LA-UR- 00-5651

Watersheds and Wildfires: A view of the Cerro Grande Fire

ABSTRACT

The Cerro Grande has been called the biggest fire in New Mexico history. The Cerro Grande blaze raged across the hillsides above Los Alamos National Laboratory (LANL), then, driven by high winds, the fire raced through the Laboratory and the Los Alamos town site. The fire destroyed 235 dwellings and left more than 400 families homeless. The human and environmental consequences of the fire are staggering.

The Cerro Grande fire burned about 43,000 acres of primarily ponderosa forest in northern New Mexico. Burn severity was high or moderate over 42% of the burned area, focused in the upper watersheds of the Pajarito Plateau. The presence of hydrophobic soils and nearly complete combustion of vegetation has altered the hydrologic characteristics and the water quality within these watersheds. Modeling demonstrated the potential for runoff to increase two to three orders of magnitude when compared to pre-fire flows.

LANL occupies 43 square miles in the approximate center of the Pajarito Plateau. Indian Pueblos, Cochiti Reservoir and the city of Albuquerque lie downstream of the Laboratory. Low levels of radionuclides bound to sediments are present in several of the canyons traversing LANL. Several nuclear facilities are present in the canyon bottoms. Rehabilitation efforts to minimize the impacts of the Cerro Grande fire ranged from contour felled trees and seeding to the construction of a ninety-foot high flood retention structure. The Laboratory is intensively monitoring runoff to evaluate post fire effects.

Fire Chronology and Extent

On May 4, 2000 a prescribed burn on Cerro Grande peak within Bandelier National Monument was intended to burn a 120-hectare meadow in the headwaters of Water Canyon and Canon de Valle. The prescribed burn was started at 8:00 p.m. in the evening and was declared a wildfire by 1:00 p.m. the following day. Relatively favorable weather conditions, backfires, and firebreaks held the fire to 4,300 acres in the first 6 days. However, winds on the seventh day pushed to fire to 20,000 acres and the town of Los Alamos was evacuated. The fire continued to burn on two fronts: to the north toward Santa Clara Pueblo and eastward through Los Alamos National Laboratory and onto San Ildefonso Pueblo. By May 14, the eleventh day, the fire progression was largely halted and it was burning only on the northern front. The fire was fully contained on June 6. The damage included the loss of an estimated 37 million trees, 235 residential structures, and 112 LANL structures.

The fire burned lands under the jurisdiction of many different entities including:

- National Park Service/Bandelier National Monument (2%)
- Department of Energy/Los Alamos National Laboratory (17%)
- US Forest Service/Santa Fe National Forest (60%)
- San Ildefonso Pueblo (1%)
- Santa Clara Pueblo (15%)
- Private/Los Alamos County (5%)

Predicted Hydrologic Impacts and Flood Protection Measures

Prediction of watershed response and flood potential were part of the BAER assessment for the Cerro Grande burned area. Two design storms were used: a 25-year, 1-hour and 100-year, 1-hour. LANL also developed a prediction of flood potential, using a more conservative design storm (100-year, 6-hour) as an extra measure of safety for designing flood protection for the nuclear facilities located in the canyons. In addition, the U.S Bureau of Reclamation developed breach hydrographs for canyons where existing structures or road crossings could act as temporary dams. The flow predictions, breach flow, and flood protection measures for critical canyons are described below.

Los Alamos Canyon:

Los Alamos Canyon was considered critical because it contained a dammed reservoir that could breach; LANL technical areas, including a decommissioned nuclear reactor; and radionuclides associated with sediments. These low levels of radionuclides are a legacy from past operational practices. The major highway into Los Alamos is located along the floor of Los Alamos Canyon and the small community of Totavi is located between the channel and the highway. The upper watershed of Los Alamos Canyon experienced 32% high intensity burn and 43% low intensity burn. Predicted storm water flows were 7,958 Liters/second (L/s) for the 25-year, 1-hour storm 61,794 L/s for the 100-year, 6-hour storm. A breach analysis for the reservoir predicted peak flow of 62,304 L/s. The flood protection measures implemented in Los Alamos Canyon were:

- Hardened the dam and emptied the reservoir;
- Evacuated TA-41 where the channel runs through a box culvert beneath a portion of the building;
- Removed nuclear reactor structures and contaminated sediments around the structures; and
- Built a low-head weir to trap radionuclides associated with sediments

Pueblo and Rendija Canyons:

Pueblo and Rendija canyons were considered critical because they provide access for the town of Los Alamos. Pueblo Canyon has a 24-m high fill structure beneath the only road across this canyon. This fill structure acts as a dam of questionable integrity. Additionally, the sewer system for the town of Los Alamos runs through the bottom of Pueblo Canyon to the wastewater treatment plant. Radionuclides, bound to sediments, that could be mobilized by increased flows, are present in Pueblo Canyon. The upper watersheds of Pueblo and Rendija canyons had 96% and 88%, respectively, high burn intensity and zero unburned area. Predicted storm flows from the 25-year, 1-hour event were 36,193 L/s in Pueblo and 67,911 L/s in Rendija. Predicted flow in Pueblo Canyon in response to the 100-year, 6-hour event was 92,776 L/s. Two breach scenarios were developed for the Pueblo Canyon fill structure. A seepage failure resulted in predicted peak flow of 254,880 L/s and an overtopping failure resulted in predicted peak flow of 1,028,016 L/s. The flood protection measures implemented in Pueblo Canyon included:

- Jacked a 2-m culvert through the fill structure to keep it drained.
- Installed debris catchers and non-plugging culverts throughout the upper watershed

Pajarito Canyon:

Pajarito Canyon contains a LANL technical area that is a nuclear criticality facility. Downstream, the canyon runs through the town of White Rock. Predicted storm flow in Pajarito Canyon in the 25-year, 1-hour event was 13,027 L/s and was predicted to be 38,846 L/s in the 100-year, 6-hour event. Breach analyses of three road crossings, assuming simultaneous failure predicted peak flow of 133,104 L/s. Flood protection measures implemented in Pajarito Canyon included:

- Construction of a 36-m high flood retention structure (21-m above ground) to maintain flow in canyon at 14,160 L/s
- Installation of sheet piling walls around the nuclear criticality facility
- Enlarging culverts in the town of White Rock

Fire Effects on Water Quality

LANL has a network of 53 gaging stations located on every major canyon, upstream and downstream of LANL and at most confluences. The stations are equipped with ultrasonic transducers that trip automated samplers to collect water samples from every flow event. The first automated sampling stations were installed in 1995 with the number of stations gradually increasing over the last five years. The higher flows predicted by the BAER assessment and LANL have been observed. One example is in Water Canyon where the pre-fire maximum flow in the past five years was 8 L/s. The peak flow during one storm event after the fire was 23,789 L/s. In the rainy season after the fire, 95 samples of stormwater runoff from about 15 precipitation events have been collected and analyzed for volatile organics, semi-volatile organics, PCBs, high explosives, metals, radionuclides, and general inorganics. Based on the analytical data received so far, four observations about post-fire runoff water quality can be made.

One observation is that no high explosives, mercury, dioxins, furans, benzo(a)pyrene, hexachlorobenzene, or PCBs have been detected. Overall few organic chemicals are present in the stormwater runoff. A second observation is that metals and minerals are elevated over pre-fire conditions. The third observation is that radioactivity dissolved in stormwater runoff is comparable to pre-fire runoff. However, the radioactivity that is present in the sediment within the runoff is elevated compared to pre-fire samples. The average cesium-137 activity in runoff sediment from stations along the Santa Fe National Forest/LANL boundary was about 0.9 pCi/g between 1996-1999. After the fire, samples of runoff sediments contained 4.5 - 9.7 pCi/g of cesium-137. The location of these sampling stations upstream of LANL indicates that the increased cesium-137 is from burning of vegetation and resultant concentration of cesium in the ash.

Finally, the fourth observation is the detection of cyanide in stormwater runoff. Cyanide had not been detected in stormwater prior to the fire. There are two potential sources of cyanide, one is the fire retardant used in fighting the fire and the second is formation of cyanide during natural combustion. Based on the data collected at LANL, the cyanide is from both sources and the relative contribution of each has not been determined. The runoff samples have been analyzed for both total and amenable cyanide. The risk from cyanide appears to be low as the stream standard for amenable cyanide was exceeded in only one sample and there were no acute effects on fathead minnows and daphnia when exposed to samples of the runoff. The trend in cyanide concentration appeared to be declining as samples were collected through the rainy season.

Keywords: Cerro Grande fire, Pajarito Plateau, surface water hydrology, water quality

Citation: Mullen, K.I. 2000. Watershed and Wildfires: A view of the Cerro Grande Fire. *in* L.A. Brennan, et. al. (eds.) National Congress on Fire Ecology, Prevention, and Management Proceedings, No. 1. Tall Timbers Research Station, Tallahassee, FL.