization materials and bar gravel next to excavated pools. Cross-sectional area needed to convey floodwater was important to ensure any wood placement does not cause bank erosion or flooding. Hydrology and hydraulic analyses were necessary for these final design decisions.

The Pool/Bar treatment involved the creation of an alternating series of pools and associated bars within the existing confines of the channel. As streambed materials were agitated to release residual product, the materials formed into pools and bars of appropriate width and spacing. Pool "tailouts" provide spawning habitat for salmonids. The pools serve as adult salmonid holding, juvenile rearing, high flow refuge, and possibly thermal refuge areas. Where possible, the Pool/Bar sequences provide more efficient fine sediment transport through the system.

A small excavator with a thumb attachment on the bucket was used to construct pools and bars. Gravel was excavated out of pools every 5-7 channel widths in length. Pool material was placed to the side to form gravel bars. Woody material was placed into the pools and at the head of some of the gravel bars. Stream stage was elevated by dam releases to help sort sediment, move fine sediment downstream, and liberate as much residual gasoline as possible.

The Step Pool treatment involved the re-arranging of boulder materials to form a series of short pools in a relatively steep portion of the channel. Step pools increase holding habitat by providing relatively quiescent zones in steep channel segments. Material was excavated and configured to increase pool volume. Wood was added to the outside bends of these pools using the thumb attachment on the excavator and spyder backhoe. Wood was cabled in place to prevent movement downstream.

LWD consisted of root wads and trunks buried securely into the channel banks such that the protruding portion offers cover to fish. Woody debris was placed in selected locations in conjunction with the Pool/Bar, Step Pool, and Bioengineered Bank treatments. These materials provide cover and refuge habitat for fish until streamside woody vegetation can fully recover. Wood was placed in pools and bank stabilization sites by the heavy equipment.

The Bioengineered Bank treatment consists of a stone and wood bank toe beneath a soil and fabric upper bank. The stone and woody debris making up the toe provides resistance to scour as well as cover for fish. The upper bank is constructed of soil wrapped securely in biodegradable coir fabric to provide resistance to erosion. The upper bank is planted with native riparian vegetation.

In addition to in-stream and riparian restoration, fish passage was improved in several locations. Several road crossings were replaced and/or designed to pass fish. Pool height was increased with boulder placement in other areas to allow for better fish passage at the upstream culverts or cascades.

Emergency restoration monitoring results

During late 1999 and throughout 2000 the fish and macroinvertebrate populations in Whatcom Creek were monitored to ensure emergency restoration had the desired effect of improving habitat conditions to support aquatic life. Macroinvertebrate communities were sampled quarterly from October 1999 through October 2000. Similarly, juvenile and adult fish densities were assessed routinely from April through November 2000.

Post-restoration channel habitat features and morphological characteristics were reviewed in September 1999 and compared to pre-restoration conditions. The objective of stream habitat surveys was to assess the physical habitat characteristics available to salmonid fishes before and after emergency restoration to ensure the resulting habitat conditions were at least as suitable for limiting life-history stages of salmonid fishes as prior to the stream work. The approach included a sequential review of macro-, meso-, and micro-habitat conditions available to the fish.

The results were clear. Emergency restoration had made an estimated 30 percent overall increase in desirable habitat characteristics with no noticeable long-lasting effects of either the burn or the residual product on macroinvertebrate or fish populations. The integration of response, restoration, and enhancement activities performed after the incident allowed very little interruption to the anadromous fish cycle. This accomplishment occurred in the presence of a rather substantial insult to the stream system.

Macroinvertebrate communities continued to diversify through October 2000 with 100 percent recovery noted in nearly all indices and stations monitored within 14 months following channel restoration activities. Similarly, the numbers, species composition, and robust condition of juvenile salmonid fishes provided further evidence of resource benefit related to the restoration measures.

The completed restoration of physical habitat had the greatest influence in the creek by improving desirable features on the reach level of scale. The overall channel gradients and stream morphologies were not altered by restoration activities, but the availability of habitat types, cover features within the study reaches, and off-channel access were markedly improved. Restoration activities focused on creating a more complex stream channel by creating and enhancing pool areas and reducing the area of homogenous, slow, flat water (run/glide). Many studies have demonstrated the importance of channel or habitat complexity in streams supporting salmonid production (Bisson et al. 1982; Platts et al. 1983; Peterson et al. 1992; Hill and Platts 1998). More specifically, the importance of pool habitats has been recognized for a number of life stages (Campbell and Neuner, 1985; Bisson et al. 1987; Nickelson et al. 1992). The diagnostics used to describe desirable habitat features including: 1) pool abundance, frequency (or spacing) and residual depths; 2) LWD frequencies and habitat function characteristics; 3) channel complexity; and 4) gravel quantities and quality, indicate dramatic improvements in habitat conditions from pre- to post-emergency restoration as described below.

By combining all of the pool habitat diagnostics, the overall net benefit of the restoration activities on the order of a 30 percent improvement in pool characteristics in the Restoration Area compared to the original channel condition. Pool abundance and depth are key fish habitat parameters relative to successful rearing production of salmonid fishes.

The total LWD count increased 31 percent overall in the Restoration Area. The number of key pieces (> 88 cu. ft) increased 40 percent. In addition, more of the wood tally (32%) was recorded in the low flow stream elevation zone after restoration, providing enhanced year-round wood debris influence compared to pre-restoration conditions. The number of pieces contributing to the formation of pools nearly doubled post restoration. The orientation of the wood with respect to stream flow was also enhanced with greater deflection of flow creating more opportunity to influence habitat conditions compared to prior conditions. And most importantly, the stability rating of the current functional LWD was improved by a factor of 2.2x compared to the prior counts of stable pieces.

Figure 2. A track hoe “Spyder” used to agitate the stream bed and release trapped fuel.

The fish community, 7 to 15 months post restoration work, was abundant and diverse and the population numbers were high. Young-of-the-year recruitment was apparent for many aquatic species. The relative condition of the fish was robust indicating healthy growing conditions with sufficient spawning and rearing habitat for ongoing production.

Young-of-the-year chum, chinook, coho, steelhead, cutthroat and rainbow trout were observed in Whatcom Creek in great abundance. Spawning runs of adult chinook salmon, steelhead trout and cutthroat trout were also observed at various times during the year. Other fish and aquatic species including juvenile and adult smallmouth and largemouth bass, pumpkinseed, three-spine sticklebacks, sculpin, Pacific lamprey, peamouth chub, bullhead catfish, and crayfish were noted.

Juvenile fish growth was extremely rapid indicating an exceptional combination of warm stream temperatures, high prey availability, and good stream rearing conditions. Densities of fish were highest in the restoration area (RA) that offers the best spawning and rearing habitat conditions in Whatcom Creek. Fish abundance in the resident fish area and downstream in the urbanized area of the creek were comparable to each other but much lower than in the RA. Areas of Whatcom Creek accessible to anadromous species exhibited faster population recovery than in the resident fish zone likely due to a greater number of available recruitment sources (tributaries, marine waters, etc.).

The observed densities of prey items and the robust condition of juvenile salmonid fishes following the incident indicate a positive ecological response following the habitat disturbance. Population explosions of a few “pioneer” or “opportunistic” species in the absence of substantial competition or predation may lead to abnormally high densities of prey organisms that are not generally as abundant in more diverse and stable communities.

Discussion

Representatives of the federal, state, and tribal trustees responded to the June 10, 1999 release and operated under the Joint Incident Action Committee established to manage the emergency phase of the incident. Natural resource assessment activities began on June 11, 1999 with the parties working together to plan and carry out the collection of ephemeral or time-sensitive data. This process was formalized on June 13, 1999 through the submittal by the RP and acceptance by the trustee representatives of a Conceptual Restoration Plan (CRP) just 3 days following the incident to help guide the emergency and long-term restoration.

The June 13 CRP:

- Established the RPs commitment to the development and implementation of a natural resource restoration plan,
- Established the JRC as the administrative body responsible for managing the joint development of assessment and restoration plans, and
- Established the RP as the administrative party responsible for the implementation of JRC plans and the management and distribution of information.

On June 22, 1999, 12 days following the incident, OPL submitted an Emergency Restoration Plan (ERP) to the JRC proposing the immediate implementation of a number of restoration activities. These activities included:

- Stabilization of streambanks and canyon walls within the burn zone to limit erosion and sediment runoff,
- Improvements to in-stream fish habitat through the excavation of pool riffle complex and back-watering of migration barriers, and completion prior to adult anadromous fish returning in mid-September 1999,
- Riparian habitat protection through limitation of access to the burn zone,
- Placement of large woody debris in selected habitats, and
- Recreational use restoration by an evaluation of park closures and reopening of trails and access outside the burn and operational zones.

The emergency restoration plans were approved by the trustees on July 12, 1999. The RP completed the emergency restoration activities discussed herein by September 1999. Adult anadromous fish began entering Whatcom Creek to spawn in the restored habitat in mid-September 1999.

As a product of the JRC, the long term restoration plan (or Draft Assessment and Restoration Plan was developed by the RP with extensive JRC guidance and assistance. The Long-Term Restoration Plan was submitted by the RP in March of 2000, 9 months after the incident. Restoration options in the plan were suggested by both the trustees and by the RP. These options have been subsequently investigated by the RP following guidelines for consideration of restoration options established by both OPA and the State of Washington.

Conceptually, many of the projects identified in the March 2000, long-term plan prepared by OPL were accepted by the trustees. However, following review of the RPs Long-Term Restoration Plan, the trustees unilaterally prepared another draft restoration plan completed in 2001 that contained many of the same project alternatives as the OPL restoration plan.

Conclusions

The Oil Pollution Act of 1990 and the subsequent guidelines that have been published do not lend themselves well to the integration of restoration with emergency response. Oil spills differ from chronic contaminant releases, typically associated with CERCLA projects, in that the release is instantaneous and requires rapid response. There is little time to develop detailed study plans and subject them to extensive and time-consuming review processes. When emergency restoration activities are considered, both trustees and responsible parties must recognize that there is a substantial reliance on trust between the participants to ensure that the RP gets appropriate credit for the restoration and the trustees achieve reasonable activities towards the ultimate compensatory package. In this and other cases, the RP has been anxious to participate in the process in order to reduce its potential exposure for compensation by minimizing interim lost use. However, the inability of the government to formally approve such complex proposals has been a concern. The RP therefore is faced with proposing and launching a restoration project with uncertain outcome. This takes a particular amount of courage and fortitude within the RP corporate structure.

In the case of Whatcom Creek, the opportunity to affect restoration concurrently with response was obvious. The RP saw value in preparing an Emergency Restoration Plan that could be reviewed to the greatest extent possible by the trustees and other resource agencies with interest in the project. The benefits were obvious. The protocol for approving such expedited activities was unclear and with the typical approach of lengthy review could potentially jeopardize the successful completion of the project. As in most other cases, successful completion of the injury

Figure 3. Gravel bar creation.

assessment and restoration lies mainly on the collaborative attitude of the personnel involved on all sides. By focusing on the ultimate goal of minimizing impact to the environment and accelerating restoration, delays can be minimized.

The particular circumstances of the Whatcom Creek case allowed effective emergency restoration for salmonid resources. They are:

- Very few representatives of any lifestage of the more than four species of salmonids were present in this stream at the time of the incident. Most of the juvenile salmon had gone to sea in the prior weeks and spawning adults were not expected to return for 6-10 weeks.
- The water quality of the stream was remediated quite rapidly.
- The state water quality standards for gasoline residuals in Whatcom Creek waters were achieved within 148 hours following the incident (Challenger et al. 2001).
- The process of releasing gasoline entrained in the subsurface sediments required the presence of large heavy equipment in the streambed itself.
- The same equipment was also required to reconstruct the streambed. Due to the toxic nature of the gasoline contamination and the high temperatures experienced, there were very few biological resources that survived the incident. Thus, the issue of permitting such activities was made substantially easier as there was not a viable ecological system present to be disturbed by any instream work.
- CERCLA as well as OPA provides that permitting of emergency restoration be expedited. The State of Washington issued emergency hydraulic permits for the work considered. Consultation under Section 7 of the Endangered Species Act for salmonids was suspended for the purposes of this project.

It is unlikely that this project could have been undertaken within several years of its consideration had it not been for the particular circumstances associated with this incident. In this case the trustees and the RP understood and agreed that immediate actions could lead to substantial environmental benefits. Both groups worked cooperatively to affect restoration. The issue of how the RP would receive credit for the restorative and compensatory actions was to be determined in the future. For the RP to consider and approve the expenditure of a large amount of money for emergency measures to restore a resource without at least verbal approval of any compensatory credit by the trustees is a risky financial and political undertaking.

Biography

Mr. Mauseth is the President and a Principal of Polaris Applied Sciences, Incorporated with over 29 years experience as a marine biologist dealing with marine and aquatic environmental problems. He provides scientific support and project management for oil and chemical spill and ship grounding emergency response, and Natural Resource Damage Assessment under the Oil Pollution Act and worldwide. Gary has a B.A. in Biology from Whitman College and a M.S. Marine Science from the University of the Pacific, Pacific Marine Station.

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