Chapter Nine

Hot Stuff

Heck, we weren't afraid of it. You just had to be schooled in it.
I knew the HPs were looking out for us.

—Clyde Hammond—

Dr. Richard Doan and John Horan, director of the Health and Safety Branch of IDO, were in Washington, D.C., to address a JCAE subcommittee studying industrial radioactive waste disposal. Representatives from the AEC's national laboratories and from private industries described for the committee the practices and standards prevailing at their sites. It was 1959. The hearings were part of a series that had begun two years earlier with inquiries on the effects of fallout from nuclear weapons testing. Judging by their questions, the committee was interested in the growing volume of waste, the consequently growing costs of managing it, and its impacts on the environment.[1]

The disposal of radioactive waste already was a subject the public knew something about. During the Manhattan Project days, Hanford had committed solid and liquid waste to the ground, a practice that relied on the ion-exchange capacity of the soil to hold radionuclides and keep them from migrating more than a few inches from their source. The practice continued during the 1950s and was reported freely to the public. *Popular Mechanics* magazine, for example, described Hanford's "hot garbage" in one of its 1955 issues. Using the sort of exaggeration that dismayed scientists, the article tried to get the point across: "Desert soil soaks up the deadly wastes with sponge-like rapidity, and earth particles trap and filter much of the radioactive material on the way down." In the late 1940s, Argonne scientists in Illinois packed waste into special containers and thought about placing these in abandoned salt mines or rocketing them into outer space.[2]

The AEC in its early years took little interest in waste disposal and declined to establish uniform policies for its laboratories. In 1948 the AEC asked its laboratory directors to meet together and suggest something. Upon taking a vote at the end of this discussion, the majority decided that each lab should solve waste disposal problems in its own way. The AEC went along with this democratic idea. By the time Bill Johnston took charge of the Idaho station, nothing had changed, so the NRTS evaluated its options without reference to prescriptions emanating from Washington.[3]

With reactors going critical at the NRTS, radioactivity became a part of daily life and had to be understood, controlled, and minimized. Radioactive waste of various kinds was going to be generated. It would come in the form of solids, liquids, and gases. Like any other hazard, it could be managed safely if it was respected. The task of inventing the testing station wasn't finished until all waste had a destination. Not only did workers have to be protected, but also the nearby population and the environment they all shared.

For solids, the IDO decided to employ a landfill. IDO's Division of Engineering and Construction developed a set of criteria and asked the USGS to find a good spot. It should be at least ten acres. Fifteen to twenty feet of sedimentary overburden should lie over the lava

When needed for protection in radiologically contaminated areas, workers wore anti-contamination (anti-C) clothing including taped shoe covers and gloves, hair coverings, respirators, and Scott Air-Paks.

Argonne National Laboratory-West 9079

Radioactive Half-Life

Radioactivity is a natural characteristic of elements like radium and uranium. It also is a characteristic of many elements that have absorbed neutrons while in a nuclear reactor.

The nuclei within radioactive atoms are unstable. They disintegrate (decay) by throwing off one or more of their constituent particles spontaneously. As time passes, the material actually changes from one element or isotope into another, one atom at a time.

No one can predict when a specific atom will decay, only the probability that a certain percentage of atoms will disintegrate within a certain period of time.

Physicists decided that the "half-life" of a radioisotope would be a convenient way to describe the decay of a substance: the time required for one half of the atoms to disintegrate.

The process of decay takes place regardless of the temperature, the pressure, or chemical conditions surrounding the substance. Different authorities identify slight differences in half-life depending on the method used to count. The number following the name of the element identifies a specific isotope that is radioactive. It is the combined number of neutrons and protons in the nucleus of each atom.

Radioisotope	Half-life	Radioisotope	Half-life
Silver-110	24.6 seconds	Krypton-85	10.73 years
Indium-114	1.198 minutes	Hydrogen-3 (Tritium)	12.32 years
Barium-137	2.6 minutes	Strontium-90	25 years
Lanthanum-140	1.687 days	Cesium-137	30 years
Cadmium-115	2.228 days	Americium-241	432.2 years
Ruthenium-97	2.44 days	Radium-226	1599 years
Iodine-131	8.040 days	Carbon-14	5715 years
Niobium-95	34.97 days	Plutonium-239	24,400 years
Hafnium-181	45 days	Iodine-129	1.72×10^{7} years
Polonium-210	138.38 days	Uranium-238	4.46×10^{9} years
Cobalt-60	5.271 years	Uranium-235	7.04×10^{8} years

rock, and it should contain plenty of clay. Workers should be able to dig vertical-walled trenches and not have them collapse. Naturally, the area needed good surface drainage and couldn't be upstream of any reactor sites. The IDO wanted to be able to get to the landfill without having to build a long, expensive road.[4]

The USGS suggested a one-hundred-acre area about two miles southwest of EBR-I and five miles west of Central Facilities. The site met most of the criteria. The depth of sediment above the lava rock, having been blown by the wind for thousands of years, was not uniformly twenty feet. However, the soil contained clay, which provided good ion-exchange and absorptive capacity. Any moisture that managed to saturate the waste and suspend radioactive isotopes would travel into the soil, where chemical reactions would tend to remove radionuclides from the water and bind them to the soil. The water would move on, albeit slowly, because fissures in the lava rock had filled with sediments, and this too would retard the movement of contaminants. The desert climate, which contributed about eight inches of precipitation per year over the Site, was an ally of the landfill plan, as very little moisture sank deeply into the soil. The geologists noted that it was unlikely, but possible, that water reaching the soil could carry contamination downward to the water table (of the Snake River Plain Aquifer).[5]

The IDO accepted the USGS recommendation and in May 1952 fenced off the first thirteen acres of the controlled access area that soon became known as the NRTS Burial Ground. In July workers opened the first trench, six feet wide and nine hundred feet long. The place was in business. Waste disposal became another of the central services provided to contractors doing experiments in the desert.[6]

Solid items came from daily routines as well as one-of-a-kind experiments. They ranged from tiny scraps of paper to heavy pieces of equipment. Around the reactor sites, the simplest wastes resulted from the very work of trying to prevent the spread of radioactivity in work areas. HPs made daily rounds of reactor areas and laboratories to check for leaks, hot spots, and radioactive dust. Using thin sheets of filter paper, they took hundreds of "swipes" every day. They also went beyond the reactor areas. One of the HPs, Henry Peterson, recalled:

Once a week at the Test Reactor Area [TRA, site of the MTR], we also surveyed the areas that were supposed to be clean. We swiped the cafeteria and all the offices. We swiped desks, drawer handles, any place where people were and the things they touched. You'd put the swipe in a little envelope, label it, and put it in your shirt pocket until you went to the lab and put it in the counter. It was no big deal—these were microcuries we're talking about. Then you'd do the floor with a wide-area detector and look for hot spots. If you found one, you used masking tape to pick it up. If that didn't do it, you'd rope off the area for cleaning later. We had to prove every week that a place was clean.

I remember one time we had to rope off the entire MTR lab wing because an analyst was sloppy. He crapped up [contaminated] a hallway by spilling something on the floor and then walked around with it on his shoe.

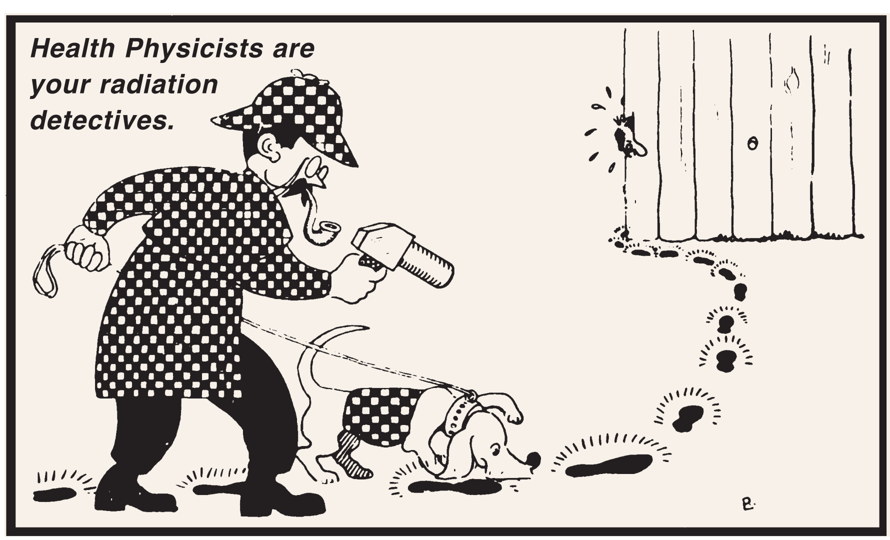
We also checked dust mops. Maintenance people were pretty thorough. Most of the time, we'd find nothing, but occasionally we did. Those kinds of practices were effective [in controlling radioactivity]. HPs didn't have a head-hunter mentality. We tried to do critiques that helped reactor operators solve problems.[7]

To find some radioactive speck was to contaminate the smear paper, however slightly. The same was true of mopheads that had done their intended job after a spill. Hot-cell work produced waste: beginners as well as experienced operators sometimes spilled a radioactive sample or broke glassware. Some items, even unbroken, were not reused once they had been contaminated. The Navy used disposable baby diapers as soak-up rags, although at other hot cells, technicians preferred women's sanitary napkins and ordered them by the gross. These, along with smear papers, gloves and glass shards, were tossed into waste bins marked with the standard yellow and magenta warning symbol and posted for radioactive waste.[8]

Larger objects included particulate filters. Having trapped radioactive dust from gases sent up laboratory vents and process stacks, these were regularly

INEEL 73-1552

Above. Aerial view of the Burial Ground in 1973. Triangular shaped area is the Subsurface Disposal Area, where transuranic (TRU) wastes were buried before 1970. Foreground shows the above-ground Transuranic Storage Area, where TRU wastes were stored after 1970. Below. Reminders such as this were placed in Site publications to make employees aware of the responsibilities associated with radioactive materials.



removed and replaced. Nuclear experiments generated contaminated debris and machinery, some of it in large and awkward shapes. Discarded pipe fittings resulted from the repair of lines that had carried contaminated fluids. Structural metal that once had been part of an irradiated fuel assembly had to be discarded. It all went to the Burial Ground.[9]

INEEL 62-2132

Above. Open trenches occasionally became susceptible to flooding from rapid snowmelt or heavy rains. Below. Workers check radioactivity at a long-tongued trailer.

Twice a week, someone went to all of the reactor buildings and labs, emptied the radioactive waste bins, boxed the contents, and trucked the load to the Burial Ground. Cardboard was sufficient for regular items, but wooden crating was used for bulky larger items. An HP went with the truck driver and took radiation readings near the waste containers and in the cab of the truck. Like everyone else, trash haulers were not allowed to exceed daily radiation dose limits. If a load, such as one containing metal parts that had become radioactive in the neutron environment of a reactor, had too high a reading, the driver used shielded containers and hauled them behind his pick-up truck on a long-tongued trailer. These loads were then transferred from the truck to their burial place with the help of cranes. Depending on how strong the radiation, workers covered the load with earth immediately or waited until the end of the week. The Burial Ground was designated for solids only, but a few sealed containers of liquid apparently found their way into the first trench.[10]

When the first trench was full, a cover of earth went over it and it was planted with native grasses. Another was opened, and then another, each location identified with the help of tags placed on the perimeter fence. The first trench served until October 1954.[11]

One trench every one or two years might have met local needs at the NRTS, but the AEC had a problem elsewhere that intruded into IDO plans. In 1951 President Truman and the defense establishment decided that the nation's security required enlarging its stockpile of nuclear weapons. They began building new weapons production plants around the country, one of them the AEC's Rocky Flats Fuel Fabricating Facility near Golden, Colorado, about sixteen miles northwest of Denver.

The plant went under construction in 1951 and began operating in 1952. Here the AEC manufactured hollow plutonium spheres that served as trigger devices for nuclear warheads. Rocky Flats machine shops also made other weapon

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parts from stainless-steel, beryllium, depleted uranium, and other metals. Waste materials were contaminated with plutonium, solvents, and other industrial chemicals. Although Rocky Flats operated no nuclear power reactors, its scientists conducted criticality experiments in connection with weapons development.[12]

At the time, the Rocky Flats plant occupied only four square miles. The water table beneath the surface was high and known not to be isolated. Furthermore, a civilian population resided near the plant. Burial of waste on-site obviously was a poor option.[13]

The AEC calculated the cost of land burial at the NRTS and at the Nevada Test Site, another AEC facility. Of the two, the NRTS was closer. In April 1954 Rocky Flats shipped several drums of low-level plutonium waste to the NRTS in a trial run. The shipment went well, the costs were reasonable, and the decision stuck. It was the first in a steady stream of shipments that flowed into the Burial Ground for decades to come. Like it or not, the IDO accommodated Rocky Flats deliveries. John Horan said later that the IDO did not like it. Rocky Flats was never consistent in how it characterized its shipments and refused to identify the contents in any meaningful detail.[14]

Some of our people got rather ornery about that, dug their heels in, and threatened not to accept it at one point. We didn't always feel they were honest about what they were sending us. We had criteria for the Burial Ground, such as "no liquids." But they did send liquids—trichloroethylene [was one of them].[15]

Rocky Flats justified keeping secrets from IDO managers as a matter of national security. The NRTS was not considered a weapons laboratory and did not have access to many of the details concerning the waste or how it was generated. After considerable haggling between IDO and Rocky Flats over this, Rocky Flats finally agreed to supply IDO with an annual memorandum summarizing the waste that had been shipped during the previous year.[16]

The fact that waste shipments came to Idaho from Rocky Flats, however, was a matter of public record. At the 1959 hearing, which was public, the chairman of the subcommittee, Carl T. Durham, interrupted a discussion on the cost of waste disposal to ask Horan:

Chairman Durham: Are you receiving any material from any other operations except what is going on at Idaho?

Mr. Horan: Yes, sir; we do. We receive a large volume of waste from the Rocky Flats plant near Denver, Colorado, but this is the only other contributor of waste at our location.

Representative [Chet] Holified: Is that a processing plant?

Mr. Horan: It is a weapons fabrication facility.[17]

Plutonium and other human-made elements have an atomic number greater than that of uranium, which is 92, and are thus referred to as "transuranic" elements, or TRU. All are radioactive, and many have extremely long half-lives. Plutonium emits alpha particles, for which a piece of paper or three inches

INEEL 61-1824

Dumpster waste included boxed items, metal containers, and other scraps.

of air is sufficient shielding. This characteristic differentiated Rocky Flats waste from fission- or activation-product waste producing beta particles or gamma rays, which required stronger shielding. When the sealed drums of TRU waste arrived at the Burial Ground, workers handled them with nothing more than a gloved hand. Typically drums were taken off the back of the truck and hand stacked in rows in the center of a pit. Material that arrived in wooden crates went around the edge of the pit. Sometimes, workers handled unusual volumes—and packages—of waste, as labor foreman Clyde Hammond recalled:[18]

Once we got a bunch of stuff from a California contractor who buried waste at sea. He had it all ready to bury and then he went broke. He had it already loaded, so it came out to the Site, and they were all concrete barrels. Some of those barrels weighed more than a ton apiece. So we buried them out here.

They had a big spill at Rocky Flats, Colorado, and we got their whole plant out there, lathes even. It was a big mess. Truck after truckloads of stuff.[19]

The "big spill" at Rocky Flats was caused by a fire in September 1957. A small pile of plutonium shavings ignited spontaneously in a glove box. Inexplicably, the glove box was made of acutely flammable plexiglas, and the fire raced out of control through the building. The fire blew out or burned hundreds of ventilation filters and melted the top of an exhaust stack. The bulky clean-up debris went to the NRTS Burial Ground packed in thousands of barrels.[20]

Courtesy U.S. Department of Energy-Rocky Flats 26568-02

By the time of the fire, the Burial Ground's first thirteen acres—and ten trenches—had been filled up. In November 1957, two months after the fire, the IDO opened up new acreage. Workers began digging pits for the bulky post-fire increase of TRU waste. They continued using trenches for the NRTS's own fission- and activation-product waste. However, when someone at the NRTS generated an item too bulky for the narrow trenches, the practical thing to do was to place it in one of the Rocky Flats pits. Thus, different waste types were mixed together in some areas. The main difference between a trench and a pit was the shape of the excavation. Pits were of varying sizes. Some of the large ones were up to 300 feet wide and 1,100 feet long. Others were as small as 50 feet wide by 250 feet long. The work presented certain challenges to equipment operators. Hammond recalled how they solved one of them:[21]

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Above. Work stations inside the Rocky Flats fabrication plant had numerous glove ports. Below. Sealed enclosures called glove boxes allowed for workers to handle plutonium without direct exposure to it.

We had to keep two feet of dirt between the solid rock and the barrels. Well, nobody knew how to do that, since we didn't know where the rock was and whether it laid evenly beneath the surface. So we drilled holes down to the rock... We'd measure the hole and then pour corn seed in the hole to fill the bottom two feet. Then when we dug the pits, the equipment operators would come in with cats and cans [tractors equipped with scrapers]. We took all that dirt off. When we hit the corn, we knew we had two feet left to the rock. That's how we dug the pits and kept our two feet of dirt on top of the rock. It worked. It was an HP's idea.[22]

This application of Yankee ingenuity eventually changed. Later excavations were made to bedrock and then backfilled with soil and clay. Another once-practical technique that flourished during the 1960s also gave way. In 1963, some combination of labor shortages (caused by strikes) and funding problems led Burial Ground operators to start rolling waste drums off the backs of trucks and let them lay in the pits where they landed. With Rocky Flats barrels coming in by the thousands, tipping them out was faster and cheaper than manhandling every barrel. The practice, which continued until 1969, was further justified by the fact that it reduced potential exposure of workers to radiation. The barrels, regarded as settled in their final resting place, were expected to deteriorate eventually, so the environmental impact of the procedure, which damaged or dented some of the barrels, was regarded as of no serious consequence.[23]

Between 1960 and 1963 the AEC designated the NRTS, along with Oak Ridge, as a disposal area for commercial radioactive wastes from such places as hospitals and universities. Previously, commercial businesses had placed this material in the oceans, but the practice was too costly to continue. No commercial landfill sites were available anywhere else in the country at the time. The designation resulted in relatively little new waste for the Burial Ground, but it provoked NRTS managers to remind the AEC that the NRTS facility lay over an aquifer. Even though the NRTS was taking no undue risks, the AEC should look for permanent waste disposal sites elsewhere.[24]

Gradually, improvements and changes occurred over the years. Different types of waste were segregated, record keeping methods grew more sophisticated, procedures and requirements became more formal. Upper limits on the level of radioactivity handled at the Burial Ground went into effect after 1957. In February 1962 nearly two inches of rain fell on snow and frozen ground, causing localized flooding. One pit and two trenches were open at the time, allowing pools to form, overflow, and carry dumped items beyond the excavated area. After this, a diversion drainage system was constructed in hopes of preventing another such episode. Guidelines were established for fissionable material (U-235, Plutonium-239) to prevent the possibility of accidental criticalities. Decades later, analysts studying the waste regretted that standardization had not arrived earlier; they could have used better information about early waste types and their specific locations. Early records of what went

A crane helps workers unload Rocky Flats barrels in 1961.

INEEL 61-1650

INEEL 58-1450

INEEL 69-6138

Above. Workers unload and stack drums of Rocky Flats waste in 1958. Delivery truck required no shielding. Below. A load of drums containing 1969 fire debris tumbles into a burial pit.

into the trenches were not complete. But the Burial Ground was intended to be a permanent facility. No one at the time imagined that someone would ever wish to disturb it.[25] As John Horan said to the JCAE at the hearing:

Senator [John O.] Pastore: For how long will that burial ground be considered quarantined?

Mr. Horan: Indefinitely.[26]

Likewise, environmental monitoring improvements came gradually to the Burial Ground. The USGS drilled a system of ten monitoring holes west of the burial trenches in 1960 so that the progress of any subsurface moisture could be detected. Film badges went up around the perimeter fence to monitor direct radiation levels at the boundary of the Burial Ground. Later years brought additional monitoring holes, test wells, and more sophisticated monitoring techniques, particularly after the public became more concerned about the possible migration of contaminants to the aquifer.[27]

With respect to the liquid wastes generated at the NRTS, Doan and Horan described for the JCAE the NRTS strategy. The philosophy was similar to that followed at AEC facilities elsewhere. It depended on whether the waste was contaminated with radioactivity or not, and if so, whether the hazard was "high-level" or "low-level." If it were low-level, the strategy was to dilute it and disperse it to nature—into the air, water table, or soil. High-level wastes were those for which such dispersion would endanger the environment. Here, the strategy was to hold onto the material, typically in stainless-steel tanks at the Chem Plant, concentrating it if possible to reduce the cost of managing it.[28]

Water was by far the major constituent of most low-level liquid radioactive (and non-radioactive) waste. Reactor operations used water by the billions of gallons every year as a reactor coolant and in canals to store irradiated fuel. Water was used in decontamination. At the Chem Plant water was used in a variety of ways—for cooling, to make up chemical reagents, for dilution, and to clean up process equipment. Evaporator condensate at the Chem Plant produced large volumes of water.

Depending on how it had been used, a stream of waste water might be contaminated by virtue of irradiation, as when it passed through a reactor, or because it had picked up particles in the clean-up of spills or equipment. To determine what level of dilution, if any, were needed before a watery waste could be dispersed to the environment, the IDO used as its guide a National Bureau of Standards handbook known as *Handbook 52*. This book identified the maximum allowable concentrations of each radioisotope that could be permitted in public water supplies. In lieu of any other guidance from AEC Headquarters, the NRTS used this handbook in its own way, as Horan described for the JCAE:[29]

Liquid radioactive wastes discharged to the ground are maintained at such levels that the concentration in water at the nearest point of use down gradient will not exceed one-tenth of the maximum permissible concentration... Solutions which are within the prescribed limits may be discharged to the groundwater table through wells, pits, or ponds. Adsorption, dilution, and decay factors determined by IDO may be used in establishing allowable concentrations at points of discharge in order to comply with our basic guide...[30]

The USGS had advised the IDO that water flowed through the aquifer at a rate of thirty-five feet per day. Horan continued:

Since this cannot be a precise determination, and recognizing that there are variations from location to location, a safety factor of 10 has been incorporated into our calculations. Therefore, we have assumed a linear velocity of 350 feet per day.[31]

Thus, the IDO had evaluated the risk inherent in discharging above an aquifer and developed formulas containing several safety factors. The formulas exaggerated the rate of flow by ten times and reduced the allowable maximums (at the point of use) by ten times. Against these factors, the half-life of each isotope was considered. The IDO Health and Safety Division then translated all of these factors into a set of disposal guidelines for each radioisotope and obliged all of its contractors to follow them when sending any liquids into the environment.[32]

To reduce the uncertainties pertaining to water flow in the aquifer, Horan stepped up environmental research. He hired, among other specialists, soils scientist Bruce Schmalz to work with the USGS on further investigations of the interplay between the waste, the soils, and the aquifer. Early research was conducted at a 600-foot-deep low-level waste injection well at the Chem Plant, into which went water that had been treated with sodium chloride—salt. The USGS drilled fifteen monitoring wells down-gradient from the injection well, thinking that the salt in the injected water would act as a convenient tracer. Each day, the Chem Plant discharge contained up to two tons of salt. When normal sampling methods repeatedly failed to detect any salt in the monitoring wells, Schmaltz tried something else:

One of the first things I did was to decide that something different needed to be done. We weren't getting anywhere, so to speak. I'd heard about the use of a florescent dye. So I and another fellow mixed up a fifty-gallon drum of this fluorescent dye and put it down the well together with a big slug of salt. The slug was, I think about fifteen tons all at once. We never did find the salt, but we found the fluorescent dye... This started the analysis of the rate of movement [of water in the aquifer] and the diminution of concentrations as a function of distance.[33]

INEEL 67-5191

Settling pond at the Test Reactor Area in 1967.

INEEL 56-3203

Sodium potassium (NaK) waste is flammable and potentially explosive in contact with water or moist air. Shooting the barrels containing it introduced air in the container, causing combustion. A fire hose was used to complete the burn of any waste not initially burned. This Nak disposal took place in Trench 7 in 1956.

Elsewhere at the NRTS, settling ponds or disposal to a drain were used instead of injection wells. This was done mainly to prevent accidental discharges of concentrations above the allowed concentrations. The ponds worked in concert with holding tanks and monitoring routines. Horan described the early system used at the Naval Reactors Facility (NRF):

The NRF had two waste tanks, 125,000 gallons each, into which all of the liquid drainage of the reactor building were collected. The liquid was then sampled when a tank was filled and analyzed in the health physics counting room...[The analysis determined what radioactive constituents were in the water.] After measurement, the waste could be pumped out in a pipe that ran underground until it reached a French drain in the southeastern area outside the fence. The Navy reactors that came after the STR [S1W] were held to a zero-leakage design standard. Little radioactive material appeared in the waste holding tanks from those plants.[34]

At TRA, Phillips used retention basins. MTR operations used demineralized water to cool the reactor and to shield the spent fuel in the canals. Despite this pretreatment to remove impurities, the water contained traces of sodium that were activated while passing through the reactor core and had a half-life of about fifteen hours. This then became part of the waste stream, but had to be held until the sodium had time to decay, about a week. In the canal, the cladding on a spent fuel element occasionally developed a pinhole leak. Fission products within the element then leached into the canal water. The water was constantly bled off and replaced with fresh water, so after such a leak, it contained traces of fission products. The water went to a soil-lined pond after passing through a filtration system. Solids settled to the bottom of the pond, the smaller particles adsorbed or absorbed by the clay. The particles continued their radioactive decay while the water evaporated. These procedures were part of the general routine, although unofficial side experiments were not unknown, according to HP John Byrom.[35]

Some interested fisherman conducted his own experiment by dumping a few fertilized trout eggs into one of the hot settlement ponds. We noticed a few large healthy(?) trout swimming around in the pond for several years after. These ponds were sampled monthly for many years—or more frequently when an incident indicated that radioactive material greater than normal had been accidentally released to the ponds.[36]

The IDO operated a hot laundry to wash coveralls and other protective clothing that had served its mission in the course of someone's work. Located at Central Facilities, the laundry drain went to a septic tank and drainfield with other sanitary waste.[37]

Also at Central was a landfill for non-radioactive waste. As a fully equipped industrial complex, the NRTS supported machine shops, carpentry shops, fabricating centers, paint shops, automotive and bus garages, electric substations, and every conceivable kind of non-radioactive laboratory—chemical, metallurgical, photographic, and dosimetry. All of these activities generated their own typical wastes—metal and wood scraps, solvents, resins, acids, caustics, broken tools, empty containers, and the like. Depending on the material, it was disposed of in the vicinity of the particular work area or it went to the landfill at Central. Sanitary waste went into sewage lagoons at each reactor complex. Even paper products had a treatment protocol. Some was shredded and incinerated; in later years, some of it was compressed, made into pellets, and sent to fuel the coal-fired power plant at the south end of the Chem Plant.[38]

Some varieties of chemical waste posed explosive hazards, and these were stored or treated by methods unique to the substance. Sodium potassium alloy (NaK), for example, could react explosively when placed in contact with water. Occasionally, small flasks of NaK had to be discarded. On one occasion, five such flasks went into a container which was then isolated in a trench at the Burial Ground. A security officer fired upon the container with a charge intended to ignite the contents and burn it. A small water supply and a hose stood by to give the NaK further encouragement to burn.[39]

Finally, wastes could take the form of gases. Procedures for releasing gases with radioactive elements, most of which were relatively short-lived, followed a similar logic as that for liquids. The dilution medium was air rather than water. These releases were subject to continuous study and research conducted jointly by the IDO and the Weather Bureau. Mechanical measures for holding, filtering, and scrubbing paralleled the measures used for aqueous wastes, as did the monitoring activities that accompanied all releases.

In the 1990s, the National Center for Disease Control undertook to identify the radiation dose to a hypothetical individual located off-site at a point of maximal exposure to Site releases between 1952 and 1989. To do this meant identifying the possible pathways by which radiation might have traveled away from the Site. The analysts who performed the retrospective study concluded that of all the potential pathways by which radiation might have reached off-site citizens, only the gaseous releases were of potential interest, and even those had been small. Solid and liquid waste disposal practices had not, at least until that time, provided a pathway to human populations, and were therefore of no consequence to the study. Solid and liquid waste practices had produced no measurable exposure to anyone beyond the boundaries of the Site.[40]