ASSESSMENT OF POTENTIAL RISKS FROM ENHANCED SURFACE WATER RUNOFF IN CY2001 DUE TO THE CERRO GRANDE FIRE

Interagency Flood Risk Assessment Team
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Introduction

The Cerro Grande fire near Los Alamos, New Mexico, USA destroyed vegetation and burned soil in the area, which directly increased the potential for flooding in Los Alamos area canyons. These floods may transport contaminants and chemicals (including radionuclides) from LANL sites, the town of Los Alamos, and burned areas to potential receptors down the watershed. The purpose of the risk assessment done by the Interagency Flood Risk Assessment Team (IFRAT) is to characterize potential risk to the public associated with contaminants transported by flooding in the aftermath of the fire.

The model used for this risk assessment estimates potential risks to people exposed to concentrations of chemicals and radionuclides measured in ash, sediment, groundwater, storm water, and surface water. Sampling and analysis of surface water (including storm water), groundwater, sediment, soils, and fish in the areas that might be affected by floods in the Los Alamos/Pueblo watershed, the Rio Grande, and Cochiti Reservoir were conducted from June 2000 to October 2001 by numerous agencies. The IFRAT estimated two types of potential health impacts from exposure to these chemicals and radionuclides. These were risks of increased cancer incidence, given as a probability, and the potential of non-cancer health effects, expressed as a hazard index.

The assessment for year 2000 sampling data indicated little additional risk compared to conditions before the fire. However there was an increase in the potential for non-cancer effects from exposure to burned material moved through the canyons by floods. The same risk assessment has been completed using the sampling results from the summer and fall of 2001 to see if there have been changes in the potential risk and hazard over time

Details and Results of year 2001 Analysis

Residential, recreational, and irrigation exposure scenarios were developed for post-fire exposure to soil, sediment, and water that contain elevated concentrations of metals, radionuclides, and organic chemicals. The scenarios are summarized in the technical summary document “IFRAT Risk Model: Purpose, Construction and Results” available on the IFRAT website (http://www.nmenv.state.nm.us/IFRAT/index.html). The resident scenario estimates potential risk associated with a 30-year exposure to soil, sediment and water. The resident was located in Lower Los Alamos Canyon in the area directly downstream of possible post-fire effects. The Los Alamos/Pueblo Canyon watershed (which includes the Los Alamos, Pueblo, Guaje, and Rendija canyon basins) was also one of the drainages most severely burned during the Cerro Grande fire. The irrigation scenario looks at risks from consumption of crops irrigated with river water containing material moved by floods as well as potential risks to the farmers irrigating the fields. The recreational scenario incorporates exposures through incidental swallowing of water and skin contact with water while swimming as well as eating fish from Cochiti Reservoir.

To evaluate potential risks from chemicals and radionuclides in floodwaters and in sediments deposited on canyon floodplains during floods, the maximum concentrations from the entire summer and fall data sets for each year were used in the risk assessment for that year. The sediment sampling results used to estimate the potential risks for 2001 came primarily from sediments that were deposited by floodwaters during the July 2nd rainstorm. The flooding from this storm was the largest seen in Los Alamos Canyon and Pueblo Canyon since the Cerro Grande fire, and was focused primarily in Pueblo Canyon. The water sampling results used to estimate the potential risks for 2001 were collected during sampling during a number of other floods in July, August, and September of 2001. Table 1 presents the maximum concentrations of inorganic chemicals and radionuclides detected in deposited sediment, shallow groundwater, surface water, and fish tissue during the 2001 sampling season.

Table 1. Maximum concentrations detected during 2001 sampling season

2001 Maximum concentration					
Compound	Sediment (mg/kg)	Canyon max unfiltered storm water (mg/L)	Unfiltered Rio Grande water (mg/L)	Filtered Alluvial Ground water (mg/L)	Fish tissue (mg/kg wet weight) game and bottom
Inorganic					
aluminum	8590	1040	0.0258	ND[1]	ND[1]
antimony	ND[1]	0.0018	0.0019	ND[1]	ND[1]
arsenic	2.1	0.140	0.002	0.0061	ND[1]
barium	162	20	0.0982	0.32	0.68
beryllium	0.91	0.123	0.00099	ND[1]	ND[1]
boron	NA[2]	0.210	0.0346	ND[1]	ND[1]
cadmium	0.27	0.024	0.000072	ND[1]	ND[1]
chromium (total)	5.4	0.487	ND[1]	0.0013	ND[1]
cobalt	4.3	0.386	ND[1]	0.0013	ND[1]
copper	11	0.793	ND[1]	0.0053	ND[1]
cyanide	NA[2]	0.000028	ND[1]	ND[1]	ND[1]
iron	10,500	637	0.0113	ND[1]	ND[1]
manganese	722	76	0.0019	0.0002	ND[1]
mercury	0.05	0.0017	ND[1]	ND[1]	0.76
nickel	7	0.739	ND[1]	0.0036	ND[1]

2001 Maximum concentration					
Compound	Sediment (mg/kg)	Canyon max unfiltered storm water (mg/L)	Unfiltered Rio Grande water (mg/L)	Filtered Alluvial Ground water (mg/L)	Fish tissue (mg/kg wet weight) game and bottom
nitrate	NA[2]	NA[2]	0.00039	ND[1]	ND[1]
selenium	0.53	0.0345	0.0013	ND[1]	ND[1]
silver	0.29	0.307	ND[1]	ND[1]	ND[1]
thallium	ND[1]	0.010	0.00018	0.0025	ND[1]
uranium (total)	NA[2]	0.137	0.0075	ND[1]	0.006
vanadium	11.5	0.631	0.0063	0.0084	ND[1]
zinc	53.3	3.29	0.0096	0.018	ND[1]
radionuclides	**pCi/g**	**pCi/L**	**pCi/L**	**pCi/L**	**pCi/g dry**
Americum-241	0.22	10	0.135	ND[1]	8.1E-04
Cesium-134	0.11	ND[1]	ND[1]	ND[1]	ND[1]
Cesium-137	1.88	65	ND[1]	ND[1]	4.8E-02
Cobalt-60	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
Europium-152	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
Plutonium-238	ND[1]	2	0.00293	ND[1]	1.2E-03
Plutonium-239	1.32	253	0.00846	ND[1]	5.0E-04
Ruthenium-106	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
Sodium-22	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
Strontium-90	0.689	25	0.449	ND[1]	4.5E-02
Thorium-228	2.28	467	0.184	ND[1]	ND[1]
Thorium-230	2.29	322	0.156	ND[1]	ND[1]
Thorium-232	2.33	391	0.278	ND[1]	ND[1]
Tritium	NA[2]	NA[2]	ND[1]	ND[1]	ND[1]
Uranium-234	2.59	354	0.198	5.25	5.8E-03
Uranium-235	0.2	15	0.0219	0.199	1.6E-03
Uranium-238	2.29	334	0.163	3.64	4.1E-03

[1] not detected in samples
[2] samples not analyzed for this compound

Most chemicals and radionuclides were detected at lower concentrations in the year 2001 samples of the deposited sediment and shallow ground water than in the year 2000 samples. Higher concentrations of some chemicals and radionuclides were found in unfiltered storm water samples because more sediment was carried by storm water in 2002. Slightly increased concentrations of cadmium and mercury were detected in deposited sediment samples in lower Los Alamos canyon; but the values were still at or below background values (0.4 mg/kg and 0.1 mg/kg, respectively). Selenium concentrations in 2001 sediment samples were above both background (0.3 mg/kg) and year 2000 concentrations. Because concentrations of other chemicals and radionuclides in these media decreased from 2000 to 2001, the total potential radiological and chemical risks for 2001 decreased for the resident scenario (Table 2). The potential for non-cancer effects (the hazard index) also decreased for the resident scenario (Table 2). Potential risk and non-cancer hazard in the irrigation scenario remained essentially the same for 2001 as they were for pre-fire and summer 2000. Potential recreational risk from radionuclides and potential non-cancer effects from recreational decreased from 2000 to 2001. Chemical risk from recreational use in 2001 (attributable to arsenic detections in water used in the swimming scenario) was 1 in 1,000,000, which is considered a negligible level of excess risk.

Table 2. Summary of risk results for the IFRAT exposure scenarios

Scenario	**Radiological risk**		**Chemical risk**		**Chemical hazard index (child)[d]**	
	2000	**2001**	**2000**	**2001**	**2000**	**2001**
Irrigation - background only	6E-04[a]	6E-04	3E-03	3E-03	45	45
Irrigation	6E-04	6E-04	3E-03	3E-03	46	46
Resident[b] - background only	7E-04	7E-04	3E-03	3E-03	58	58
Resident[b] - pre-fire	6E-04	6E-04	2E-03	2E-03	46	46
Resident[b] - post-fire	7E-04	6E-04	3E-03	2E-03	66	51
Recreational	5E-06	4E-06	0[c]	1E-06	6	5

[a] 1E-03 represents 1 chance in 1,000 of incurring a cancer over a lifetime; 1E-04 represents 1 chance in 10,000; 1E-05 represents 1 chance in 100,000; and 1E-06 represents 1 chance in 1,000,000
[b] exposure scenario for a resident equals 6 years' exposure as a child plus 24 years' exposure as an adult
[c] no chemical carcinogens were detected in Rio Grande or Cochiti fish in 2000
[d] children have a higher potential than adults for exposure leading to non-cancer effects

The risk assessment of calendar year 2000 floods identified a number of chemicals and radionuclides as substantially contributing to the potential risks and hazards of exposure to materials moved through flooding. Key contributors to potential cancer risk both pre- and post-fire included strontium-90, thorium-228, cesium-137, arsenic, and chromium (VI). Primary contributors to the potential non-cancer effects (hazard index) were manganese and arsenic. These patterns also occurred in 2001 for both the resident and irrigation scenarios. Much of the potential exposure to these chemicals and radionuclides in the model occurred as result of uptake through plants grown in ash and sediment containing soil and subsequently consumed by people. This led to the recommendation that people avoid adding sediment and ash transported by the flood to their gardens. The irrigation scenario did not show similar elevated risk in either year for crops irrigated with water that may have some of this material in it. Recreational radiological risk and chemical hazard were unchanged from 2000 to 2001. No chemical carcinogens were detected in Rio Grande water or Cochiti fish in 2000, but 2001 sampling data for the Rio Grande contained detections of low concentrations of the chemical carcinogen arsenic which generated a negligible excess risk associated with swimming in this water.

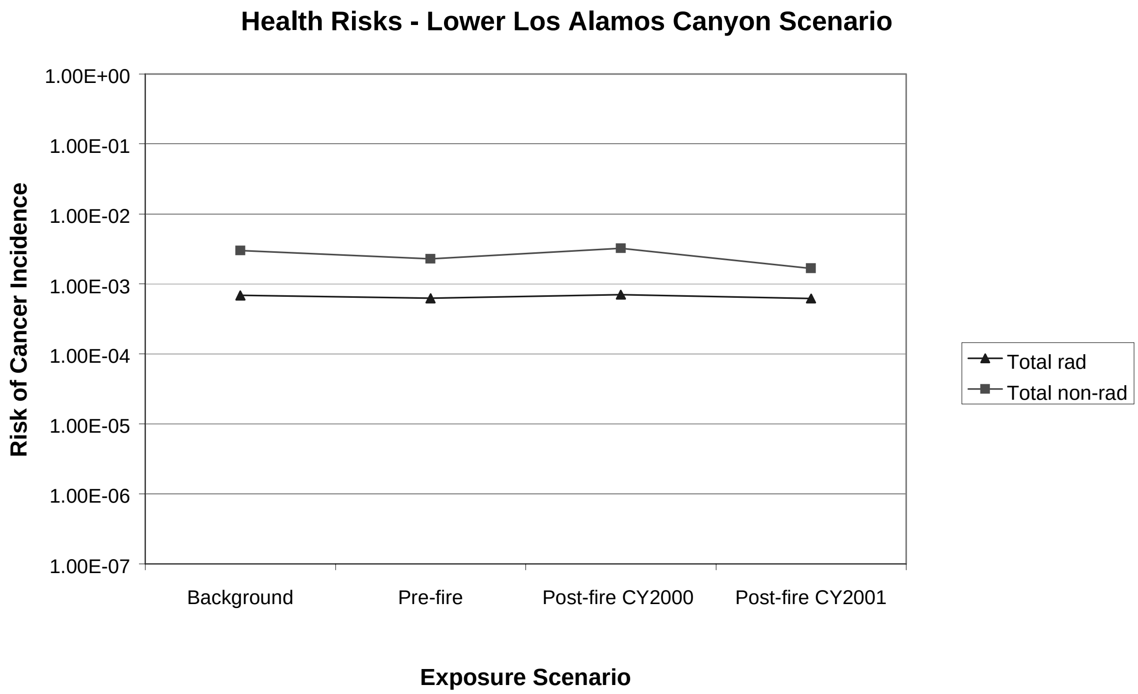
The potential risk and hazard numbers in Table 2 are presented in the graphs at the end of this document. The total risk and hazard index estimates for the scenarios for exposure to background and pre-fire concentrations as well as potential risk and hazard for exposure to concentrations seen in the summer and fall of 2000 and 2001 are shown. Additional graphs show the incremental changes in risk and hazard from one year to the next. Estimates of potential radiological risk, chemical risk, and chemical hazard in the irrigation scenario remain essentially unchanged from pre-fire conditions through one and two years post-fire. Estimates of potential radiological risk, chemical risk, and chemical hazard in the resident scenario have decreased from 2000 to 2001.

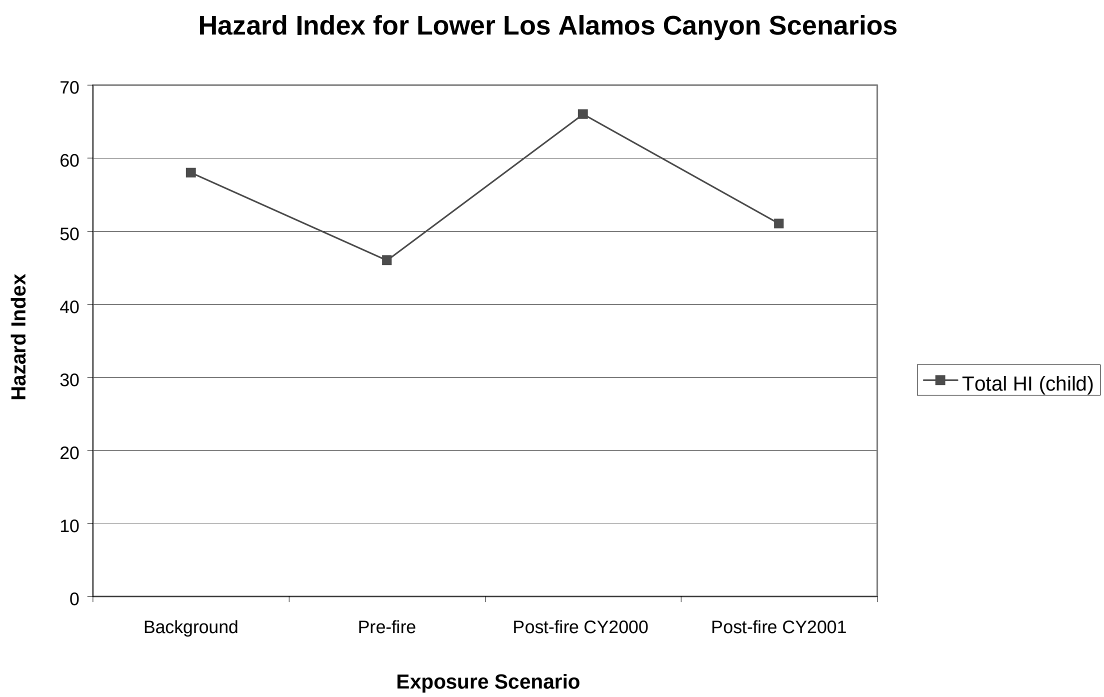
The changes seen from 2000 to 2001 in the concentrations of chemicals and radionuclides may reflect changing conditions in the Los Alamos/Pueblo watershed or the effects of floods on the system. The sediment data reflects potential exposure within the Los Alamos and Pueblo canyons, which is the canyon system most heavily impacted by the Cerro Grande fire. The results of calculations using Rio Grande water for the irrigation scenario, as well as calculations for the recreational and fish consumption scenarios reflect concentrations resulting from storm effects across all the canyons draining the Los Alamos National Laboratory and areas outside of the Laboratory.

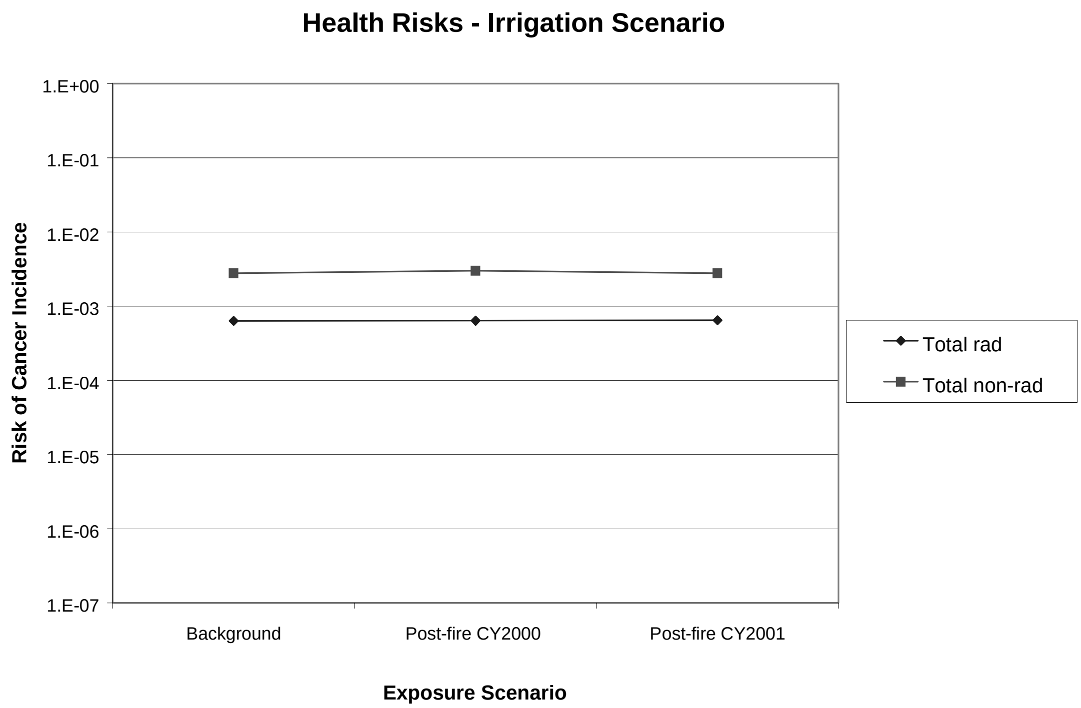
The updated IFRAT risk assessment uses actual sampling concentrations to model estimates of risk to the public. An independent risk assessment concurrently conducted by the Risk Assessment Corporation (RAC) assesses potential risk from storm runoff and movement of materials by calculating estimates of potential concentrations in runoff from a mathematical model of the flooding and release sites. RAC uses those modeled numbers to calculate estimates of risk of potential future exposures. Because one study assesses potential long-term risk using currently measured concentrations in sediment and water and the other study calculates potential concentrations in sediment and water from which potential risks are estimated, the results of the two models are not directly comparable. However, the data used in the IFRAT risk assessment has been provided to RAC.

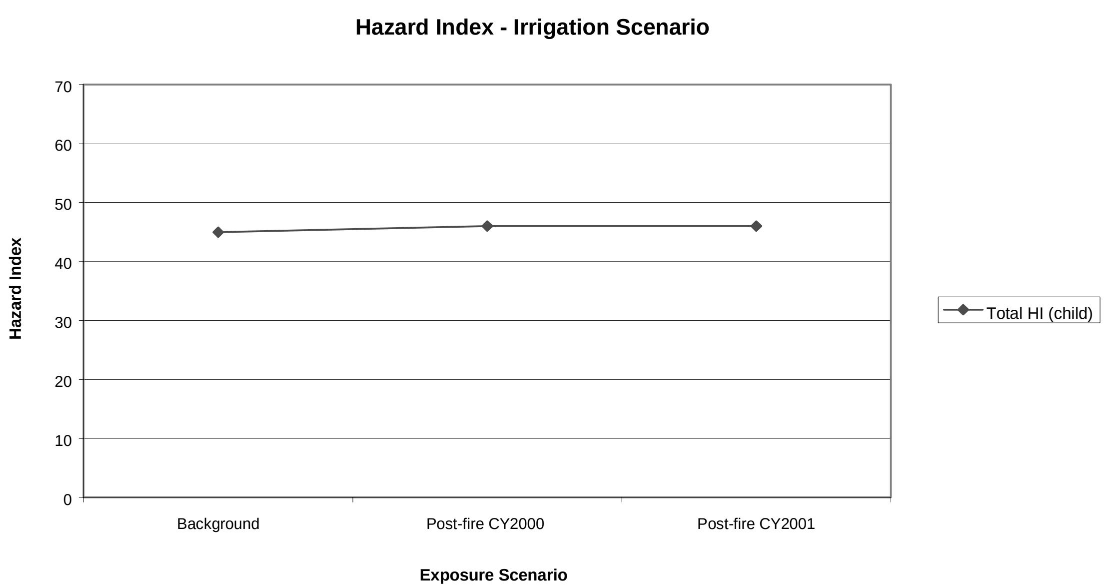
Conclusions

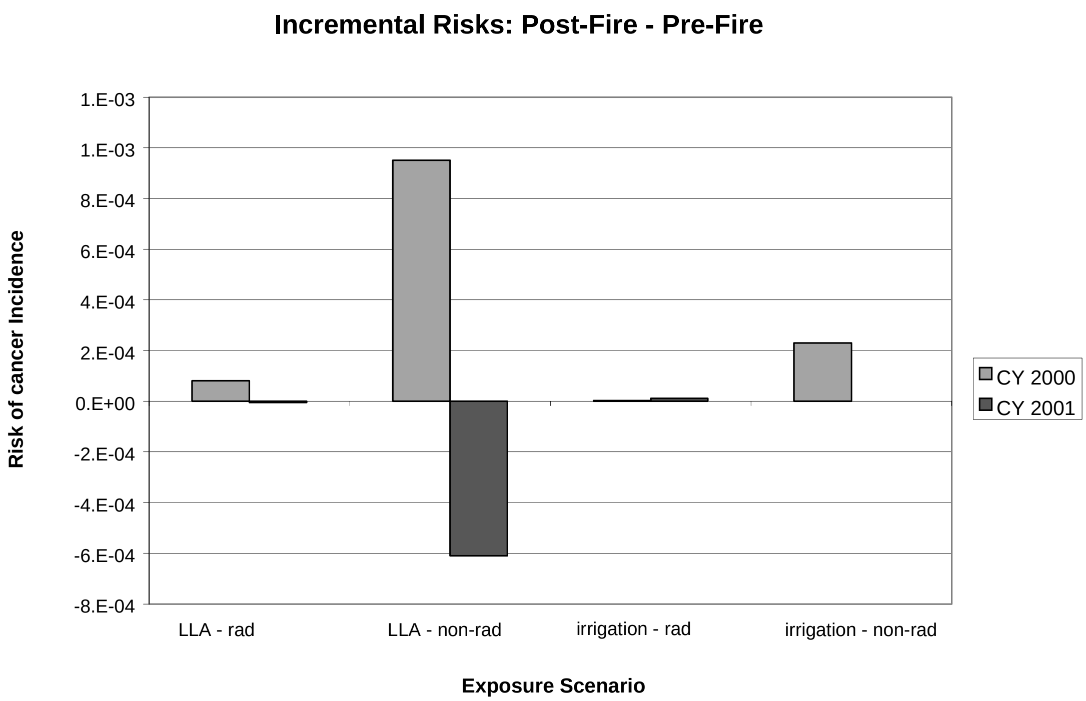
There were changes in the concentrations of chemicals and radionuclides from pre-fire to 2000 and from 2000 to 2001. Two years of data show some changes in concentration in sediment and water, but little change in potential risk and hazard associated with exposure to material in water and deposited with sediment by floods. The first two years of post-fire sampling indicate that potential risks and hazard remain essentially similar to pre-fire levels. Recommendations remain the same as presented at the July 2001 public meeting to avoid use of ash as an amendment in home gardens. Monitoring efforts will continue in 2002 to assess any potential changes and impacts from flooding related to the Cerro Grande fire.

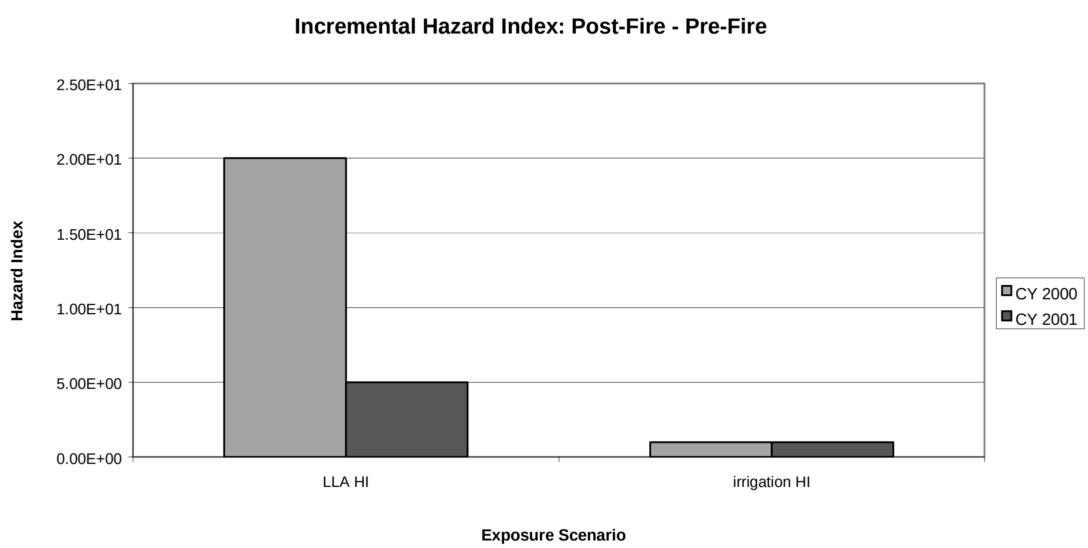

Health Risks - Lower Los Alamos Canyon Scenario
Risk of Cancer Incidence
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
Background
Pre-fire
Post-fire CY2000
Post-fire CY2001
Exposure Scenario
Total rad
Total non-rad


Hazard Index for Lower Los Alamos Canyon Scenarios
Hazard Index
70
60
50
40
30
20
10
0
Background
Pre-fire
Post-fire CY2000
Post-fire CY2001
Exposure Scenario
Total HI (child)


Health Risks - Irrigation Scenario
Risk of Cancer Incidence
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Background
Post-fire CY2000
Post-fire CY2001
Exposure Scenario
Total rad
Total non-rad


Hazard Index - Irrigation Scenario
Hazard Index
70
60
50
40
30
20
10
0
Background
Post-fire CY2000
Post-fire CY2001
Exposure Scenario
Total HI (child)


Incremental Risks: Post-Fire - Pre-Fire
Risk of cancer Incidence
1.E-03
1.E-03
8.E-04
6.E-04
4.E-04
2.E-04
0.E+00
-2.E-04
-4.E-04
-6.E-04
-8.E-04
LLA - rad
LLA - non-rad
irrigation - rad
irrigation - non-rad
Exposure Scenario
CY 2000
CY 2001


Incremental Hazard Index: Post-Fire - Pre-Fire
Hazard Index
2.50E+01
2.00E+01
1.50E+01
1.00E+01
5.00E+00
0.00E+00
LLA HI
irrigation HI
Exposure Scenario
CY 2000
CY 2001