A Summary of ATSDR's Evaluation of Iodine-131 Releases from the Oak Ridge Reservation

About Iodine-131 Releases from the Oak Ridge Reservation

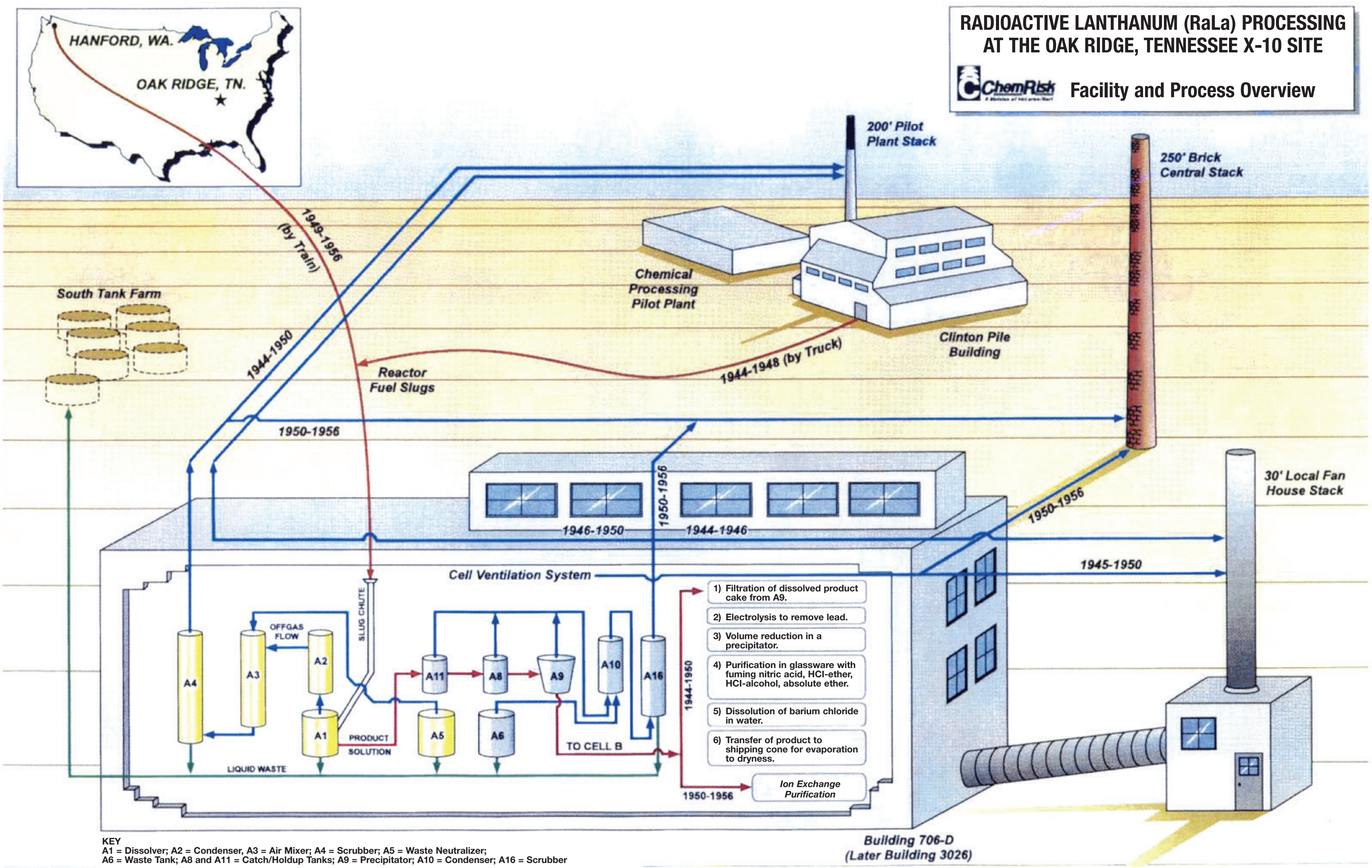
In 1942, the federal government established the Oak Ridge Reservation (ORR) in Tennessee's Anderson and Roane Counties. The ORR was part of the Manhattan Project—a top-secret federal government program to research, develop, and produce special radioactive materials for nuclear weapons. The government built three facilities—the Y-12 plant, the K-25 site, and the S-50 site—at the ORR to enrich uranium and built the X-10 site to design and demonstrate processes for producing and separating plutonium (see Figure 1).

Figure 1. RaLa Processing
This is a photograph of the X-10 site's Clinton Pile Building, later known as the Graphite Reactor. From 1944 to 1956, a major X-10 operation was the production of radioactive lanthanum (RaLa) for use in nuclear weapons development. The RaLa process produced radioactive iodine as a byproduct. This radioactive iodine was released to the outside air from the Pilot Plant Stack (the dark stack in the background).

The ORR's X-10 site was formerly known as Clinton Laboratories. Today it is the Oak Ridge National Laboratory (ORNL). In 1943, the X-10 site was initiated as a pilot project to demonstrate plutonium production and separation. Over time, operations at the X-10 site broadened to include nuclear fission product separation, nuclear reactor safety and development, and radionuclide production for worldwide use in the medical, industrial, and research fields. One major effort at the X-10 site involved the production of radioactive lanthanum (RaLa), which took place from 1944 to 1956 (see Figure 2). Early atomic weapon design development at federal governmental facilities in Los Alamos, New Mexico used RaLa produced at the X-10 site to test implosion processes. Los Alamos scientists also used RaLa for atmospheric radiation tracking tests.

Most of the radioactive iodine generated at the ORR came from the X-10 site, with the RaLa process being the most significant source of radioactive iodine releases. Radioactive iodine is a RaLa processing byproduct emitted from X-10's smokestacks (see Figure 1) and vents, and historically entered the air surrounding the X-10 site. The most significant releases of radioactive iodine at the ORR—in the forms of iodine-131 (I-131) and iodine-129 (I-129)—occurred from 1944 to 1956.

Figure 2. Radioactive Lanthanum (RaLa) Processing at the X-10 Site (1944–1956)



Who is ATSDR?

The Agency for Toxic Substances and Disease Registry (ATSDR) is the principal federal public health agency charged with evaluating the human health effects of **exposure** to hazardous substances in the environment. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. Congress created ATSDR to implement the health-related sections of the 1980 Superfund law and other laws that protect the public from hazardous waste and environmental spills of hazardous substances.

What is ATSDR Doing at the Oak Ridge Reservation?

Because people in the ORR area wanted to know if I-131 releases could affect their health, ATSDR conducted a public health assessment (PHA) to evaluate whether past, current, and potential future exposures to I-131 released from the X-10 site could be harmful to people who live in communities near the ORR. ATSDR uses the PHA process to evaluate previous studies and environmental data to determine whether releases of hazardous substances from sites such as the ORR could affect the health of people in nearby communities. The PHA is the primary public health process that ATSDR uses to:

- ❖ ***Identify*** off-site populations that could have been exposed to hazardous substances,
- ❖ ***Determine*** the potential health effects of exposure,
- ❖ ***Address*** the health concerns of people in the community, and
- ❖ ***Recommend*** any needed follow-up public health actions to address exposure.

What Information Did ATSDR Use to Evaluate I-131 Releases?

In assessing the potential for past public health hazards associated with radioactive iodine releases from the ORR, ATSDR reviewed the following:

- A Tennessee Department of Health (TDOH) document entitled *Reports of the Oak Ridge Dose Reconstruction, The Report of Project Task 1: Iodine-131 Releases from Radioactive Lanthanum Processing at the X-10 Site in Oak Ridge, Tennessee (1944–1956)—an Assessment of Quantities Released, Off-Site Radiation Doses, and Potential Excess Risks of Thyroid Cancer* (referred to as the Task 1 report).
- Continuous air monitoring data collected in 1953, 1955, and 1956. This is the period when processing of RaLa at the X-10 site resulted in releases of radioactive iodine from the brick central stack.
- I-129 concentrations in deer harvested from ORNL in 1979–1989.

Further, ATSDR reviewed the most recent studies investigating thyroid-induced diseases associated with exposures to radioactive iodine released during the 1986 Chernobyl nuclear accident. ATSDR also reviewed literature concerning noncancerous and cancerous impacts of radioactive iodine on the thyroid.

ENVIRONMENTAL HEALTH TERMS

Exposure
Contact with a substance through swallowing, breathing, or touching it.

ENVIRONMENTAL HEALTH TERMS

Current and future human exposure
For the purposes of the ORR I-131 evaluation, this refers to exposures occurring from 1991 to the present as well as any potential future exposures.

Past human exposure
For the purposes of the ORR I-131 evaluation, this refers to exposures occurring from 1944 to 1991.

What is Radioactive Iodine and How Could it Affect My Health?

In this fact sheet ATSDR frequently uses the term *radioactive iodine* to represent all isotopes of iodine released from the X-10 site. Iodine consists of both radioactive and nonradioactive forms, referred to as isotopes. Two of these isotopes, known as I-131 and I-129, were the most important radioactive isotopes released into the environment by the RaLa process. I-131 and I-129 are produced by the fission of uranium atoms during the operation of nuclear reactors. They are also produced from plutonium or uranium when a nuclear weapon detonates. Immediately after they are produced, these isotopes begin to decay. During the decay process the isotopes emit radiation in the form of beta particles and gamma radiation. ATSDR's PHA primarily focuses on exposure to radiation from I-131, the isotope that is most likely to affect people if they are exposed to it. Radiation from I-131 targets the thyroid, a quarter-size, hormone-producing gland located at the base of the neck (see Figure 3).

ATSDR considers I-131 as the most significant radioactive isotope released to the environment during the RaLa process. I-131 gives the greatest radiation dose to the thyroid in the smallest amount of time. Once I-131 is ingested, it concentrates in the thyroid gland. Approximately 30 percent of iodine entering the bloodstream is deposited in the thyroid. People exposed to I-131, especially during childhood, may have an increased lifetime risk of thyroid disease, including thyroid cancer. I-131 decays rapidly in the environment, with a half-life of approximately 8 days. Following a single internal dose of I-131, within 75 days 99.99 percent of it is removed from the body.

I-129 is another form of radioactive iodine important in the RaLa process. Unlike the short half-life of I-131, I-129 has a half-life of about 15.7 million years. Although I-129 remains in the environment for a very long time, the rate of decay is very low, limiting radiation and limiting the potential health risks. Before much of the I-129 decays, bodily processes remove it from the thyroid.

For further information on I-131 and thyroid cancer, see the National Cancer Institute Web site at *http://www.cancer.gov/i131*.

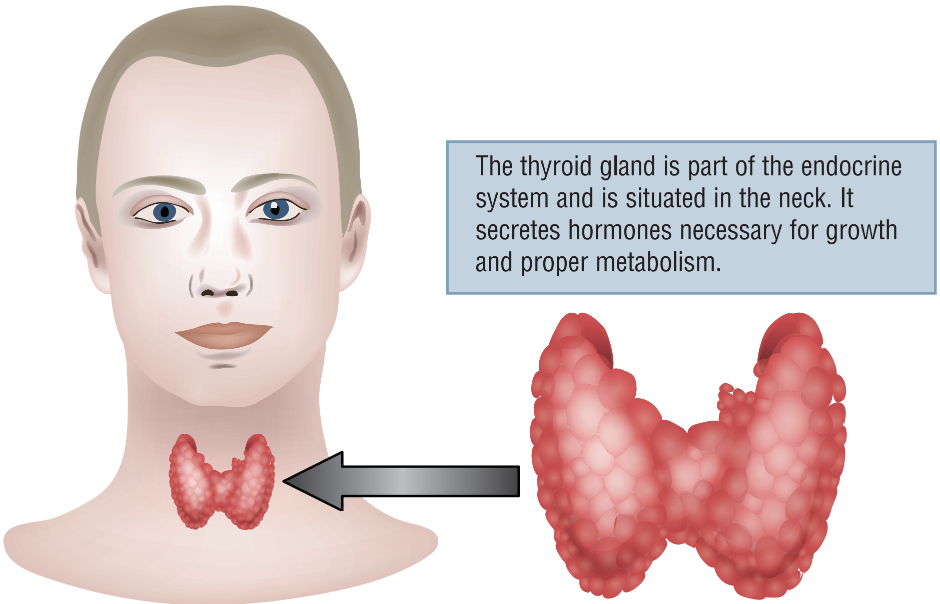
Evaluation of Current (1991–present) and Future Exposures

I-131 released from RaLa processes at the X-10 site in the 1940s and 1950s is no longer present in the air, soil, biota (i.e., plants and animals), or any part of the food chain. Since 1991, the ORR has generated no significant air releases of radioactive iodine. ATSDR does not expect any current or future exposures to radioactive iodine from this site. ATSDR has, therefore, concluded that **current and future human exposure** to radioactive iodine from the ORR does not pose a health hazard. Any radioactive iodine released from the X-10 site has long since decayed completely or is not present in the ORR-area environment at levels that constitute a health hazard.

Evaluation of Past I-131 Releases (1944–1991)

Assessing **past human exposure** by measuring the amount of I-131 taken up by people in the vicinity of the ORR is no longer possible. As previously stated, I-131 does not remain in the body for long periods of time. A scientific method referred to as dose reconstruction was used to help evaluate whether in the past (from 1944 to 1956) individuals were exposed to harmful levels of I-131 released from the X-10 RaLa process. Dose reconstruction involves gathering and evaluating information about the amount of I-131 released during the RaLa process, the behavior of I-131 in the environment and in the body, and the past activities of individuals living near the X-10 site. It is used to determine how people have been exposed to I-131 and to estimate the radiation doses that people might have received in the past.

Figure 3. The Human Thyroid Gland: The Target Organ for Radioactive Iodine



- Drinking milk was the most important way people were exposed to I-131 because cows and goats that graze in pastures had concentrated levels of I-131 in their milk and were a potential source of exposure for residents. Once I-131 is ingested, it is easily absorbed by the body and concentrates in the thyroid gland. Approximately 30 percent of the radioactive iodine that is ingested is deposited in the thyroid. Children typically accumulate higher doses of radioactive iodine in the thyroid than do adults because children have a more active thyroid and drink more milk than adults.
- Radiation may affect cells in the thyroid gland so that they do not function properly, or may cause the cells to grow abnormally. In sufficient doses, I-131 may be especially harmful to the thyroid. I-131 can give a large radiation dose to the thyroid gland in a short period of time. Because the radiation dose is dependent on the organ mass and a child's thyroid gland is smaller than an adult's, the impact of I-131 is greater on a child's thyroid gland. Since I-131 concentrates in the thyroid, the most likely health effect is the development of thyroid disease.
- Studies have shown that the thyroid gland's exposure to external radiation can cause a variety of diseases. These include disorders of thyroid function, such as hypothyroidism (underactive thyroid) and growth disorders, such as thyroid tumors. Thyroid tumors may be benign or malignant (a malignant tumor is cancerous). The most likely minimum radiological dose required to result in thyroid tumors is 10,000 millirem (10 rads). The risk to the thyroid is affected by age at exposure, gender (women are affected more than twice as often as men), genetic makeup, and dose or dose rate to the thyroid. Studies from the Chernobyl nuclear accident suggest that the appearance of thyroid disease, especially thyroid cancer, following the intake of radioactive iodine is age-dependent. Other types of thyroid disease (e.g., autoimmune thyroid diseases) are generally not known to be caused by radiation.
- Other health effects that may be linked with radioactive iodine exposure at very high doses include autoimmune (non thyroid-related) and cardiovascular disease. Compared to the well-documented adverse effects radioactive iodine has on the thyroid, considerable uncertainty surrounds the association between radioactive iodine and other health effects.

The TDOH Oak Ridge Dose Reconstruction Task 1 Report

To evaluate the potential health effects of I-131 releases, TDOH conducted an in-depth dose reconstruction of radioactive iodine releases from the 1944–1956 RaLa processing at the X-10 site. The TDOH's Oak Ridge Dose Reconstruction Task 1 Report estimated I-131 releases into the atmosphere during RaLa processing operations and estimated I-131 concentrations in neighboring communities (see Figure 4). The Task 1 team also predicted thyroid gland radiation doses for the off-site populations, given certain geographic proximity to the X-10 site and other factors that contributed most to exposures (e.g., consuming local goat's milk). Nevertheless, these radiation doses generated by the Task 1 team are only estimates, with a wide range of radiation doses and without much certainty in the dose calculations. Also, this dose reconstruction evaluated only past I-131 releases, not present or future releases. The dose reconstruction has, however, helped to answer the following questions:

Dose Reconstruction

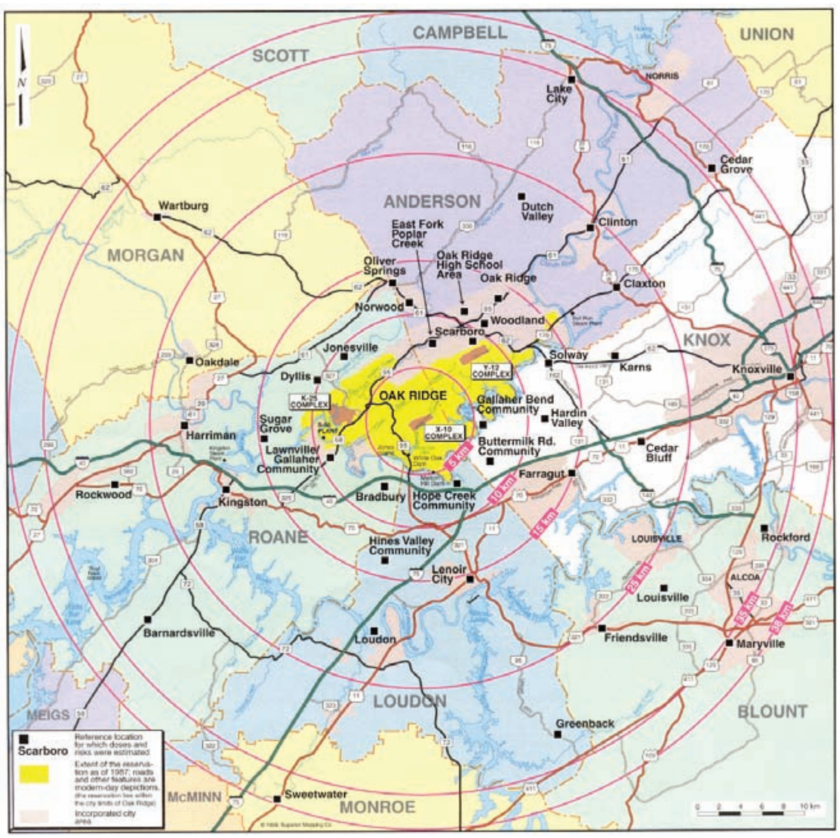
In July 1999, TDOH released the Task 1 Report of the Oak Ridge Dose Reconstruction. The Task 1 report focused on I-131 releases from the X-10 site.

The Task 1 study area included 41 locations within 24 miles (38 kilometers) of the X-10 site. Figure 4 shows a more detailed map of the study area.

- When were exposures likely to be highest?
- Who was most at risk of exposure to X-10 radioactive iodine releases?
- Where were exposures likely to be highest?

The Task 1 investigators also helped identify key factors that contributed to uncertainty in dose calculations. The full report is available at *http://health.state.tn.us/CEDS/OakRidge/ORidge.html*.

Figure 4. Task 1 Study Area for I-131 Releases (1944–1956): Locations Within 24 Miles (38 Kilometers) of the X-10 Site



How Much I-131 Was Released During RaLa Processing at the X-10 Site?

Exhaust (referred to as "off gas") rising from smokestacks (see Figure 2) was among the most significant source of radioactive iodine released from RaLa processing. From 1944 to 1950, exhaust was released from a 200-foot tall pilot plant stack and a 30-foot tall local fan house stack. Later, exhausts from RaLa processing were routed to a central treatment facility and, after passing through pollution control systems, released to a 250-foot tall central stack. After reviewing historical records of RaLa operations at the X-10 site, the Task 1 investigators were able to estimate I-131 releases from 1944 to 1956, including the I-131 released during a RaLa accident on April 29, 1954. Table 1 shows the estimated amount of I-131 released. Most of the releases (70 to 85 percent) were in the elemental form of iodine, which readily transports through the atmosphere. The Task 1 report indicated that I-131 releases from RaLa processes from 1944 through 1956 likely ranged from 8,800 to 42,000 curies (Ci). Still, limitations in available data on pollution controls and on I-131 forms (i.e., **elemental iodine**, **organic iodine**, and **particulate iodine**) have resulted in much uncertainty about these modeled estimates of I-131 releases.

Table 1. Estimated Amount of I-131 Released from RaLa Processing (1944–1956)

	Percentile*		
	2.5	50	95
RaLa Operations			
Elemental I-131	6,300	16,000	36,000
Organic I-131	940	3,600	17,000
Particulate I-131	0.046	0.15	0.54
1954 RaLa Accident			
Elemental I-131	110	280	560
Organic I-131	0.57	2.8	16
Particulate I-131	0.017	0.08	0.32
Estimated Total I-131 Released from RaLa Processing†			
Total I-131	8,800	21,000	42,000

Notes:

* The percentile is a value on a scale of one hundred that indicates the percent of a distribution that is equal to or below it. Thus in the table, the value 2.5 means there is a 2.5 percent chance that the releases are lower than the table value.

† Because of statistical analyses and uncertainty calculations, the totals do not sum.

Radiological units are in curies.

ENVIRONMENTAL HEALTH TERMS

Elemental iodine
Iodine that readily converts to a gaseous state and is easily transported in air.

Organic iodine
A nonreactive form of iodine. During RaLa processing at the X-10 site only small amounts were released.

Particulate iodine
Iodine in a solid rather than gaseous state. It is typically deposited close to where it is released.

ELEMENTS OF AN EXPOSURE PATHWAY

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Point of exposure
The place where someone can come into contact with a substance present in the environment.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

Receptor population
People who could come into contact with hazardous substances.

How Much I-131 Reached Communities Near the ORR?

The Task 1 team first established how much radioactive iodine was released through the RaLa process. Then the team determined how far the iodine might have traveled and how much of it settled on the ground. A number of influencing factors were considered when determining how much radioactive iodine actually settled in nearby communities. These factors included distance from the stacks, weather conditions, and the form of iodine. As with all radioactive material, radioactive iodine can travel through air as particulate or as gas and can contaminate soil, sediment, water, plants, and animals. The prevailing wind would have carried much of the radioactive iodine away from and downwind of the stacks. The Task 1 team predicted the maximum atmospheric I-131 concentrations at each of the 41 locations within the 24-mile dose reconstruction study area. The dose reconstruction atmospheric dispersion model indicated that the I-131 releases were most highly concentrated in the downwind communities of Gallaher Bend and Bradbury. The maximum concentration of I-131 in these communities was predicted as approximately 5.5 picocuries per cubic meter (pCi/m^3) in air. This is about four times higher than the I-131 airborne concentrations measured in the city of Oak Ridge.

How Were People Who Lived Near the ORR Exposed to I-131?

The Task 1 team used models and applied health-protective assumptions to provide estimates of plant and animal radioactive iodine uptake, and to predict the I-131 doses for people living in communities surrounding the reservation. A number of different **exposure pathways** (e.g., drinking local cow's or goat's milk, eating locally grown vegetables, and breathing air) were identified whereby people could have been exposed to radioactive iodine. Potentially exposed populations were identified and unique factors that influenced the extent and duration of their exposures were also determined. Several factors were identified as contributing most to a person's I-131 exposure. Figure 5 describes how most people were exposed to I-131 originating from the X-10 site. Figure 5 also provides examples of several exposure possibilities explained in more detail below.

Diet—Drinking milk was one of the most important ways in which people might have been exposed to I-131. Because goats and cows typically graze over large areas of pasture near the X-10 site, and iodine tends to concentrate in their milk, a relatively low release of I-131 can result in a relatively high I-131 concentration in milk. The Task 1 report indicated the highest estimated I-131 radiation doses to the thyroid gland were to people who consumed goat's milk. The next highest doses resulted from the consumption of backyard cow's milk. Smaller amounts of I-131 may have also come from drinking local commercial dairy milk, from eating eggs, beef, and goat meat, and from consuming other dairy products and leafy vegetables.

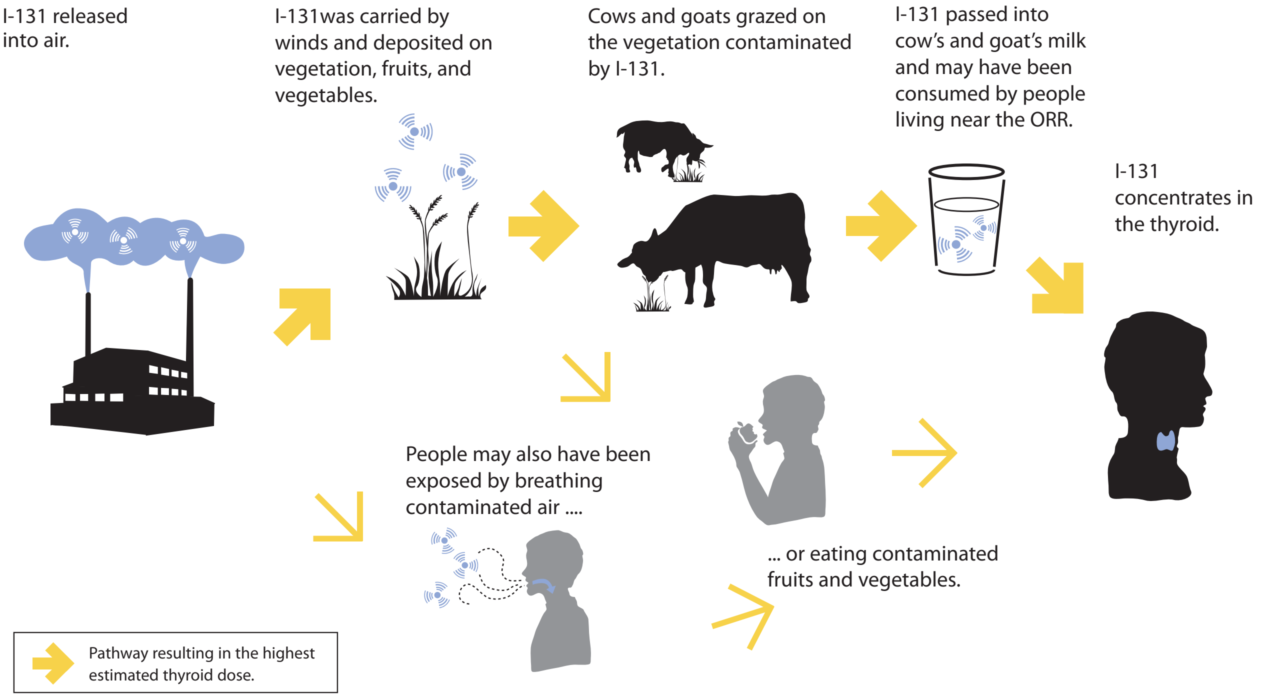
Location—The Task 1 report indicated that I-131 releases could have potentially affected a study area as large as 24 miles (38 kilometers) from the X-10 site. The highest radiation doses to the thyroid gland were estimated for individuals living in Gallaher Bend, a town about 3.5 miles east of the X-10 site. The lowest doses within the study area were estimated for individuals in Wartburg, which is about 20 miles northwest of the X-10 site (see Figure 4).

Age—Children's thyroids typically absorb higher amounts of radioactive iodine than those of adults, and children drink more milk than adults. A child's thyroid gland (again, where iodine concentrates) is smaller than an adult's. Because radiation doses depend on organ mass, the effect of I-131 uptake is greater in children. In addition, children are more sensitive to the effects of I-131 in their bodies than are adults.

Year of Birth—In general, people born in years with the highest I-131 releases were predicted to receive the highest doses. For example, higher doses (about 4 to 5 times higher) were estimated for people born from 1944 through 1952; the lowest exposure doses to the thyroid were associated with birth years 1920, 1930, and 1956 (up to 66 rads).

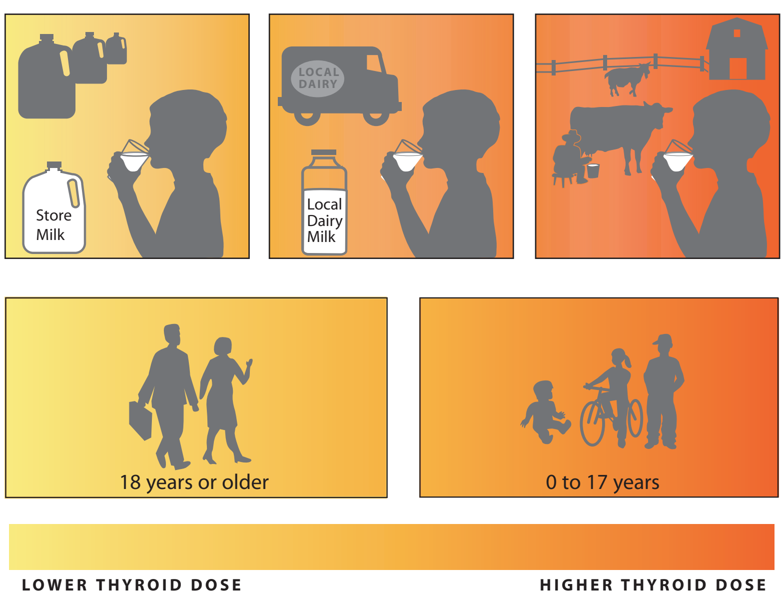
Figure 5: How Were People Exposed to I-131 from the X-10 Site?

During the RaLa processing at the X-10 site from 1944 to 1956, people living in communities near the reservation received most of their exposure to I-131 from drinking contaminated milk.



Location

The Task 1 radiation dose estimates to the thyroid indicated that I-131 from X-10 RaLa processing may have impacted areas as far as 24 miles from the X-10 site. Factors such as prevailing winds and atmospheric dispersion, along with estimated I-131 releases, were considered in the models to predict ground-level air concentrations of I-131 at different locations. These estimated ground-level air concentrations were used to estimate radiation doses to the thyroids of hypothetical individuals at each location evaluated by the Task 1 report. The recently identified historical monitoring data provide strong evidence, however, that I-131 releases did not extend beyond the X-10 site boundary at levels that would constitute a public health hazard.



Milk Consumption

Drinking backyard cow's or goat's milk resulted in higher estimated radiation doses to the thyroid than drinking milk obtained from a local commercial dairy. Drinking goat's milk contributed more to an individual's estimated thyroid dose than drinking backyard cow's milk. Much lower thyroid doses resulted from drinking milk obtained from a market that sold milk obtained from regional distributors.

Age of Resident

Infants and children who were less than 18 years of age at the time of RaLa processing are the most susceptible populations because their thyroids typically absorbed higher amounts of I-131 than an adult's and they drank more milk than adults.

Evaluation of Additional Historical Environmental Monitoring Data

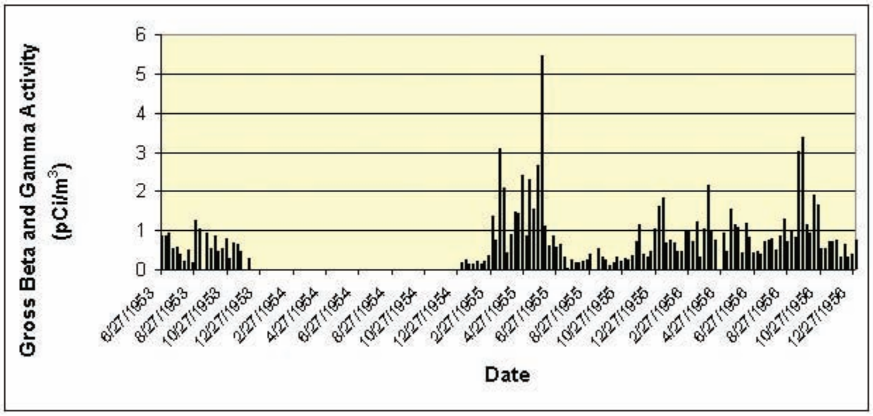
Additional Environmental Monitoring Data and I-131 Releases

The continuous air monitoring data collected during RaLa processing and the sampling of iodine in thyroids of deer harvested on X-10 grounds and at off-site locations suggest that releases of radioactive iodine did not extend past the X-10 site boundary at levels that would constitute a public health hazard.

Since the development of TDOH's Task 1 report in 2000, two additional historical datasets related to RaLa processing at the X-10 site have been discovered. The datasets include the results of continuous air monitoring (CAM) covering much of the early and mid-1950s for locations at or near the X-10 site. The datasets also include reports on levels of I-129 measured in the thyroids of deer taken near the X-10 site. It is important to note, however, that certain limitations exist with the environmental monitoring data, and that these limitations add some uncertainty to any conclusions drawn from that data. For example, the CAM data used in these analyses were reported as gross beta/gamma measurements of long-lived radioactivity. Consequently, there is no way of determining whether the radioactivity was specific to radioactive iodine released from RaLa processes at the X-10 site or whether the radioactivity was possibly captured from other more distant sources (e.g., all ORR sources, Nevada test site releases, other countries' tests, or naturally occurring radioactive elements). The additional environmental data are briefly summarized below.

- **Historical continuous air monitoring data**: The ORR established 10 on-site CAM stations in and around the X-10 site to monitor radionuclides (gross beta and gamma) released to the air during RaLa processing from 1944 to 1956. In addition to the on-site locations, seven monitoring stations were located along the ORR perimeter. Figure 6 presents air monitoring results from the on-site monitoring station farthest from the X-10 site, Rock Quarry (HP-8), located 4 miles east of the RaLa processing facility, but within the same valley. The reported data show that the highest radioactivity occurred during the week of May 30, 1955. Table 2 shows the average long-term radioactivity at on- and off-site monitoring locations. The HP-8 monitoring station had the lowest average long-term activity of all on-site stations. This indicates that the most concentrated radioactive iodine releases from the X-10 site may not have traveled beyond the immediate X-10 site area.
- **Iodine content in thyroids of deer harvested from on- and off-site locations**: Grazing animals can ingest iodine compounds deposited on grasses or other food sources. Because iodine is concentrated in the thyroid, monitoring of this organ is used to indicate the amount of contamination in the environment. From 1985 through 2003, approximately 8,500 deer were harvested at ORNL and a radiological scan was conducted on each animal. Of this total, 170 animals exceeded the ORR cesium-137 screening value of 5 picocuries per gram (pCi/g) in deer tissue. A recent analysis was performed using a portion of this dataset, which included data collected from 1979 to 1989. The study evaluated I-129 (a surrogate for I-131 but with a very long half-life) concentrations in deer thyroids in relation to the collection location. The investigators found that only those deer collected within a small area of the reservation (the White Oak Lake area) had elevated levels of I-129 in their thyroids. Deer taken from off-site locations did not have similarly elevated levels.

Figure 6. Rock Quarry (HP-8) Air Monitoring Results for 1953, 1955, and 1956



Note:
The weekly CAM data included the last half of 1953, 1955, and 1956; the data for 1954 were not available.
pCi/m3 – picocuries per cubic meter

Table 2. Average Long-Term Gross Beta and Gamma Activity at On- and Off-Site Locations

Location	Station	Distance from the Main X-10 Stack (miles)	Average Long-Term Gross Beta and Gamma Activity (pCi/m3)
N 3550	HP-1	On-site	84.4
W 3001	HP-2	On-site	35.1
S 1000	HP-3	On-site	27.7
W 3513	HP-4	On-site	18.9
E 2506	HP-5	On-site	190.7
SE 3012	HP-6	On-site	16.6
W 7001	HP-7	On-site	14.3
Rock Quarry	HP-8	On-site (4.8)	8.5
A-10 Site	HP-9	On-site	14.8
S 2007	HP-10	On-site	32.5
Kerr Hollow Gate	HP-11	4.7	6.7
Midway Gate	HP-12	6.6	5.0
Gallaher Gate	HP-13	4.6	6.3
White Wing Gate	HP-14	5.6	6.7
Blair Gate	HP-15	4.4	8.3
Turnpike Gate	HP-16	5.5	7.5
Hickory Creek Bend	HP-17	4.7	8.9
Berea, Kentucky	B	130	10.1
Corryton, Tennessee	C	41	12.4
Kingston, Tennessee	K	18	10.1

Note:
The data cover the years 1953 (last half of year), 1955, and 1956.

Uncertainty and Limitations of the Task 1 Dose Reconstruction

Because Task 1 investigators had to rely on incomplete data for modeling I-131 releases from X-10's stacks and vents, much uncertainty surrounds the dose calculations presented in the Task 1 report. The available data limitations raise uncertainties about the affected area, and they raise questions about the events from 1944 to 1956 that would have most likely exposed people to iodine releases from RaLa processing. The following explains the basis for—and the implications of—the uncertainties in the Task 1 report.

- **Amount of radioactive iodine released**. The information regarding the amount of radioactive iodine released from X-10's stacks and vents is not complete since these release points were not specifically monitored. Because of the absence of any known RaLa release data when the dose reconstruction was in progress, the Task 1 report relied on models for estimating historical releases from the stacks and vents. This is one of the most significant sources of uncertainty in the estimates of radiological doses to the thyroid from I-131 releases.

- **Form of the released iodine**. The specific form of radioactive iodine released (i.e., elemental iodine, organic iodine, or particulate iodine) is not precisely known. Were the specific form of the releases significantly different from that presumed, it would ultimately affect the predicted radioactive iodine doses. Certain forms of radioactive iodine are more reactive in the environment than others and would be more readily taken up by plants and animals.

- **Efficiency of the RaLa process scrubbers**. Typically, the exhaust (off gas) from RaLa processing was routed to scrubbers that attempted to remove the radioactive contaminants from the air stream before release of the off gas from the stacks. Like the form of the released iodine, the efficiency of these scrubbers (as well as the form of the releases) is not precisely known since scrubber efficiency varied with the form of the released iodine. For example, the scrubbers could remove about 50 to 95 percent of elemental radioactive iodine. But the scrubbers were less efficient in removing organic radioactive iodine, typically achieving only from 1 to 10 percent removal efficiency. The greater the removal efficiency, the less radioactive iodine that was released to the air from stacks and the less I-131 that was available for accumulation in plants, animals, and ultimately, people.

- **Type of RaLa processing considered**. RaLa operator logbooks and other sources of information provide persuasive evidence that releases of radioactive iodine were not continuous events; rather, iodine was released in batches at various times throughout RaLa operations. In many cases, the time period between releases was longer than the approximately 8-day physical half-life of I-131.

What Does ATSDR Recommend to Reduce the Uncertainties?

To reduce some of the uncertainties associated with estimated thyroid doses in the Task 1 report, ATSDR recommends collecting soil samples downwind and upwind of ORNL (on- and off-site) and analyzing these soil samples for I-129. Although I-131 has a very short half-life and the I-131 from the RaLa process is no longer present in the environment, the current radioactivity of I-129 in the soil can be used to evaluate past I-131 concentrations. ATSDR believes these data on I-129 in the soil can be used to better characterize those areas affected by X-10 radioactive iodine releases and, thereby, allow for more accurate identification of any exposed population.

Uncertainty in Estimated I-131 Thyroid Doses for Residents Living Near the ORR

ATSDR believes that individuals who were under the age of 18 and who had received a thyroid radiation dose in excess of 10 rads should be considered the critical, sensitive population. Prudent public health practice suggests that those residents whose estimated doses exceeded 10 rads should be monitored for thyroid-related diseases.

That said, however, identifying the population that truly received exposure doses greater than 10 rads is difficult. As stated, the thyroid dose estimates in the Task 1 report involve considerable uncertainty. This uncertainty is largely attributed to the reliance on incomplete data used to model radioactive iodine releases. The uncertainty also results in lower- and upper-bound thyroid dose estimates that vary from 10 to 100 times above or below the central estimate (or average) thyroid dose.

The historical air monitoring and deer thyroid data suggest that the Task 1 report may have overestimated the extent of the contamination caused by X-10 RaLa releases by perhaps a factor of 10. Therefore, it is possible that estimated doses were actually closer to the Task 1 report's lower-bound estimates than to the report's central estimates.

Table 3 compares thyroid dose estimates for a female born in 1952 consuming backyard cow's milk in 10 selected communities using the central estimate values presented in the Task 1 report versus what would be expected based on the historical air monitoring and deer thyroid data. The table shows that using the Task 1 report's estimates, a female born in 1952 consuming backyard cow's milk in three communities (Bradbury, Gallaher Bend, and Hardin Valley) would have estimated doses exceeding 10 rads, whereas based on the results of the historical environmental monitoring data, none of the residents in the 10 selected communities would have received estimated doses exceeding 10 rads.

Table 3: Comparison of Thyroid Dose Estimates for Selected Communities

Community	Direction from X-10 Site	Distance from X-10 Site	Task 1 Estimate[1]	Historical Monitoring Data Estimate[2]
Bradbury	Southwest	3.7 miles	30	3
Cedar Bluff	East	13.1 miles	8.2	0.82
Clinton	Northeast	15.8 miles	5.5	0.55
Dyllis	Northwest	6.3 miles	4.1	0.41
Farragut	Southeast	9.4 miles	9.9	0.99
Gallaher Bend	East	3.9 miles	39	3.9
Hardin Valley	East	7.5 miles	19	1.9
Kingston	Southwest	11.8 miles	7.8	0.78
Lenoir City	South	9.6 miles	6.2	0.62
Scarboro	North	5.8 miles	1.4[3]	0.14

Notes:
For estimated doses, all units are in rads (same as centigrey [cGy]).
[1] All dose estimates are central estimates (i.e., the average, rather than the lower- or upper-bound estimates) and are based on a female born in 1952 who consumes backyard cow's milk and other local produce (i.e., fruits, vegetables, dairy products, and meats).
[2] The Task 1 report's estimates are reduced by a factor of 10 to account for the findings from the recently discovered air monitoring data (1953, 1955, and 1956) and deer sampling data (1979–1989).
[3] Since Scarboro is a more urban community, the Task 1 investigators based the dose estimates on a female born in 1952 who consumes regionally mixed commercial milk and inhales I-131.
The dose expected to result in an increased risk of thyroid cancer is 10 rads. Cells are shaded orange if the estimated I-131 dose exceeds this value.

What Conclusions Did ATSDR Reach about Potential Health Effects Related to Past Exposure to I-131 Released from ORR's X-10 Site?

The RaLa process at the X-10 site released radioactive iodine from 1944 to 1956. Those who lived near the ORR during this time period might have come in contact with radioactive iodine in their food (primarily from drinking local cow's or goat's milk) or in the air they breathed. The extent to which off-site communities were affected by radioactive iodine releases from the X-10 site in the past cannot be determined; ATSDR could not satisfactorily determine whether residential exposures to I-131 occurred as a result of X-10 site RaLa processing at levels sufficient to cause harmful health effects. The specific reasons for this conclusion are presented below.

- The lack of sufficient environmental data resulted in large uncertainties associated with the modeled Task 1 report's thyroid dose estimates. The wide range in the lower (2.5th percentile) and upper (97.5th percentile) bound values provides evidence of substantial uncertainty in the estimated thyroid doses. For a hypothetical individual, the range between many of the estimated lower and upper thyroid doses spanned two orders of magnitude (i.e., vary by a factor of more than 100). Therefore, the estimated doses could vary from 10 to 100 times above or below the central estimate (or average) thyroid dose. Consequently, because of the uncertainty in the Task 1 report's dose estimates, identifying the population that truly received exposure doses greater than 10 rads is problematic.
- The Task 1 dose reconstruction models suggest that from 1944 to 1956 radioactive iodine released from RaLa processing affected areas extending as far as 24 miles from the X-10 site. Recently discovered historical air monitoring data from the 1950s and deer thyroid data from 1979 to 1989 suggest, however, that radioactive iodine released into the environment from RaLa processing did not extend beyond the X-10 site boundary at levels that would constitute a public health hazard.

Nevertheless, after reviewing the most recent data related to thyroid-induced diseases from the 1996 Chernobyl nuclear accident, and given the limitations in the data and the uncertainty in the Task 1 report's dose estimates, ATSDR did conclude the following about past I-131 exposures:

- Individuals who were living near the ORR and were at least 21 years of age† during the initial years of RaLa processing would not be expected to develop thyroid diseases resulting from exposure to I-131 releases from the X-10 site.
- ATSDR considers the critical-sensitive population with the potential for developing thyroid diseases, including thyroid cancer, as those persons who were under the age of 18,† who lived near the ORR during the years of RaLa processing, and who may have received a thyroid radiation dose in excess of 10 rads. However, because insufficient information is currently available, ATSDR cannot make a definitive public health statement regarding the potential for health effects from past I-131 releases for persons who were living near the ORR and who were under age 18 at the time of RaLa processing at the X-10 site.

† The literature regarding health effects is inconclusive for individuals 18 to 20 years of age.

ATSDR's Recommendations

ATSDR recommends collecting soil samples downwind and upwind of ORNL (on- and off-site) and analyzing these soil samples for I-129. Although I-131 releases from X-10 RaLa process is no longer present in the environment, the current radioactivity of I-129 in soil can be used to evaluate past I-131 concentrations. ATSDR believes that data collected for this I-129 analysis can be used to reduce the uncertainties associated with the estimated thyroid doses in the Task 1 report and to better define the off-site populations potentially impacted by I-131 releases.

As a prudent public health practice, ATSDR recommends that residents who lived in the potentially affected communities and were 18 years or younger between 1944 and 1957 discuss the need for thyroid exams with their local physician.

What Other Issues is ATSDR Evaluating at the Oak Ridge Reservation?

In addition to the public health assessment on I-131 releases from the X-10 site, ATSDR scientists have released or are conducting PHAs on the following Oak Ridge Reservation issues:

❖Mercury releases from the Y-12 plant

❖Uranium releases from the Y-12 plant

❖Polychlorinated biphenyl (PCB) releases from the X-10 site, the Y-12 plant, and the K-25 site

❖Uranium and fluoride releases from the K-25 site

❖Contaminant releases from the TSCA Incinerator

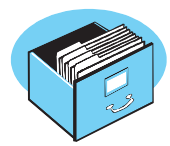
❖Contaminated off-site groundwater

❖Screening for current chemical exposures

❖Radionuclide releases from the X-10 site to White Oak Creek

Where Can I Get More Information?

Visit one of our records repositories



The records repositories are located at the Oak Ridge Public Library, the Department of Energy Information Center in Oak Ridge, the Harriman Public Library, the Kingston City Library, Roane State Community College, and the Rockwood Public Library. These repositories have copies of all reports that ATSDR has completed to date, along with reports completed by other agencies.

Visit the ATSDR Web site

More detailed information on I-131 releases from the RaLa process at the X-10 site is available from ATSDR's Web site at *http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html*. The ATSDR Web site has links to past publications, schedules of future events, and other information of interest.

Contact ATSDR directly

Contact ATSDR representatives by calling the agency's toll-free number, 1-800-CDC-INFO (1-800-232-4636), or by directly contacting Paul Charp or Jack Hanley.

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