AN ABSTRACT FOR THE THESIS OF

Scott Allen Crail for the degree of Master of Science in Radiation Health Physics presented on May 3, 1999. Title: Implementing a Radiation Monitoring Program at a Solid Waste Landfill.

Abstract approved: Redacted for Privacy

Jack F. Higginbotham

More and more, modern society is incorporating the use of radioactive materials into everyday uses. And with society using more radioactive materials, the odds of it being accidentally disposed of into the solid waste stream increases.

There are several radiation systems available which market themselves as being complete and "ready to go". While it is true that a person could purchase one of these systems and would have coverage of the landfill, such a system does not provide the necessary education, response and liability protection programs. Indeed, it would be feasible to foresee a scenario where installing a systems could lead to an increase in liability and employee problems.

As a result, Coffin Butte Landfill worked with the author to establish a complete radiation monitoring program. This program encompasses everything from installment of the system to employee education and training. It also examined the myriad and murky depths of federal and state regulation dealing with solid and radioactive waste to help the landfill set an acceptance policy and minimize liability. This led the author to the belief that the combination of federal and state

regulations imply a requirement for landfills to have a working radiation monitoring program .

Future government action remains uncertain as pertaining to a requirement for landfills to maintain a radiation monitoring system. Indeed, current state regulations are out of sync with federal regulations regarding acceptable public exposures. It is hoped that, with this study's help, Coffin Butte Landfill and Oregon State University will continue with the established relationship and be prepared to respond to regulation changes.

Implementing a Radiation Monitoring Program at a Solid Waste Landfill

By

Scott Allen Crail

A THESIS

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APPROVED:

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Major Professor, representing Radiation Health Physics

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Head of Department of Nuclear Engineering

Redacted for Privacy

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Redacted for Privacy

Scott Allen Crail, Author

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INTRODUCTION

Modern society is incorporating the use of radioactive materials into many everyday uses. And with society using more radioactive materials, the odds of it being accidentally disposed of into the solid waste stream increases. Radioactive materials have many uses in modern day society such as: nuclear medicine (including local examples such as Good Samaritan Hospital and the Corvallis Clinic), industrial radiography, veterinary practices and research institutions (such as OSU which has over 400 licensed radioactive material users). They all have the potential of disposing of their radioactive materials in the solid waste stream. Recent studies have indicated that more than one third of hospital solid waste loads contain levels of radioactive materials that the user's internal monitoring programs failed to detect (Bangart, 1991).

Although applicable federal laws (Clean Water Act, Resource Conservation and Recovery Act) do not specially require solid waste landfills to establish radioactive material monitoring programs, many landfills have adopted such programs to protect themselves from undue liability and bad public perception.

There are several radiation systems available which market themselves as being complete and "ready to go"(Figure 1). While it is true that a person could purchase one of these systems and would have coverage of an area, such a system does not provide the necessary education, response and liability protection programs. Indeed, it would be feasible to foresee a scenario where installing a system could lead to an increase in liability and employee problems.

With the continuing wide spread use of radioactive materials in our society, opportunities for radiological protection personnel are expanding from the traditional areas to solid waste management. This expansion is based more on the requirements of solid waste landfills to manage the public's perceived view of waste management and its perceived risk versus the actual risk of a source powerful enough to endanger human health being accidentally disposed of in the solid waste stream. This paper examines the various issues that must be addressed when installing a radioactive waste monitoring program in a municipal solid waste landfill.

Like most nuclear facilities, landfills face the problem of NIMBY (Not in My Back Yard) syndrome. Most often problems arise when a local group of citizens have concerns about the operation that are not addressed properly, or even ignored. In frustration and ignorance, the local residents form groups that are dedicated to fixing the problem or, in extreme cases, shutting down the entire operation. It is my belief that the best way to fight NIMBY is to not only address the concerns of the citizens but to anticipate the concerns and address them before the local population even thinks of them. The management of Coffin Butte (Hunt, 1998) believes it can accomplish this goal by being a good neighbor.

Coffin Butte is a medium sized landfill (about 350,000 tons of waste per year) located in the Central Willamette Valley in Oregon. It serves an area encompassing five counties with a population of approximately 450,000. Its coverage area is a mix of rural small town and small cities. Licensed radiation users in the region include a university with a TRIGA research reactor and approximately 400 separate license holders on campus, 2 regional nuclear medicine and radiation therapy centers, and approximately 500 other industrial and medicine license holders. Commercial haulers have twenty-four hour access to the landfill through the use of a card key system that automatically registers weight and debits their accounts.

Figure 1. Landfill Monitoring System. Note the location of the detector boxes to the left and right of the truck.

Radioactive Incidents at Solid Waste Landfills

A growing number of operators of landfills are monitoring waste shipments for radioactive constituents. This has lead to several cases where loads from hospitals and industry have tripped the alarms of monitoring systems already in place. In most cases this leads to the load being rejected and sent back to the generator.

Case 1

A licensee had three incidents involving the release of disposable diapers containing microcurie amounts of ^{131}I from diagnostic procedures (Bangart, 1991). The diapers triggered the local landfill's monitoring system. During unloading, the contaminated diapers were retrieved. The quantity of ^{131}I reported ranged from 150 to 290 μcuries.

Case 2

A state representative reported that ^{131}I, originating from a hospital was found in a county landfill. The material was urine containing 60 μCi of ^{131}I from a diagnostic renal study and was contained within a collection bag from a catheter device. Surface radiation levels were found to be 3 mSv per hour (Bangart, 1991).

Case 3

A 42 cubic yard waste container from a hospital caused a counter at a landfill to trigger the alarm indicating the presence of radioactive materials in the container (Bangart, 1991). Personnel from the landfill contacted the hospital and requested their assistance in the recovery operation. Hospital personnel went to the landfill and recovered one bag of trash containing radioactive materials. Investigation revealed that the bag came from a room of a patient who had undergone ^{131}I therapy.

Case 4

The former owners of The Parks Township site disposed of radioactive (primarily uranium and thorium) and non-radioactive waste during the late 1960's and early 1970's(Hickey, 1998). At the time, the disposals were allowed under 10 CFR 20.304. This provision was later rescinded and some of the waste was known to exceed the resulting NRC radiological criteria for decommissioning. The NRC then required the owners to remediate the site to achieve acceptable standards. While this was never considered a solid waste landfill, it is an example of how changing government regulations can affect landfills.

Landfill Characteristics

Many people still associate today's landfills with the image of the "old town" dump. Decades ago, the formula for disposing of trash at the dump was to dig a large hole in the ground and toss in any garbage. Fortunately, methods of refuse disposal have changed and as a result, the sanitary landfill has emerged.

Contrary to what many believe, a landfill can be a "good neighbor" to its surrounding communities. Wildlife protection areas within the landfill are set aside for both endangered species, as well as other rare wildlife found in the area. The final plans guarantee that once a landfill has closed, its appearance will match the surrounding area. Systems are in place at all of the landfills to make sure that the landfill does not have a negative impact on the neighboring communities. Monitoring and control systems are in place for groundwater protection, leachate control, gas migration and run-off and will continue to be operated for fifty years after the landfill is closed. Buffer zones, or strips of undisturbed land that circle the landfill, are present at each site. They protect the adjacent communities from noise, odor and off-site gas migration. The landfill has worked to ensure that protected ridgelines will remain undeveloped and the community's view of the landfills is pleasant. Random spot checks are performed on vehicles and commercial loads that enter the landfill for the presence of hazardous materials. Those found carrying hazardous materials are turned away. The landfill staff also observes all loads as they are being dumped in order to catch any household or illegal waste in the load.

The landfill operates a permanent center available to those residents who wish to dispose of their household toxics. These centers are free of charge. Landfill staff is trained in hazardous waste recognition and is prepared to handle toxic emergencies. (Personal communication with B. Hunt at Coffin Butte, 1997)

Equipment

The radiation monitoring system installed at Coffin Butte Landfill is the Model 3523 Radiation Monitoring System by Ludlum Instruments. The Model 3523 Radiation Monitor System is designed to detect low levels of γ radiation in loads passing through the system. The monitor is very easy to use and requires only minimal operator interaction. Upon power up, the monitor requires approximately fifteen seconds to measure background reading. It is then ready for operation. Diagnostic routines provide assurance that the system is operating correctly and indicators warn of possible failures.

Two three inch (7.6 cm) diameter by 3 inch (7.6 cm) thick sodium iodide (NaI) scintillation detectors provide coverage on both sides of a vehicle. The detectors have 0.71 inches of lead shielding and are housed in a NEMA4X weather tight fiberglass enclosure (Figure 2). The Model 3523 Radiation Monitor is a two channel dynamic monitoring system. The system was placed at the scale/fee booth of the landfill. This was done to increase counting time while trucks stop for approximately thirty seconds to be weighed and pay their fee. The actual arrangement of the detector units is varied from the recommended setup pattern. The recommended setup was to place the detector units on each side of the road so that the detectors are at the midpoint of the truck when it is stopped. In order to allow room for fee personnel to collect fees unhampered, the detector unit on the west side of the scale was placed further back. It ended up being placed about a foot from the rear of most commercial trucks. Unfortunately, this provides coverage of smaller trucks (pickups) and cars with only one detector unit. This short coming is addressed by the decreased likelihood that these types of vehicles would be carrying radioactive materials and the increased time that it takes for them to be processed through the scale/fee system, which allows for a longer counting period. The detector units receive power and communicate alarms to the microprocessor through twenty-foot cables that were run under the scale and through holes drilled through the concrete of the fee booth. Each detector has its own high voltage power supply to minimize the risk of total system failure (Ludlum Measurements, 1996).

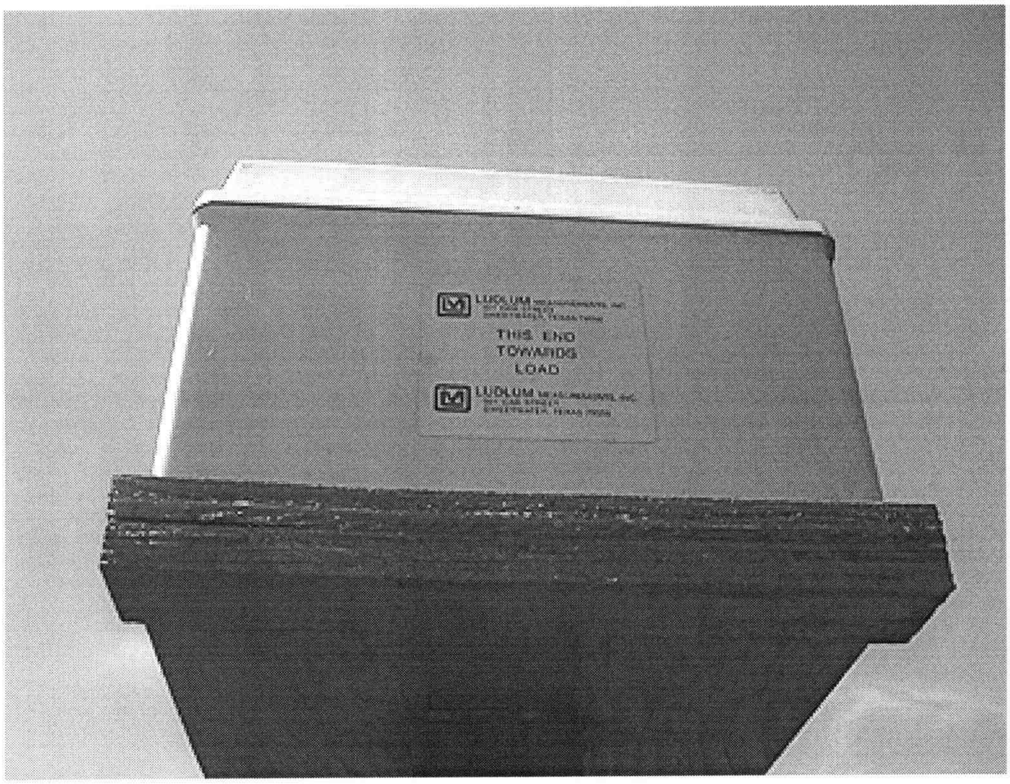

Figure 2. NaI Detector.

The microprocessor-based electronics are constructed in a steel box (Figure 3). This unit provides automatic background compensation and automatic alarm point setting above the current background reading. It provides for a reading on its scale from zero to twenty microrem. The system also allows the operator to determine which detector is alarming by lighting appropriate detector lights. It also has a loud audible alarm and flashing red light to ensure that the fee booth personnel are quickly aware of the presence of radioactive materials. The microprocessor was hung on the side of a permanent cabinet, where it's scale is easily readable and the alarm can be clearly heard throughout the booth.

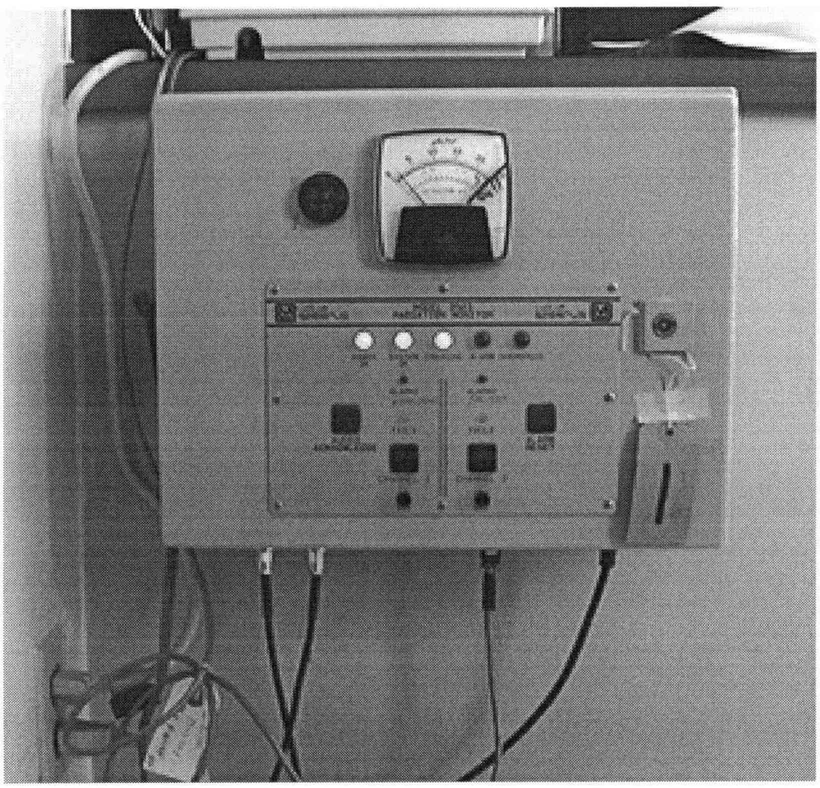

Figure 3. The 3523 Microprocessor unit.

At the request of the landfill operators, a printing system was installed to give written notice of alarms, especially those that happen after hours. The idea for this system was to let the landfill operators know if a source had come in while the fee booth was closed. If the alarm is sounding when the fee booth personnel enter the booth, they compare the time of the alarm with the scale record to see if a truck was present when the system tripped. If there is a correlation, then consulting personnel are called and they attempt to locate the source of the radioactivity. To date this has not happened.

The entire Model 3235 Radiation Monitor System is powered through an Universal Power System (UPS) to smooth the very unreliable electric current that is available at the fee booth.

Currently the system is set to alarm at twice background (approximately 6 mSv). The alarm point is set this low to allow for the inherent shielding present in the non radioactive portion of the waste, the iron sides of the truck, and the distance between the detectors and the side of the truck necessary to ensure the detectors are not damaged (approximately three feet). This low level is complimented by the low background radiation of the fee booth area. The low level of background radiation is due the fact that the fee booth was constructed at the base of the landfill on clay. This clay minimizes the amount of radon in the area because it is not very permeable to gasses.

The other equipment bought for the program is to be used only by the radiological health consultants. This equipment consists of a hand held survey meter with a pancake probe. The purpose of this meter is to allow the consultant to locate the approximate location and strength of the source.

Future purchases

Future purchases include the acquisition of a Bicron microrem meter. This would give the staff the ability to locate weak sources quicker and easier. It would also enable the consultants to perform a gamma pathway analysis to determine the acceptability of low levels of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) waste. I would prefer the Bicron due to its more even response across the energy spectrum.

ALARM RESPONSE

The following procedures were developed to give guidance to the fee booth personnel and to allow them to continue normal operations based on the actual risks. It was designed to minimize the amount of time that the waste truck must spend waiting for health physics personnel to respond. Anything that gave a reading less than 25 mSv (full scale) is turned away and sent back to the generator with the correct pamphlet. It is then the generator's responsibility to ensure proper disposal occurs

Coffin Butte Landfill Monitoring Procedures

1. Upon alarm sounding, immediately notify driver to pull away from the fee booth and pass in front of the detectors again (Figure 4). If the alarm sounds a second time, have the driver pull his vehicle to the designated holding area. Have the driver turn off his vehicle and return to the booth after he gets to the holding area. Record readings on monitor box into the log . Be sure to clear the alarm between passes.

2. Have the driver walk in front of the detectors to ensure he is not the source of the alarm. When driver returns have him walk in front of monitors to verify that it was not the driver that set off the alarm. Certain medical procedures involve injecting radioactive materials into the patient. It is possible that the driver is not

aware that this procedure was done and he could be the reason the alarm is sounding. If it is the driver, ask him to return to his truck and wait for management personnel to arrive. Record the reading on the monitor box into the log and onto the pamphlet.

3. If the driver is not the cause for the alarm and the meter is reading less than twenty microrem give appropriate pamphlets to driver and have him return the waste load to the generator. If the meter reading is all of the way to the right (equal to or greater than twenty microrems), have the driver stay away from his truck.

4. Notify management personnel of the problem.

5. Contact health physics personnel.

6. Reset alarm.

When the radiation specialist arrives, the truck will be surveyed to determine the hazard and approximate location of the radioactive waste. The origin of the waste will be determined by using the driver's list of pickup addresses for that load and the list of licensed radioactive material users. If appropriate, the Oregon Radiological Health Protection Services will be contacted at (503) 731-4014.

Figure 4. Truck Triggering Alarm. This truck is conducting a second pass to ensure the first alarm was not a false one. It turned out that the driver had undergone a nuclear medicine procedure the day before.

In order to facilitate the public's questions when the alarm is tripped the following pamphlets were developed. They are color coded to help the fee booth personnel know the correct pamphlets to give to the drivers. Blue pamphlets are given to the driver of the waste truck when his load is to be turned back to the generator (less than 20 microrem). Yellow pamphlets are given to the driver of the truck when his load is being held at the landfill (greater than or equal to 20 microrem). Red pamphlets are taken by the driver to give to the waste generator when he returns the load. Although they appear to be quite similar, all three pamphlets are included here so that the differences may be noted. They are reproduced in the same format that they are published.

THE COFFIN BUTTE RADIATION MONITORING PROGRAM - FOR DRIVERS RETURNING THE WASTE LOAD TO THE GENERATOR

(Blue Pamphlet)

Meter reading (truck) ________micro-rem

Meter reading (truck) ________micro-rem

Meter reading (driver) ________micro-rem

If you are reading this pamphlet, you've probably just been turned away from Coffin Butte Landfill because your load caused the radiation monitoring system to alarm. And like anyone would in this situation, you have a lot of questions. Coffin Butte Landfill has produced this pamphlet to answer your most pressing questions.

Am I in danger?

Since you've been sent back to the generator with your load, you can assume the amount of radiation in your truck is very small (under 20 microrem). Your actual reading is written on the front of this pamphlet. A microrem is a term scientists use to describe the amount of radiation that a person is receiving. To put the small amount in your load in perspective, you would receive 2,000 microrem flying from Portland to New York. A normal x-ray taken to check for broken bones exposes a patient to 53,000 microrem for each picture taken. (Waltar, 1995) Sounds like a lot? Not really! Even with the most sensitive equipment, scientists can't see any changes to the cell in your body until you've been exposed to over 40,000,000 microrem(Hall, 1994)!

Then why does Valley Landfills monitor radiation at such a low level? (Or even at all?)

Coffin Butte Landfill is dedicated to protecting both human health and the environment of its neighbors. And in order to fulfill that mission the landfill has voluntarily imposed much stricter rules on itself than that required by the already strict state and federal regulations. Thus Coffin Butte Landfill has a zero acceptance policy on radioactive materials. To be sure that no radioactive materials enter the landfill, the radiation monitor system has been set very, very low.

How did radioactive materials get into my truck?

Radioactive materials exist all around us, every second of every day. The sun exposes us to over 30,000 microrem every year. Granite in the foundations of houses and the rocks around us expose us to about the same amount. We even have a small amount of natural radiation in our bodies that give us over 40, 000 microrem every year(Waltar, 1995)! The material that set off the alarm at the landfill (remember, it is designed to alarm at very low levels) could be granite from house debris. Or it could be radioactive medicines given to patients in a hospital to help fight cancer or help diagnose strange diseases. Either way, the landfill can not accept it until strict tests are performed by radiation safety specialists to determine what the material is. And unless it's naturally occurring radiation, such as granite or rock, it's not getting in Coffin Butte.

What do I do now?

The main thing is to return the load back to the generator. You will also be given a red pamphlet to give the generator when you return the load. Then return to your route and notify your dispatcher.

What if I have more questions?

Coffin butte has a team of radiation safety specialists available to answer your questions. These people work with radiation on a daily basis and have received extensive training and education, so if you have more questions or concerns let us know.

THE COFFIN BUTTE RADIATION MONITORING PROGRAM
- FOR THE WASTE GENERATOR
(Red Pamphlet)

Meter reading (truck) ________micro-rem

Meter reading (truck) ________micro-rem

Meter reading (driver) ________micro-rem

If you are reading this pamphlet, you've probably just been told your waste has been rejected by Coffin Butte Landfill because your load caused the radiation monitoring system to alarm. And like anyone would in this situation you have a lot of questions. Coffin Butte Landfill has produced this pamphlet to answer your most pressing questions.

Am I in danger?

You can assume the amount of radiation in your truck is very small (probably about 20 micro-rem). Your actual reading is written on the front of this pamphlet. A microrem is a term scientists use to describe the amount of radiation that a person is receiving. To put the small amount in your load in perspective, you would receive 2,000 microrems flying from Portland to New York. A normal x-ray taken to check for broken bones exposes a patient to 53,000 microrem for each picture taken. Sounds like a lot? Not really! Even with the most sensitive equipment, scientists can't see any changes to the cells in your body until you've been exposed to over 40,000,000 microrem!

Then why does Valley Landfills monitor radiation at such a low level? (Or even at all?)

Coffin Butte Landfill is dedicated to protecting both human health and the environment of its neighbors. And in order to fulfill that mission, the landfill has voluntarily imposed much stricter rules on itself than that required by the already strict state and federal regulations. Thus Coffin Butte Landfill has a zero acceptance policy on radioactive materials. To be sure that no radioactive materials enter the landfill, the radiation monitor system has been set very, very low.

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And unless it's naturally occurring radiation, such as granite or rock, its not getting in Coffin Butte.

What do I do now?

If you still wish to be considered for disposal at Coffin Butte Landfill, you must contact the landfill office at (541) 754-2018. They will put you in touch with radiation safety experts who will work with you to determine what can be done with your waste.

What if I have more questions?

Coffin butte has a team of radiation safety specialists available to answer you questions. These people work with radiation on a daily basis and have received extensive training and education so if you have more questions or concerns let us know.

THE COFFIN BUTTE RADIATION MONITORING PROGRAM FOR DRIVERS ASKED TO WAIT AT THE LANDFILL

(Yellow Pamphlet)

Meter reading (truck) ________micro-rem

Meter reading (truck) ________micro-rem

Meter reading (driver) ________micro-rem

If you are reading this pamphlet, you've probably just been asked to park your truck at Coffin Butte Landfill because your load caused the radiation monitoring system to alarm. And like anyone would in this situation, you have a lot of questions. Coffin Butte Landfill has produced this pamphlet to answer your most pressing questions.

Am I in danger?

You can assume the amount of radiation in your truck is very small (under 20 micro-rem). Your actual reading is written on the front of this pamphlet. A microrem is a term scientists use to describe the amount of radiation that a person is receiving. To put the small amount in your load in perspective, you would receive 2,000 microrems flying from Portland to New York. A normal x-ray taken to check for broken bones exposes a patient to 53,000 microrem for each picture taken. Sounds like a lot? Not really! Even with the most sensitive equipment, scientists can't see any changes to the cell in your body until you've been exposed to over 40,000,000 microrem!

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How did radioactive materials get into my truck?

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And unless it's naturally occurring radiation, such as granite or rock, it's not getting in Coffin Butte.

What do I do now?

After you safely park your truck, return to the fee booth and wait for the arrival of a special team of radiation experts that Coffin Butte landfill has hired to respond to incidents like these. When they arrive, they will survey your truck to determine the location of the radiation and how much is present. They will also work with the generator of the waste to determine what kind of material is present in the load. After they have done this, they will work with Coffin Butte Landfill's management to determine what should be done next. Above all stay calm.

What if I have more questions?

Coffin butte has a team of radiation safety specialists available to answer your questions. These people work with radiation on a daily basis and have received extensive training and education, so if you have more questions or concerns let us know.

Landfill Policy

Coffin Butte Landfill has a policy of no initial acceptance of radioactive wastes. What this means is that if the radiation system alarms, the waste is either turned away to the generator or held at the landfill without being dumped (depending on the monitor reading). Initially all alarms were held at the landfill, but with the consultants having an average response time of twenty minutes, the turn away system was implemented. The present system only holds trucks reading twenty microrem or higher because that is the highest reading on the meter and we do not want to turn away a load with high enough levels to possibly cause harm to the driver or the public.

Drivers that are turned away are given the red pamphlet to give to the generator of the load. This pamphlet tells the generator how to contact the landfill and set up an appointment to have a radiation specialist survey the load and help determine what can be done with the load.

Coffin Butte has chosen to accept Naturally Occurring Radioactive Material (NORM) on a case by case basis. They recognized the low inherent risk of such material and realize that proper disposal is the only reasonable alternative. In order for NORM to be accepted, prior arrangement must be made with the landfill.

Coffin Butte will not accept Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) at this time due to a conflict in state and federal regulations. The gamma pathway analysis that the state says must be done before

TENORM can be disposed of in a sold waste landfill is based on the basis that five hundred millirem per year to the public is acceptable. Current federal regulations allow no more than one hundred millirem per year to the public. Until this conflict is cleared up, the landfill will not accept TENORM in order to protect itself from future liability.

Type of expected radioactive waste	**example**	**half life**
Hospital waste	I-131	8 day
Hospital waste	Tc-99m	6 hours
NORM	Granite	Varied
TENORM	Thorium Brick	Varied

Table 1. Expected waste

Applicable Regulations

Federal Regulations

There are no federal regulations specifically instructing operators of landfills to establish a radiation monitoring program. NRC (10 CFR) and DOT (49 CFR) regulations assume that the monitoring will be conducted by license holders or shippers. Probably the most applicable regulation is enforced by the Environmental Protection Agency through 40 CFR 258.20 (Subpart C of the Resource Conservation and Recovery Act). Under this regulation landfill owners are required to establish "a program for preventing the disposal of regulated hazardous wastes... (which) must include... (1) random inspections of incoming loads...(2) records of inspections...(3) and training of facility personnel to recognize regulated wastes."

Oregon Regulations

Oregon is considered an agreement state by the Environmental Protection Agency. What this means is that Oregon officials, in this case Oregon Department of Environmental Quality (DEQ) officials, regulate solid waste landfills in Oregon. They must follow rules at least as stringent as federal rules but may apply more stringent regulations at the behest of the state legislature. Oregon has chosen to do so.

Title 36 ORS 453.307 describes the definition of hazardous substances for the State of Oregon as including radioactive waste and material as defined in Title 36 ORS 469.300. This chapter in turn defines radioactive waste as "all material which is discarded, unwanted, or has no present lawful use and contains mined or refined naturally occurring isotopes, accelerator produced isotopes and by product material, source materials, or special nuclear materials." It also allows for exemption of certain materials (smoke detectors, etc.)

Title 36 ORS 453.010 defines a radioactive substance as " a substance which emits ionizing radiation.

Division 50 OAR 345-050-006 states "...no discarded or unwanted radioactive material may be held or placed for more than seven days at any geographical site in Oregon." Division 50 OAR 345-050-0010 through 345-050-0036 then goes on to allow for the exemption of very small quantities of materials (NORM) which present little possible risk and ways to determine if naturally-occurring radioactive materials (NORM) meets these criteria. It is interesting to note that the way to determine if a material meets this exemption was written under the old regulatory standards of a five hundred millirem exposure to the public being acceptable. This is no longer the case and leaves this exemption in an indeterminate standing.

After examining both the federal and state regulations, it appears there is an implied liability for landfills that do not have a monitoring system in place and functioning. Since Oregon DEQ officials must work under both state and federal rules, it is possible, when both are taken together, to state that a landfill without a monitoring system is not fulfilling the spirit of Resource Conservation Recovery Act's (RCRA) requirement to have a program to prevent the disposal of hazardous waste as defined by the State of Oregon. This could possibly result in a landfill being forced to share in the liability of a radioactive material that was a disposed of incorrectly.

Education

As part of the program's implementation, it was determined that an education program should be started. Initially the focused was on employee education and fear reduction, but the program was soon expanded to educate the public on the monitoring program.

Employee education

Initially employee education was all that made up the education component. Our goal was to explain to the staff why the landfill needed a radiation monitoring system, without causing undue alarm. We did this by conducted biannual training sessions where we covered types and sources of radiation, effects of radiation, how to protect oneself against the effects of radiation, and the liability issues that the landfill faced. We then covered, step by step, what to do when the system alarmed.

Since the inception we have realized that the biannual training program did not cover new employees hired between sessions. In order to fix this problem we produced a thirty minute film that covers all of the topics covered in the training sessions. This film is shown to new employees as part of their initial orientation.

Public education

Public education training is conducted only at the request of the landfill management. To date we have only done it once. This occurred at the Adair Village clubhouse and consisted of a ten minute talk outlining the program, why Coffin Butte spent the money to begin the program, and the actual risks of any sources that might find their way to the landfill.

Verification

Before we put the system in place, we wanted to determine the smallest amount of radioactive material that the system could detect and alarm for. After examining the type of license holders, the type and amount of radioactive materials used, and past histories from other landfills, we decided to base our calculation on both Tc-99m and I-131. As stated before the alarm point was set at twice background. Average background readings are 3 microrem per hour.

Isoshld II

ISOSHLD II is a deterministic computer code that bases its results on Point Kernel calculations. It uses distances to detector, thickness and density of shields, and detector angles to determine dose. It also has set geometries that allow the user to easily set the project dimensions. The dimensions of the models were taken by hand (see Figure 5).

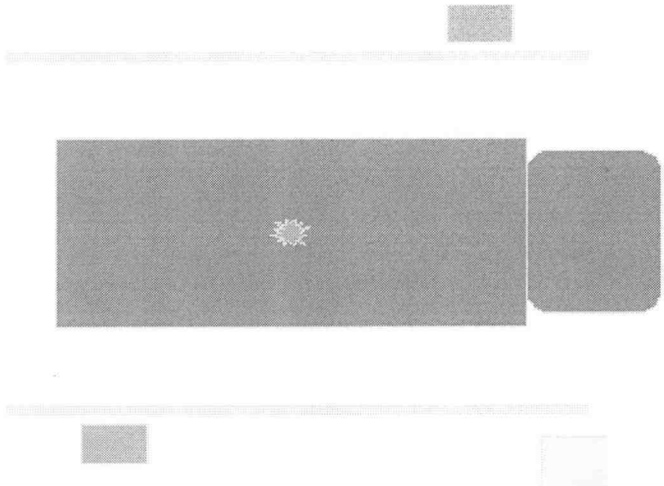

Figure 5. ISOSHD II Model layout. Blue boxes represent monitors. The model is not to scale.

Using ISO-PC, and an average trash density (effective Z) of 2.39 g/cm^3 (calculated from the averaged weight of loads and the dimensions of the drop off box), we calculated that the system would alarm for quantities as low as twenty microcuries of Tc-99m and three microcuries of I-131.

shield	**thickness (cm)**	**density (g/cm3)**
source	0.01	1
hospital waste	122	0.239
iron truck wall	0.317	7.86
air	91.4	0.00129

Table 2. ISOSHD II dimensions and densities

To verify these numbers, we set up an experiment using a radium irradiator that was present at Oregon State University. With the help of Oregon State's Radiation Center and TRIGA reactor staffs, we developed a system that would put a tight beam of radiation through a load of compacted hospital waste to where it could be read on the other side of the truck. We used reference density for the iron walls of the truck. These numbers were compared to a calculated run and compared poorly ($2.39 g/cm^3$). This may have been due to the difficulty in finding the center of the beam under difficult weather conditions.

experimental reading (μR)	**r**
65	0.83
80	0.8
100	0.795
55	0.86
85	0.8
75	0.79
80	0.8

Table 3. Truck verification experiment

Results

The overall result of the project can be seen in the case studies that follow. These cases show that the monitoring program is functioning properly and that the landfill staff has been properly trained on how to respond to an alarm.

Case 1

Three weeks after the program was initiated, a truck from a nearby DOE site was dumping clean, non-contaminated soil into the landfill. Unfortunately, an elderly man, who was also disposing of waste, was dusted with the soil and became angry with the driver of the truck. Upon learning that the truck was driven by DOE employees, the man began to assume he had been exposed to radioactive materials and was becoming ill. The landfill was contacted by the man's lawyer the next day. When it was explained that the landfill had a radiation monitoring system operating, the lawyer promptly said goodbye and hung up. There has been no further contact with either the man or his lawyer.

Case 2

A load from a local hospital caused an alarm while being weighed. The load was dumped at the landfill and an adult diaper was determined to be the source. The originating hospital took possession of the diaper.

Case 3

In mid August 1998, a truck set off the alarm system as it was being weighed. Following procedures the truck was returned to the generator and health physics personnel notified. Since the generator was unable to determine the source of the radioactivity, the health physics personnel agreed to assist them. Initial surveys on the outside of the truck indicated the source was spread throughout the eighteen-foot waste container. After opening the container, the source of the radioactivity was determined to be thorium enriched bricks that were used as a flue liner for the production of fiberglass materials. The flue was old and was being replaced. Using the techniques described in Oregon Administrative Rule Division 30, 345-050-0035, that exempts NORM under specific conditions, the material was determined to be higher than legally acceptable. The generator disposed of the waste at other facilities.

Lessons Learned

1. Neighbor's perceived risks and NIMBY can be managed by presenting the actual risks from radiation levels for which the system is set to alarm for and risks of everyday activity. Above all be proactive and honest.
2. Liability risks far outweigh actual risks for this type of program.
3. Setting the alarm point at twice background seems to walk the line between too many false alarms and not enough sensitivity.

Conclusion

In the course of developing this program, we managed to form a bridge between the local business community and the university that benefited all of the participants. The community benefited from an increased awareness of the reality of the risks of radioactive materials and the student benefited from the experience gained while working in the consulting fields.

Future government action remains uncertain as pertaining to a requirement for landfills to maintain a radiation monitoring system. Indeed, current state regulations are out of sync with federal regulations regarding acceptable public exposures. It is hoped that, with this study's help, Coffin Butte Landfill and Oregon State University will continue with the established relationship and be prepared to respond to regulation changes.

Bibliography

Andersen, J.R. and J.N. Dornbush. April 1987. Influence of a Sanitary Landfill on Ground Water Quality. Washington State Department of Ecology.

Bangart, Richard. 1991. NRC Information Notice No. 91-03 : Management of Wastes Contaminated with Radioactive Materials (Red Bag and Ordinary Trash)

Beck, H. 1973. Solid State Dosimetry. CRC Press. Rockville Md.
Brunner & Keller. 1972. *Sanitary Landfill Design & Operation.* USEPA.
Coffin Butte Landfill. 1997. Coffin Butte Landfill Pamphlet
Eisenbud, M. 1953. Radioactive Dust From Nuclear Detonations. Science 117, pg 141-147.

EPA. 1982. Background Information Document (integrated risk assesment); Final rule for radionuclides. Report EPA 520/1-84-00202, Vol. 2. US Environmental Protection Agency, Washington, D.C.

Hall, Eric J. 1994. *Radiobiology for the Radiologist, Fourth Edition.* Lippincott – Raven Publishers. Philadelphia, Pennsylvania.

Hickey, John W. N. 1998. Notice of Consideration of Amendment of Request for the Babcock and Wilcox Shallow Land Disposal Area in Parks Township, Pennsyvania and Opportunity for a Hearing. Federal Register. Vol 63, No 237.

Hughes, F.M., R.A. Landon and R.N. Farvolden. *Hydrogeology of solid waste disposal sites in northeastern Illinois; a final report on a solid waste demonstration grant project.* Washington, U.S. Government Printing Office, 1971.

ISO-PC Version 1.98. August 1994.

Moghissi, S. 1986. *Radioactive Waste Technology.* American Society of Nuclear Engineers, New York

Robinson, William D. *The Solid Waste Handbook.* John Wiley & Sons, New York, N.Y., 1990.

Tchobanoglous, George. *Solid Waste Engineering Principles and Management Issues.* McGraw-Hill, New York, N.Y., 1985.

Waltar, Alan E. 1995. *America the Powerless, Facing Our Nuclear Energy Dilemma*. Cogito Books, Madison, Wisconson.

Washington State Department of Ecology. Solid Waste Landfill Design Manual. June 1987.

Zach, R., and Mayoh, K. 1984. Soil ingestion by cattle: a neglected pathway. Health Physics. 46, 426-431.

APPENDICES

Appendix 1

Landfill Logsheet

date	time	name and address of generator	Truck reading # 1	Truck reading # 2

Appendix 2

Sample Radiation Monitor Report

Incident report

Date of incident: 7 April, 1998

Time of Incident: 1200

Waste Hauler: Corvallis Disposal

Waste Generator: Evanite

Suspected Material: Zirconium refractory brick containing either Radium (and its associated daughter products) or Thorium. Categorized as a Naturally Occurring Radioactive Material. (NORM).

Approximately 1200, I received a call from the fee booth stating that there was a truck from Evanite that was causing the radiation monitoring system to alarm. I proceeded to the landfill where after discussing the origin of the load with the driver, I approached the truck and began a survey. Background was 3 microR per hour. The trucks readings ranged from 10 microR at the front right of the truck to 25 microR at the back left. I called Evanite and discussed the situation with Randy

Armatas, the health and safety manager. He preferred to handle it at the Evanite site and requested we return the load.

After briefing Beanietta Hunt, I left the landfill site. While driving back to town I remembered the driver mentioning that he had to hurry so he could pick up the remaining loads. I took this to indicate that he meant more loads from Evanite so I decided to go directly to Evanite to check out the remaining loads and preempt the monitor alarming again. I was met by Randy Armatas and Michael Amen, a health and safety consultant from Woodward-Clyde. We surveyed the remaining two DOBs and determined that they contained radioactive materials also. When the DOBs were opened, we found the radioactive material to be zirconium refractory bricks, used in making fiberglass as a channel from the smelter to the mold area. Initially there was some concern because they had held a rather large cesium source, but when we compared the levels (between 50 and 70 microR at contact) with the new brick they were the same indicating the radioactive material was in the brick.

After leaving Evanite, I conducted a literature search for rules governing the disposal of radioactive materials in Oregon. While the Oregon Health Division's radioactive materials section said that building materials were exempt, Oregon Department of Energy's rules (OAR section 345-050-0006 through 345-050-0036) said that NORM must pass certain tests in order to be acceptable to a solid waste landfill.

Appendix 3

I-131 Isoshield Run

```
Run started at 13:56:28  01/07/99

 ______________________________________________________
|                                                      |
|   ISO-PC  Version 1.98          August 1994          |
|   originally ISOSHLD-II;  RIBD was removed           |
|                                                      |
|   Please send questions or comments to:              |
|   Paul D. Rittmann, PhD CHP   509-376-8715           |
|   Westinghouse Hanford Company       H6-30           |
|   PO Box 1970           Richland, WA  99352          |
|______________________________________________________|
```

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production
7/6/94 PDR

Run Title: LANDFILL

3.0 mCURIES OF I-131

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
I -131	3.00E-03	3.000E-03

Gamma Only -- No Bremsstrahlung !

3.0 mCURIES OF I-131

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	0.000E+00	1.290E-03	1.290E-03
LITHIUM	0.000E+00	2.390E-01	0.000E+00	0.000E+00	0.000E+00

```
IRON      0.000E+00  0.000E+00  7.860E+00  0.000E+00  0.000E+00
-----------------------------------------------------------------
 Totals:  1.000E+00  2.390E-01  7.860E+00  1.290E-03  1.290E-03
-----------------------------------------------------------------
```

```
 3.0 mCURIES OF I-131

 Source             Shields        Distance to Detector, X =
2.139E+02 cm
  Point              Slab            Offset from Normal, Y =
2.740E+02 cm
                                 Angle with Shield Normal = 52.02
degree
  Shield Thickness: 1.000E-02, 1.220E+02, 3.175E-01, 9.144E+01,
1.325E-01 cm
  Distances from Dose Point to the Outside of
    (1) Source Region: 2.139E+02 cm   (2) Next Layer: 9.189E+01 cm
  Dose Buildup Data for Shield 4 with Effective Atomic Number  7.26
  Gamma Only -- No Bremsstrahlung !

         Exposure Rate - Isometric (ISO)  : 5.968E-06 rem/hr =
5.968E-08 Sv/hr



 Closing:  This ISO-PC Run is Concluded!

 Finish run at 13:56:29  01/07/99
 Input File (Z:\ISOSHD\2LAND.IN) is shown below:

1         2 LANDFILL
3.0 mCURIES OF I-131
&INPUT NEXT=1, IGEOM=1, NSHLD=4, X=213.9, Y=274, T(1)=.01,
T(2)=122,
T(3)=0.3175, T(4)=91.44, OPTION=0, DUNIT=5, ISPEC=1,
WEIGHT(300)=.003 &
 H2O    1      1.0
 TR     5             0.239
 Fe     9                     7.86
1AIR    3                              0.00129
```