Summary of Analytical Results
Environmental Monitoring for Radionuclides in the Environs of the Byron Nuclear Power Plant

February 3, 2012

Preface

The IEMA Bureau of Environmental Radiation Safety (BERS) routinely monitors for radioactivity in the environment surrounding nuclear power plants and other nuclear facilities in Illinois.

During the Unusual Event at the Byron Nuclear Power Plant on January 30, 2012, steam was vented from Unit 2 at a higher rate than normal. Steam vented from nuclear power plants often contains small amounts of tritium. While IEMA did not anticipate finding elevated levels of tritium in the environment as a result of the vented steam, an environmental monitoring team was dispatched the following day to collect environmental samples around the Byron Nuclear Power Plant. The samples were delivered to IEMA's radiochemistry laboratory in Springfield for analysis.

What is tritium? See a Tritium Fact Sheet following the conclusion of this summary.

Water Samples

As part of IEMA's routine environmental monitoring program, water samples were collected at four different locations on January 11, 2012. On January 31, 2012, IEMA revisited the same sampling locations to collect samples for comparison.

IEMA Tritium Results for Water Samples

Sample Location	Collection Date	Tritium (pCi/L)
A	1/11/2012	Activity concentration is no more than 227 pCi/L, with 95% confidence
A	1/31/2012	Activity concentration is no more than 251 pCi/L, with 95% confidence
B	1/11/2012	Activity concentration is no more than 226 pCi/L, with 95% confidence
B	1/31/2012	Activity concentration is no more than 248 pCi/L, with 95% confidence
C	1/11/2012	Activity concentration is 519 pCi/L +/- 99.5 pCi/L, with 95% confidence
C	1/31/2012	Activity concentration is no more than 248 pCi/L, with 95% confidence
D	1/11/2012	Activity concentration is no more than 226 pCi/L, with 95% confidence
D	1/31/2012	Activity concentration is no more than 248 pCi/L, with 95% confidence

A comparison of the before and after results for IEMA's sampling locations generally show no measurable differences. In fact, only the sample collected before the Unusual Event on January 11, 2012 at Sample Location C had a measurable activity concentration (519 pCi/L). The USEPA maximum contaminant level for tritium in drinking water is

20,000 pCi/L. Therefore, the measured activity concentration (519 pCi/L) is almost 39 times less than the USEPA maximum contaminant level for tritium in drinking water.

Consuming water at an activity concentration of 519 pCi/L for a year would result in a dose of approximately 0.1 millirems (mrem). This is one-hundred times less than you would receive from a single chest x-ray (10 mrem).

What does "519 pCi/L +/- 99.5 pCi/L, with 95% confidence" mean? The unit pCi/L represents picocuries per liter of water. The counting error is 99.5 pCi/L, expressed as an interval at the 95% confidence level. There is measurement (i.e. counting) error associated with radiochemistry results. This can be compared to opinion polls preceding elections which always include margins of error (e.g. 47% of the people surveyed stated they intend to vote for Candidate A, 41% of the people surveyed stated they intend to vote for Candidate B, and the poll had a margin of error of +/-5%). A result of "519 pCi/L +/- 99.5 pCi/L, with 95% confidence" means that "IEMA is 95% confident that the sample has between 419.5 pCi/L and 618.5 pCi/L of tritium".

Vegetation Samples

In addition to water samples, IEMA collected four vegetation samples on January 31, 2012. These samples were analyzed on gamma spectrometers.

IEMA Gamma Spectroscopy Results for Vegetation Samples

Sample Location	Collection Date	Radionuclides Identified (pCi/grams)
E	1/31/2012	Potassium-40 (K-40): Activity concentration is no more than 6.37 pCi/g, with 95% confidence
F	1/31/2012	Potassium-40 (K-40): Activity concentration is no more than 5.39 pCi/g, with 95% confidence
G	1/31/2012	Potassium-40 (K-40): Activity concentration is 3.50 pCi/g +/- 1.14 pCi/g, with 95% confidence
H	1/31/2012	Potassium-40 (K-40): Activity concentration is no more than 3.26 pCi/g, with 95% confidence

Potassium-40 was identified in the vegetation samples. Potassium-40 is a naturally occurring radionuclide and is found in anything containing potassium. For example, bananas are rich in potassium and therefore contain potassium-40; in fact, the activity concentration of an average banana is approximately 3.5 pCi/gram.

Sampling Locations

Water Sampling Locations

Sample Location	Description
A	Southwest 1
B	Southwest 2
C	Northeast 1
D	Northeast 2

Vegetation Sampling Locations

Sample Location	Description
E	Southwest 3
F	Southwest 4
G	Northeast 3
H	Northeast 4

Conclusion

IEMA did not observe measurable increases of radiation in the environment as a result of the Unusual Event at the Byron Nuclear Power Plant.

See Next Page for Tritium Fact Sheet

TRITIUM FACT SHEET

What is tritium?

Tritium (H-3) is a radioactive isotope of the element hydrogen that is naturally occurring. It is also produced during the operation of nuclear power plants. Tritium contains two neutrons that ordinary hydrogen does not, making it unstable. Tritium has a half-life of 12.3 years and emits a weak beta particle (an electron from the nucleus).

Because both tritium and normal hydrogen react with oxygen to form water, tritium is commonly found in water used by nuclear facilities. Tritium replaces one of the stable hydrogen atoms in the water molecule, H_2O, and creates tritiated water, which is colorless and odorless. Because tritiated water is chemically identical to normal water, the tritium cannot be filtered out of the water.

Where does tritium come from?

Tritium is produced naturally in the upper atmosphere when cosmic rays strike air molecules. It is also produced during nuclear weapons explosions, bombarding hydrogen with neutrons in a particle accelerator, and in commercial nuclear reactors producing electricity.

Most of the tritium produced in a reactor is as a byproduct of the absorption of neutrons by an element known as boron. Boron is used in nuclear reactors to help control the fission chain reaction. Tritium can also be produced (to a lesser extent) from the fission process itself, or when neutrons are absorbed by other chemicals (e.g., lithium or heavy water) in the reactor coolant water. Nuclear power plants routinely and safely release dilute concentrations of tritiated water. These authorized releases are closely monitored by the utility and reported to the NRC. The reports are made available to the public.

What are some uses of tritium?

The primary use for tritium is in situations where a dim light is needed but batteries or electricity is not available. Examples of tritium use include exit signs, aircraft dials, gauges, luminous paints, wristwatches, and rifle sights.

What are the radiation protection limits for contaminants in drinking water?

Under the authority of the Safe Drinking Water Act, US Environmental Protection Agency (US EPA) sets the Federal legal limits for contaminants in drinking water. These limits are called maximum contaminant levels, and water suppliers must provide water that meets these standards. While EPA's drinking water standards do not apply to private drinking water wells, many State authorities have adopted the EPA's drinking water standards as legally enforceable groundwater protection standards; those standards are often used in assessing water from private wells.

In 1976, US EPA established a limit on the dose that a member of the public shall receive from radioisotopes in drinking water: the total dose from all radioisotopes may not exceed 4 mrem per year. In addition, EPA established a maximum contamination level of 20,000 picocuries per liter (pCi/l) for tritium in drinking water.

In 1991, US EPA calculated that the tritium concentration required to exceed the 4 mrem per year dose limit is 60,900 pCi/L. However, US EPA has kept the 1976 value of 20,000 pCi/L for tritium in its latest regulations.

<u>How long will tritium remain in the ground</u>?

Tritium has a half-life of 12.3 years, meaning that half of the original tritium will be gone (decayed) in 12.3 years.

Years	Percentage Tritium Remaining
0	100
12.3	50
24.6	25
26.9	12.5
49.2	6.25

<u>How do you dispose of tritium</u>?

Since tritium is chemically indistinguishable from ordinary water, the primary method of dealing with tritium is dilution. Discharges from power plants are closely monitored and any discharge is mixed with non-radioactive water to make the concentration below the federal limits.

<u>What is the effect of tritium entering the body</u>?

Everyone is exposed to tritium in small amounts everyday because it occurs naturally in the environment and the foods we eat. Tritium is almost always found as a liquid and primarily enters the body when people eat or drink food or water containing tritium or absorb it through their skin. People can also inhale tritium as a gas in the air. Tritiated water can enter the body via inhalation, ingestion, absorption through the skin or via open wounds. Tritium contains two neutrons that ordinary hydrogen does not making it unstable. It undergoes radioactive decay transforming into helium and emitting a beta particle (an electron). The beta particle is low energy and has low penetrating power. One to two hours after uptake, tritiated water will be evenly distributed throughout the body’s fluids. The dose received from tritium is dependant upon the initial ingested quantity and the resident time in the body. This dose will be distributed throughout the whole body. Approximately ten days after exposure, half the tritium will be excreted. Increasing liquid intake will shorten this time.

<u>Is the radiation dose from tritium any different than the dose from natural background radioactivity or medical procedures</u>?

The type of radiation dose from tritium is the same as from any other type of radiation, including natural background radiation and medical administrations. Humans receive approximately 82% of their annual radiation dose from natural background radiation, 15% from medical procedures (e.g., x-rays), and 3% from consumer products. Doses from tritium and nuclear power plant effluents are a negligible contribution to the background radiation to which people are normally exposed and they account for less than 0.1% of the total background dose (NCRP, 1987).

What are the possible health risks from tritium radiation exposure?

The beta radiation from tritium can cause three potential health effects: cancer, genetic effects and effects on the fetus.

Along with other national and international regulatory agencies responsible for radiation protection, the NRC assumes that any exposure to radiation poses some health risk, and that risk increases as exposure increases in a linear, no-threshold (LNT) manner. The LNT assumption suggests that any increase in dose, no matter how small, incrementally increases risk. Conversely, lower levels of radiation proportionately decrease the risk, such that very small radiation doses have very little risk. The health risks include increased occurrence of cancer and genetic abnormalities in future generations.

Although high doses and high dose rates may cause cancer in humans and genetic abnormalities in an embryo or fetus, public health data have not established the occurrence of these health risks following exposure to low doses and low-dose rates — below about 10,000 millirem (mrem).

How does the effect of drinking tritiated water compare to other exposure sources?

As an example, assume that a residential drinking water well sample contains tritium at the level of 1,600 picocuries per liter. The radiation dose from drinking water at this level for a full year (using EPA assumptions):

a. at least 10,000 times lower than the dose from a medical procedure involving a full body computed tomography (CT) scan (e.g., 3,000 to 10,000 mrem from a CT scan vs. 0.3 mrem from tritiated drinking water)

b. 1,000 times lower than the dose from natural background radiation (e.g., 300 mrem from natural background radiation vs. 0.3 mrem from tritiated water)

c. 100 times lower than the dose from either dental x-rays or natural radioactivity (potassium) in your body (e.g., 30 mrem from potassium vs. 0.3 mrem from tritiated water)

d. 10 times lower than a round-trip cross-country airplane flight (e.g., 3 mrem from New York to Los Angeles and back vs. 0.3 mrem from tritiated water)