

HEALTH CONSULTATION

Evaluation of Potential Cancer Risk From Exposure to Gypsum at the A-4 Gypsum Pond

Bunker Hill Mining and Metallurgical Complex
Smelterville, Shoshone County, Idaho

EPA FACILITY ID: IDD048340921

Prepared by:

Bureau of Community and Environmental Health
Division of Health
Idaho Department of Health and Welfare
Under Cooperative Agreement with the
U.S. Agency for Toxic Substances and Disease Registry

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ACRONYMS

- ATSDR Agency for Toxic Substances and Disease Registry
- BCEH Bureau of Community and Environmental Health
- CDRI Cancer Data Registry of Idaho
- CIA Central Impoundment Area
- EPA Environmental Protection Agency
- IDEQ Idaho Department of Environmental Quality
- PHD Panhandle District Health Department

PURPOSE, BACKGROUND AND STATEMENT OF ISSUES

Purpose and Statement of Issues

In spring 2000, the Cancer Data Registry of Idaho (CDRI) received an inquiry from a physician in Kellogg, Idaho about the incidence of brain cancer in the Kellogg community. In June 2000, CDRI sent a letter to the physician informing him there was not an increased rate of brain cancer. CDRI stated they would perform a periodic review of brain cancer and would request local cancer registrars immediately report new brain cancer cases in the area to CDRI (called rapid case ascertainment). In January 2001, CDRI reanalyzed the data based on a newly diagnosed case, and found that an area of Kellogg did have a statistically significant elevated rate of brain cancer. The area of focus was defined as a census block group located in Kellogg; bounded by I-90, South Division Street, McKinley Avenue, and the East Smeltonville Loop. There were three cases of brain cancer diagnosed among residents of the block group from 1990-2000 with only zero to one case expected based upon rates in Idaho. A survey of the three cancer cases and two others who resided outside the area of focus but worked in the area, found no common factor or exposure that linked the cases (CAWG 2001). An additional case of brain cancer was identified after CDRI completed the survey.

In August 2001, the Administrator of Joint School District Number 391 contacted CDRI with a concern about cancer cases among school employees at Kellogg Middle School and Kellogg High School. CDRI data showed information about five cases of cancer diagnosed among approximately 83 employees of the Kellogg Middle and High Schools since 1996. There were two cases of primary brain cancer and one case each of leukemia, meningioma, and adenocarcinoma (uncertain primary site). The two cases of brain cancer were previously identified in the above investigation. The distribution of cancer by site was different from the overall Idaho distribution for the age group 20-59. The more commonly seen cancers for this age group include breast, prostate, melanoma and lung cancers. When CDRI investigated known or suspected risk factors for the four types of cancer (brain, leukemia, meningioma, and adenocarcinoma), radiation exposure was the only known risk factor identified (Johnson 2001).

CDRI contacted the Panhandle District Health Department (PHD) about the existence of past or current radiation sources in the Kellogg area. The only possible source of radiation identified was gypsum. The material was found in gypsum ponds which were produced to store the waste by-product of manufacturing of phosphoric acid at the Bunker Hill site. All of the ponds contained similar gypsum materials. Samples were taken from the A-4 Gypsum Pond in October 2001 because it was the easiest location to sample. The following discussion focuses on the results of the sample analysis and the A-4 Gypsum Pond.

The Bureau of Community and Environmental Health (BCEH)-formerly known as the Bureau of Environmental Health and Safety, Division of Health, Idaho Department of Health and Welfare, the Idaho Department of Environmental Quality (IDEQ), PHD, and the CDRI worked collectively to determine the appropriate sampling and analysis of the A-4 Gypsum Pond. As part of BCEH's cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), BCEH conducted this health consultation to evaluate the health risk to the surrounding community from radionuclides in the A-4 Gypsum Pond.

Site Description

The Bunker Hill Mining and Metallurgical site (Bunker Hill site) is located in the Silver Valley within the Coeur d' Alene River Basin. For nearly 100 years, most of the mines in the Coeur d' Alene Mining District, as well as the Bunker Hill smelter, discharged liquid and solid waste directly into the South Fork of the Coeur d'Alene River and its tributaries.

In 1916, the Lead Smelter was constructed and the blast furnace began operation in July 1917. Prior to this time, the local ore concentrates were shipped off site. In the late 1930s, an electrolytic antimony plant was built and a slag fuming plant was installed a few years later for zinc recovery. These processes continued in much the same manner until the 1980s. In 1928, an electrolytic zinc plant began operation. It was the first commercial refinery in the United States to produce zinc of 99.9+ purity. Over the years, the plant grew in capacity. Two sulfuric acid plants were added to the zinc facilities in 1954 and 1966. The Phosphoric Acid/Fertilizer Plant was built in 1960. Phosphate rock was delivered via rail from southern Idaho and Wyoming. The primary products from this plant were phosphoric acid and pellet-type fertilizers of varying mixtures of nitrogen and phosphorus. Phosphate rock, anhydrous ammonia, and sulfuric acid were the chief raw materials used to produce the phosphoric acid and fertilizer. The gypsum, a waste-by-product of phosphoric acid production, was disposed of in impoundments in Magnet Gulch (Gypsum Pond A-1), near the mouth of Magnet Gulch between old Highway 10 and the [Central Impoundment Area] CIA (Gypsum Pond A-4), and finally on the middle cell of the CIA (Gypsum Pond A-5). Gypsum Pond A-1 was built in 1960 and abandoned in 1964; Pond A-4 was built in 1964 and abandoned in 1970 when gypsum was directed to the CIA (Dames & Moore 1991). The chemical nature of the gypsum deposited in Gypsum Pond A-4 is calcium sulfate and the gypsum pond contains radioactive materials, including uranium and radium (McCulley 1994). See Appendix A for maps of the site.

The A-4 Gypsum Pond covers approximately 13.5 acres. The impoundment extends approximately 1,600 feet from east to west and approximately 550 feet from north to south. The gypsum is contained on the north by a constructed embankment and on the south by a road. The Remedial Investigation indicated that the pond is approximately 37 feet deep. It is estimated that the volume of gypsum in the A-4 facility is 485,000 cubic yards. A thin layer of mine waste rock covers the pond as a protective cap.

DISCUSSION

Environmental Sampling Analysis

Six gypsum samples were collected by IDEQ and analyzed by Idaho State University for gamma-ray emitting radionuclides in the range from 88 to 2000 keV (kiloelectron volt) of gamma-ray energy. The radionuclides identified are listed in Table 1 including their concentrations using the risk assessment method developed by the US Environmental Protection Agency (EPA 1991) and their uncertainties expressed as two estimated standard deviations. The

average crust and soil concentrations of these radionuclides (Eisenbud and Gesell 1997) are also listed in Table 1 for comparison.

Table 1. Gamma-ray analysis for six phosphogypsum samples compared to the average natural concentrations (pCi/g)

Samples	Potassium 40		Lead 212		Actinium 228		Bismuth 214		Lead 214		Radium 226		Uranium 235	
	Value	2 s	Value	2 s	Value	2 s	Value	2 s	Value	2 s	Value	2 s	Value	2 s
A4-1 I	4.86	0.33	0.35	0.03	0.34	0.04	12.62	0.33	13.25	0.63	15.9	1.13	nd	
A4-1 II	4.24	0.29	0.30	0.03	0.29	0.03	9.43	0.26	9.85	0.47	17.53	1.22	nd	
A4-5 I	1.45	0.16	0.13	0.01	0.15	0.03	15.54	0.35	15.98	0.61	22.79	1.41	nd	
A4-5 II	1.77	0.18	0.15	0.02	0.13	0.02	13.03	0.35	13.67	0.65	21.33	1.49	nd	
A4-6 I	3.56	0.25	0.24	0.02	0.19	0.02	15.44	0.41	16.27	0.77	18.17	2.15	nd	
A4-6 II	3.20	0.22	0.22	0.02	0.23	0.03	13.15	0.30	13.71	0.52	20.43	1.28	0.15	0.10
Natural Crust*	23		1.2		1.2		1.0		1.0		1.0		0.04	
Natural Soil*	10		1.0		1.0		0.6		0.6		0.6		0.03	

2 s: two estimated standard deviations;

nd: not detected

* Data from Environmental Radioactivity from Natural, Industrial, and Military Sources, 4th edition, Academic Press 1997 (Eisenbud and Gesell 1997).

The radionuclides identified with concentrations higher than the average crustal and soil concentration include bismuth 214 (Bi 214), lead 214 (Pb 214), radium 226 (Ra 226), and uranium 235 (U 235).

Ra 226 and its decay products Bi 214 and Pb 214 are gamma-ray emitting radionuclides of the uranium 238 (U 238) chain and are expected to be in radioactive equilibrium under the analytical conditions used. These are elevated by a factor of 10 to 15 from natural concentrations. The Bi 214 and Pb 214 are actually better measures of Ra 226 than the direct measurement of Ra 226 because the gamma-ray yield of Ra 226 itself is quite small and of low energy.

U 235 was undetectable in 5 of the 6 samples and the one detection is accompanied by a fairly large uncertainty.

Exposure Pathway

In the past, the A-4 Gypsum Pond had the potential to result in airborne emissions to the public and workers at the site. The pond is located within a half mile of the site project office and the Kellogg Middle School and High School. It is also located within one mile of residential areas. A 1994 report (McCulley 1994) showed that the pond had a protective cap of a thin layer of mine waste rock. In 1996, approximately six inches of clean dirt was placed over the top of the pond

(Hanson 2002). It is not clear if the thin layer of mine waste rock was in place prior to the 1994 report. While relatively stable if left undisturbed, the gypsum in the pond can be resuspended into the air if the crust of the pond is disturbed by construction or other activities. Anecdotal information indicates that precipitation causes the gypsum to form a hard crust on the uppermost layers that stays intact unless disturbed. It is possible that the crust may have been disturbed in the past, especially during the years (1964 to 1970) when the plant was actively pumping gypsum into the pond.

Public Health Implications

The gypsum pond contains radioactive materials, including uranium and radium. Uranium and radium are found naturally in small amounts in rock, soil, water, and air. These two elements may become concentrated in soils as the result of mining activities. Radium and uranium are naturally occurring radioactive metals that can exist in several forms called isotopes. Radium 226 releases its radiation at a very slow rate (known as its half life). The half-life of radium 226 is 1,600 years. Radium can enter the body when it is breathed in or swallowed. It is not known if it can be taken in through the skin. If you breathe radium into your lungs, some may remain there for months; but it will gradually enter the blood stream and be carried to all parts of the body, especially the bones. Very small amounts leave the body daily through the feces and urine. There is no clear evidence that long-term exposure to radium at the levels that are normally present in the environment (for example, 1 pCi of radium per gram of soil) is likely to result in harmful health effects. However, exposure to higher levels of radium over a long period of time may result in adverse health effects such as anemia, cataracts, fractured teeth, cancer and death. In general, the greater the total amount of your exposure to radium, the more likely you are to develop one of these diseases (ATSDR 1990).

Uranium naturally occurs in rocks, soil, water, plants, and animals. Once rocks are mined for uranium, it is extracted and chemically converted to more useable forms such as uranium dioxide. Natural uranium is composed of three isotopes, uranium 234, uranium 235 and uranium 238. Uranium 235 is present at less than 1% in naturally occurring uranium. The half life of uranium 235 is approximately 70,000,000 years. Human health effects associated with exposure to uranium are not well understood for naturally occurring uranium, although evidence of kidney effects was seen in people who work in uranium mines. There is evidence that uranium can cause lung cancer and uranium has been weakly associated with sarcoma (ATSDR 1999).

The A-4 Gypsum Pond contains uranium and radium which are radioactive elements that undergo a decay process. When these elements decay, they release radiation and create new elements, or daughter products. These daughter products are part of the decay chain and will continue to decay until a stable element is created. Bismuth 214 and lead 214 are radium 226 decay chain members. The main contributors to the theoretical risk from radionuclide sources in the gypsum pond are radium 226 and uranium 235. When estimating cancer risk, a conservative slope factor was used that incorporated the decay or daughter products. Thus, the dose contributed by the daughter products in addition to the parent products was incorporated. The theoretical estimated cancer risks (Fromm 2003) to the residential population are:

$$\begin{aligned} \text{Radium 226 risk level} &= 1.326 \times 10^{-7} \\ \text{Uranium 235 risk level} &= 7.099 \times 10^{-10} \\ \text{Total Cancer Risk} &= 1.333 \times 10^{-7} \end{aligned}$$

There are many uncertainties associated with the theoretical cancer risk calculations. In general, BCEH made very conservative or cautious assumptions whenever possible to insure the risk was not underestimated. For example, the highest levels of radiation detected were used to calculate the cancer risk; BCEH assumed nearby residents were exposed to gypsum for approximately 30 years; and it was assumed that the residents were located at the center of the pond where the concentrations were expected to be highest (Note: No one resides on the pond. There are no plans to permit the construction of homes or businesses on the ponds. BCEH assumed people resided on the pond only to determine if there was a theoretical health risk in a worst case scenario). Risk was evaluated using the soil ingestion and the inhalation exposure routes. When site-specific information was not available, conservative default parameters were used (Fromm 2001, Fromm 2003).

BCEH's total theoretical cancer risk assessment for the residential population, if they reside on the pond, exposed to the A-4 Gypsum Pond is 1.333×10^{-7} . This means that the chance of getting cancer from exposure to the gypsum in the Kellogg area is approximately one in ten million. Based on BCEH's cancer risk assessment, an increased cancer rate is not expected from exposure to the radioactive gypsum in the Kellogg area. Because no one resides or visits on a regular basis, the theoretical risk is actually significantly (orders of magnitude) lower than what is present above.

ATSDR Child Health Considerations

ATSDR and BCEH recognize the unique vulnerabilities of infants and children to environmental contaminants. Children are less developed and may experience developmental harm from exposure that would not be experienced by a completely developed adult. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

No information was found to suggest that children would be at risk from unusually high exposures to gypsum found in the A-4 Gypsum Pond in Kellogg, Idaho. Therefore, children are not considered to be at greater risk than adults in the area.

CONCLUSIONS AND RECOMMENDATIONS

Based on BCEH's cancer risk assessment, an increased cancer rate is not expected from exposure to the radioactive gypsum in the Kellogg area. According to ATSDR's Interim Public Health Hazard Categories (see Appendix B), BCEH has determined gypsum from the A-4 Gypsum Pond in Kellogg, Idaho to be a No Apparent Public Health Hazard. BCEH has no recommendations at this time.

PUBLIC HEALTH ACTION PLAN

The CDRI sent a follow-up letter to the Joint School District Number 391 Administrator to provide information about the investigation, and the results of the sampling analysis (see Appendix C).

BCEH and the CDRI will periodically review cancer incidence for the Kellogg Middle and High Schools.

REFERENCES

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Certification:

The Idaho Bureau of Community and Environmental Health prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.


Technical Project Officer, CAT, SSAB, DHAC

The Superfund Site Assessment Branch (SSAB), Division of Health Assessment and Consultation (DHAC), ATSDR has reviewed this health consultation and concurs with its findings.

 G. RE
Team Leader, CAT, SSAB, DHAC, ATSDR

Appendix A

Site Map

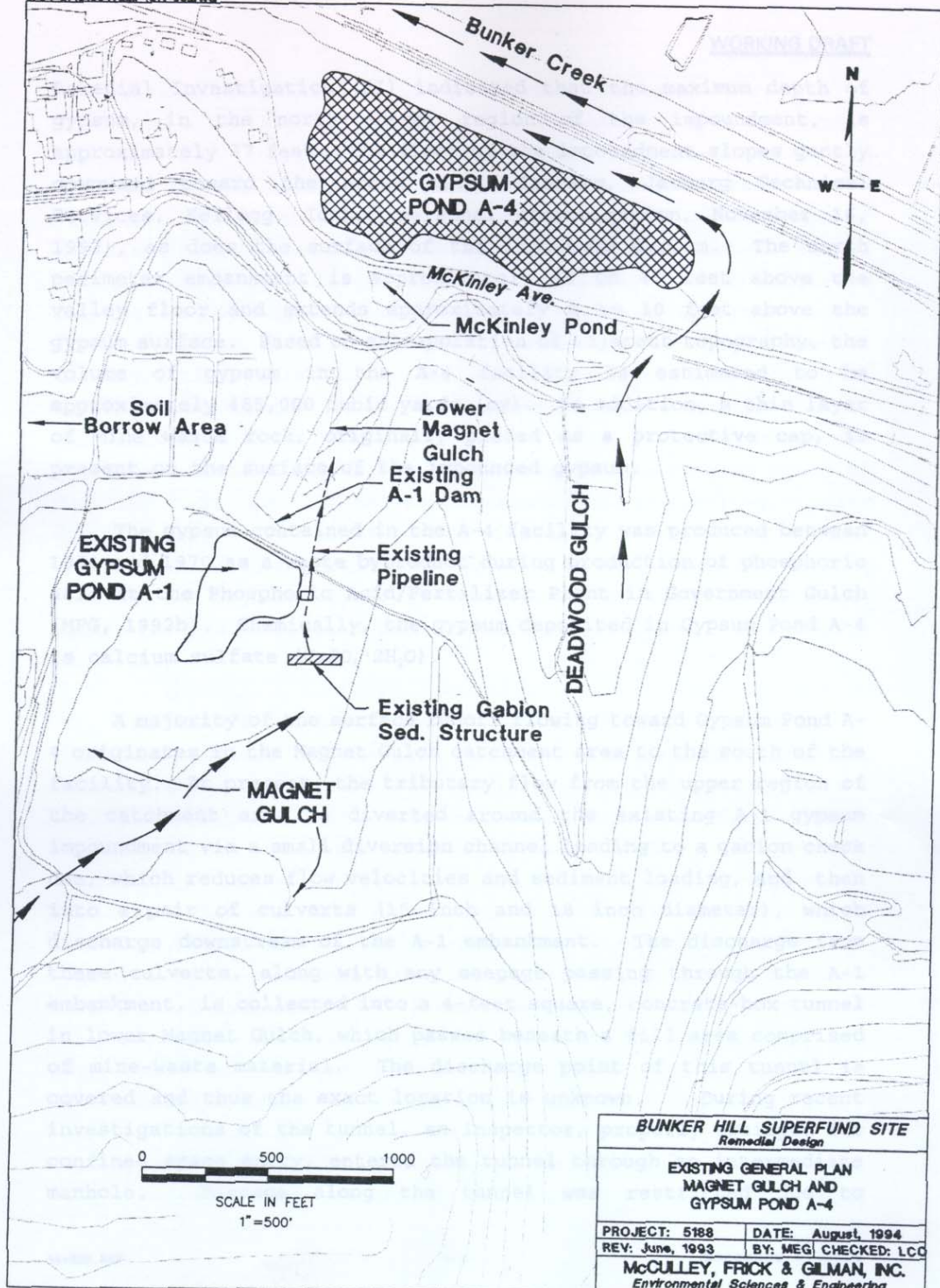


Figure 1-1

Appendix B

ATSDR Interim Public Health Hazard Categories

ATSDR Interim Public Health Hazard Categories

CATEGORY/DEFINITION	DATA SUFFICIENCY	CRITERIA
<p>Urgent Public Health Hazard</p> <p>This category is used for sites where short-term exposures (<1yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.</p>	<p>This determination represents a professional judgment based on critical data, which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* indicated that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the pre of serious physical or safety hazards.</p>
<p>Public Health Hazard</p> <p>This category is used for sites that pose a public health hazard due to the existence of long-term exposure (>1yr) to hazardous substance or conditions that could result in adverse health effects.</p>	<p>This determination represents a professional judgment based on critical data, which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one of more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.</p>
<p>Indeterminate Public Health Hazard</p> <p>This category is used for sites in which “critical” data are insufficient with regard to extent of exposure and/or toxicological properties at estimated exposure levels.</p>	<p>This determination represents a professional judgment that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.</p>	<p>The health assessor much determine, using professional judgment, the “criticality” of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.</p>
<p>No Apparent Public Health Hazard</p> <p>This category is used for sites where human exposure to contaminand media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.</p>	<p>This determination represents a professional judgment based on critical data, which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures, exposure to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.</p>
<p>No Public Health Hazard</p> <p>This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.</p>	<p>Sufficient evidence indicates that no human exposures to contaminand media have occurred, none are now occurring, and none are likely to occur in the future.</p>	

*: Such as environmental and demographic data; health outcome data; community health concerns information; toxicological, medical, and epidemiological data; monitoring and management plans.

Appendix C

Letter to the Jt. School District No. 391 Administrator from CDRI

November 1, 2001

Greg Godwin
Jt. School District No. 391
800 Bunker Avenue
Kellogg, ID 83837

Dear Mr. Godwin:

The purpose of this letter is to update you on progress made by the Cancer Analysis Work Group (CAWG) and our public health partners regarding cancer in the Kellogg area. In my letter to you of August 15, 2001, several conclusions made by CAWG were relayed:

- Cancer rates for some cancers are elevated in Shoshone County, at least partly related to higher smoking prevalence;
- Brain cancer was elevated over the time period 1990-2000 for a small area near the schools, but a survey of cases revealed no common factors;
- There have been somewhat more cases of cancer among school employees than expected, but this is based on a small number of cases, so is subject to large statistical variation;
- The distribution of cancer by site/type among school employees is atypical for the age groups represented.

At that time I stated that CAWG would be working with other public health partners to investigate the possibility of radiation exposure as a potential common cause of these cancers, and continue to monitor cancer incidence in the area. Since that time, CAWG has learned of an additional case of brain cancer in the area and about the loss of one of your former teachers. We wish to express our condolences for your loss.

As stated in the letter of August 15, 2001, radiation exposure is the only known risk factor we identified which could increase risk for several of the types of cancers seen among current and former employees of the middle and high schools in your school district. Also stated was that this is not unanticipated, as radiation is a risk factor for many cancer sites. We have been working with the Idaho Division of Health and the Idaho Department of Environmental Quality (IDEQ) to determine background radiation levels and if there were additional radiation exposures due to the production of gypsum in the area.

On October 12, 2001, a conference call was held with IDEQ, Division of Health, and Panhandle District Health Department staff to discuss the preliminary risk screening of

particulate emissions from gypsum ponds at the Bunker Hill Superfund site. The preliminary risk screening was based upon one composite sample collected from two gypsum ponds in September, 2001. The sample was of a smaller quantity than specified according to laboratory protocol. Additionally, the laboratory at Idaho State University performed a radiation scan letting the sample equilibrate for two weeks instead of the preferred month equilibration. The proper sampling technique would have been to collect a full sample of the gypsum and let it come to equilibrium (approximately one month) to more accurately measure the radioisotope progeny. There are about 405 to 418 cases of cancer per 100,000 people in Idaho each year. Results of the preliminary risk assessment for the gypsum ponds, conducted by Dr. Jeff Fromm (IDEQ), assuming a residential exposure of 30 years with a person in the middle of the source, show an additional risk of cancer of 1 case per 5,000,000 people. This is a very low risk, in the range considered acceptable by the US Environmental Protection Agency.

Because of the caveats of the sample and analysis technique described above, additional samples were collected which will be analyzed after reaching equilibrium. Results from these samples are expected in early January, 2002. More definitive risk assessment values will be available at that time.

The call participants also discussed conducting a radioactive analysis of air filters collected in Kellogg in the late 1980s. After the conference call, IDEQ and Panhandle District Health Department staff determined that any filters which showed any accumulation of particulates were consumed previously in the particulate analytical process. Thus, filters are not available for radioactive analysis.

We will contact you as soon as the final risk assessment for the gypsum ponds is complete, approximately early January. Please contact me if you have any questions or need additional information at 208-338-5100 x214 or cjohnson@teamiha.org.

Sincerely,

Christopher J. Johnson, MPH
Epidemiologist

Enclosures

cc: Jerry Cobb, Panhandle District Health Department
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