WASTE MANAGEMENT PRACTICES TO CONTROL BIOLOGICAL TRANSPORT OF RADIOACTIVITY AT THE HANFORD SITE

A. W. Conklin
Rockwell Hanford Operations
Safety and Quality Assurance
Richland, Washington 99352

ABSTRACT

One of the goals of waste management in the Hanford Site 200 Areas is to prevent biological intrusion into, and transport from, waste storage and disposal sites. Practices established to achieve these goals include the elimination of deep-rooted vegetation on waste sites to prevent plant root intrusion into radioactivity, selective herbicide application to prevent regrowth of these plants, planting of shallow-rooted plants to successfully compete with deep-rooted plants for moisture, surface stabilization, and environmental surveillance. Past biological transport incidents have included transport by Russian thistle by way of physiological plant processes, bird access into exposed contamination, and animals burrowing into radioactive waste disposal sites. Rockwell Hanford Operations, through mitigative actions and continued surveillance, has made significant progress in eliminating, or better isolating source terms, thus preventing or inhibiting problems from recurring. Approximately 60% of source term acreage requiring stabilization or decontamination has been completed.

INTRODUCTION

Rockwell Hanford Operations (Rockwell), as a prime U.S. Department of Energy contractor, manages the fuel reprocessing and radioactive waste management facilities in the Hanford Site 200 Areas. The Hanford Site is located within the Pasco Basin in southeast Washington State, approximately 270 km southeast of Seattle and 200 km southwest of Spokane. The 200 Areas are approximately in the center of the Hanford Site, 11 km south of the Columbia River. A major activity in Rockwell's Waste Management Program is to ensure that radioactive waste is isolated from biota, or if intrusion takes place, conduct whatever mitigative action is necessary to eliminate the problem. This activity is accomplished through an interim stabilization program, which is designed to eliminate deep-rooted vegetation growth, provide additional clean fill to further isolate waste, and provide a clean surface that is easily monitored for further intrusion. This monitoring is accomplished through Rockwell's Environmental Surveillance Program.

The Rockwell Environmental Surveillance Program (conducted by the Environmental Surveillance and Control Group) is designed to determine the adequacy of radioactive waste containment systems, to ensure that biota intrusion remains at a minimum, and to determine the impact on the 200 Area environment. [1]

Biological transport of radionuclides, for the purpose of Rockwell monitoring efforts, is defined as follows:

- Upward movement of subsurface radioactive waste to the surface by physiological plant processes
- Dispersion of such plants by wind to uncontaminated areas
- Deposits of contaminated feces and urine by animals that have gained access to waste sites and ingested radioactive materials
- Movement of contaminated animals that have ingested radioactive materials directly or consumed other contaminated animals
- Nest building by animals and insects using contaminated material
- Physical dispersion of radioactivity by burrowing animals.

TRANSPORT BY VEGETATION

Several deep-rooted plant species potentially involved in physiological uptake of radioactivity are common to the Hanford Site. A Rockwell Waste Management Program goal is to eliminate or prevent the growth of these species where waste is buried. Several waste sites in the 200 Areas are known or suspected sources of contaminated vegetation growth. Tumbleweeds (Russian thistle) and other annuals absorb radionuclides through the root system, die, break off, and migrate, primarily via prevailing and high winds. Although tumbleweed is the principal plant type involved, other species such as sagebrush and rabbitbrush (both perennials) can also be included. Vertical transport of radioactivity by plant processes has been observed in the past, with ^{90}Sr as the principal radionuclide transported. Strontium-90 concentrations in contaminated tumbleweed samples have ranged from background to 3.2 pCi/g. [2] Areas of contaminated vegetation growth have been reduced significantly in recent years through an accelerated radiation area cleanup and stabilization program. Source terms have included tank farms, dry waste disposal sites, cribs, trenches, ditches, and ponds. [3] Before a concentrated stabilization effort and herbicide spraying program began, these source sites were numerous.

Rockwell's Waste Management Program Office maintains an interim stabilization program that includes the addition of clean fill and revegetation, further isolating plant root growth from waste, as well as providing a clean surface that is easily monitored for changes. Revegetation, followed by routine selective herbicide application, inhibits the ability of tumbleweeds to compete for ground moisture.

As a result of these recent stabilization efforts and the ongoing herbicide spray program, the number of sources in the 200 Areas has been reduced significantly (Fig. 1).

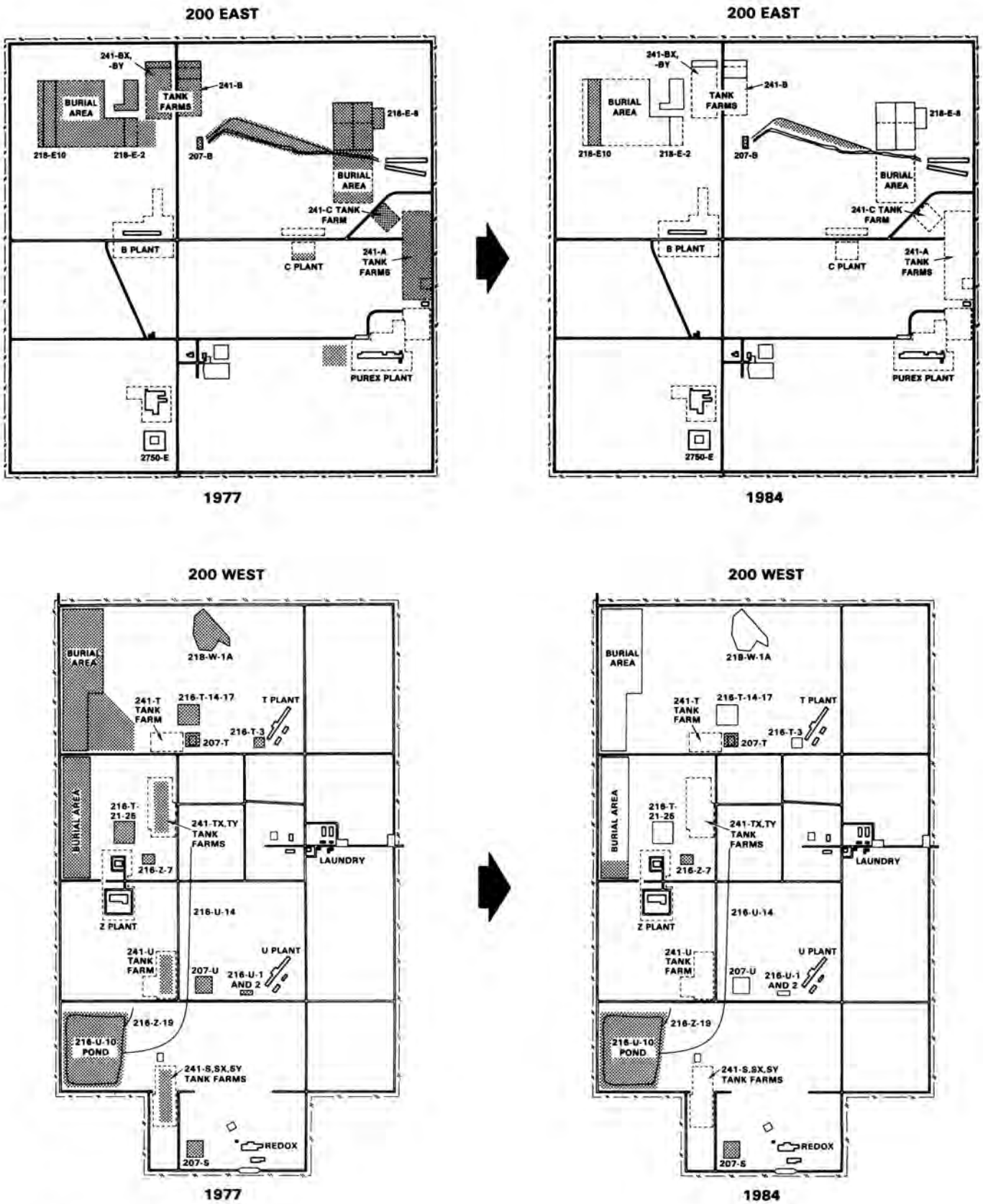

Fig. 1. Progress in Contaminated Vegetation Control.

TRANSPORT BY ANIMALS

Biological transport involving animals can be divided into two categories: the uncovering of radioactive material by animal intrusion, and the physical transport of radioactive materials away from the source. Historically, animals in the 200 Areas that have been involved in such incidents have included mice, ground squirrels, jackrabbits, badgers, coyotes, and a number of birds, including pigeons, swallows, and blackbirds.

Though biological transport was first observed early in the Hanford Site history, the first documented major biological transport incident was recorded in 1958 when a Radiation Monitor, surveying the BC Crib and Trench area, discovered radioactive rabbit feces. Following the initial discovery, it was learned that a 4 mi^2 area, now known as the BC controlled area, was contaminated with spotty contamination in the form of animal feces and urine. A source was determined to be one of the backfilled BC trenches where an animal had burrowed into the side of the trench exposing salty radioactive waste. Other animals apparently used that hole as a salt lick, and the area was subsequently contaminated. Since that time, aerial surveys have estimated that the contamination spread throughout that 4 mi^2 area is approximately 14 Ci of ^{137}Cs and up to 80 Ci of ^{90}Sr. In 1960, mitigative action was taken to prevent animal burrowing into the site area. In 1981, further action was taken when the BC Cribs and Trenches were surface-stabilized with the addition of several feet of clean fill and revegetated.

The goal of Waste Management is to prevent a similar incident from recurring. This is acomplished through Rockwell's Environmental Surveillance Program. The BC Crib area is now surveyed at least semiannually to ensure that no biological intrusion, either plant or animal, is recurring. To monitor the contamination present in the BC controlled area, a series of survey plots was established in 1977 in previously known contaminated areas, as well as areas that were not contaminated, to ensure that no migration of contamination occurs. No significant changes have been observed. Partial cleanup of the area has taken place. Plans for the remainder are under way.

Another significant biological transport incident was discovered in October 1981, when pigeons intruded into radioactive waste, ingested it, and subsequently transported it to other locations in the 200 Areas. The incident developed in early 1981 when two contaminated dead pigeons and contaminated feces were found at U Plant during a routine radiological survey. An investigation was initiated following the discovery of several areas contaminated by feces (to 40 mrad/h at 2 in.). This investigation included potential sources such as ponds and ditches, tank farms, retention basins, reprocessing plants, and the 204-S Waste Unloading Facility, which was used intermittently to unload radioactive liquid waste tank cars for transfer to tank farms. Though several sites were identified as potentially contributing to contaminated pigeons, only the 204-S Facility was identified as a major source through radioisotope fingerprinting (see Table I for data comparison). Until replacement by a new waste

TABLE I

Radionuclide Content of Representative Pigeon Fecal Samples and 204-S Samples

Radionuclide	204-S Unloading Facility samples				Pigeon feces (pCi/g)			
	Sediment		Water		221-U	221-T	Redox	200 Area batch plant
	N sump (pCi/g)	S sump (pCi/g)	N sump (pCi/mL)	S sump (pCi/mL)				
^{54}Mn	<2.9E3	2.6E1±4.4E0	(a)	(a)	<7.8E1	1.6E2±1.4E1	(a)	<3.7E2
^{57}Co	<3.8E4	(a)	<2.0E2	<8.0E-1	1.7E2±3.4E1	(a)	2.4E3±4.1E2	(a)
^{60}Co	6.5E4±2.9E3	1.2E3±1.4E1	1.7E3±1.4E1	1.2E0±2.0E-2	2.3E2±3.0E2	3.4E2±1.7E1	1.5E3±4.1E2	7.0E2±1.4E2
^{90}Sr	5.0E5(b)	1.1E2(b)	2.1E3(b)	7.7E1(b)	3.5E4(b)	4.1E4(b)	1.0E4(b)	8.7E3(b)
^{106}Ru	<4.7E4	<1.1E2	<2.3E2	<1.5E0	3.6E3±7.9E2	2.2E3±1.8E2	<1.6E4	1.4E4±3.9E3
^{125}Sb	6.2E4±1.1E4	1.5E2±1.9E1	2.9E2±4.1E1	<1.2E0	2.8E3±3.6E2	4.5E3±7.2E1	1.6E4±3.5E3	1.3E4±2.0E3
^{134}Cs	2.8E5±5.6E3	3.4E2±9.2E0	3.4E2±2.0E1	7.0E-1±1.0E-1	1.5E4±2.1E2	3.3E2±2.4E1	5.0E4±1.7E3	6.7E4±1.1E3
^{137}Cs	2.9E6±1.5E4	6.2E3±2.5E1	2.5E3±3.3E1	1.4E1±3.2E-1	1.2E5±4.8E2	2.6E3±3.4E1	4.8E5±4.8E3	5.5E5±2.8E3
^{144}Ce	4.3E4±1.2E4	1.2E2±1.9E1	2.1E±4.6E1	<9.0E-1	<5.8E2	3.8E3±7.6E1	<7.3E3	<3.5E3
^{152}Eu	<6.5E3	<2.6E1	<6.0E1	<5.0E-1	6.7E2±1.1E2	2.1E2±3.6E1	<5.0E3	<1.2E3
^{154}Eu	8.6E4±6.0E3	3.6E2±1.5E1	2.3E2±2.5E1	<6.0E-1	2.7E2±7.8E1	6.9E3±1.2E2	3.5E3±9.5E2	2.1E3±4.0E2
^{155}Eu	8.2E4±5.7E3	4.3E2±8.6E0	1.5E2±3.2E1	<6.0E-1	<2.1E2	2.6E3±3.4E1	<3.0E3	<1.2E3
$^{239,240}Pu$	>5,000(a)	2.4E1(b)	(c)	3.0E-2(d)	(c)	3.6E3(b)	7.3E0(b)	6.4E0(b)
^{241}Am	4.3E4±7.7E3	1.8E2±1.1E1	7.2E1(b)	<3.0E-2	<3.1E2	1.9E3±4.0E1	6.2E1(b)	4.3E2(b)

(a) Data not available because specific radionuclide not included in gamma analysis for this sample.
(b) Standard error not available.
(c) Isotope not recovered during specific analysis.
(d) Represents minimum value; more precise value not possible due to incomplete recovery during analysis.

unloading facility could occur, temporary mitigative actions were taken which included an orchard cannon and distress call to scare the birds, and a net to prevent intrusion. The facility has since been decommissioned, with most components being dismantled and buried in a nearby dry waste disposal site and the remainder buried in situ under clean fill and revegetated.

Several other biological incidents have occurred since detailed records were kept beginning in 1977 (Table II). All have included either individual animals or a small number of animals.

TABLE II

Selected Biological Transport Incidents in the 200 Areas (through 1982)

Date	Vector	Location	Contamination
1958-1960	Coyote and rabbit feces	BC Cribs outer area	100,000 cpm
6/1/77	Bird nest (swallow)	In crane near Z Plant	130 mrad/h
6/14/77	Wasp nest (mud)	In J.A. Jones Lorain backhoe at 3000 Area	70 mrad/h
8/24/77	Rabbit fecal pellets	Near 155-TX Diversion Box excavation	100 mrad/h
4/4/78	Coyote scat	Northeast corner of 200 West Area	340,000 dpm
5/16/78	Bull snake	In 241-S Tank Farm	8,000 cpm
5/22/78	Bee swarm	In 102-BY Pump Pit	400 cpm on total swarm
6/23/78	Dead mouse	In J.A. Jones tool box near 223-S Facility	5 mrad/h
7/12/78	Bird nest (swallow)	In rafter framework of 202-S west dock	100 mrad/h 2,400 dpm
8/17/78	Mouse	Near 241-C Tank Farm outside the radiation zone	35 mrad/h
4/23/79	Mouse feces	ITS-2 Compressor Bldg.	35,000 cpm
5/7/79	Mouse feces	241-T Lunchroom	6,000 cpm
6/4/79	Dead bird	Semiwork hot shop	15,000 cpm
2/19/80	Mouse nest in recorder	PUREX storage gallery	60,000 cpm
3/11/80	Bird pellet containing rodent bone fragments	BC Crib area road	100,000 cpm
5/2/80	Family of rabbits	241-A Tank Farm	40,000 cpm
10/81	Pigeons and feces	200 Areas	Background to 40 mrad/h
1/82	Blackbird nests	REDOX front entrance	100,000 cpm
8/82	Mice	Cross-country vent station	100,000 cpm
10/82	Mice	216-B-7A,B Cribs	70,000 cpm

cpm = counts per minute beta-gamma as detected by a P-11 count rate meter.

dpm = disintegrations per minute alpha is detected by alpha detector on a count rate meter.

mrad/h = beta-gamma indication field is detected by a Cutie Pie (CP) dose-rate meter.

No biological transport incident has ever been demonstrated to be a significant radiological hazard to personnel within the 200 Areas. Following discovery, the sources are either eliminated or isolated, followed by cleanup of the contamination spread.

PREVENTION OF FUTURE INCIDENTS

While elimination of all individual biological transport events may not be practical at this time, Rockwell's Waste Management Program has been successful in the elimination of sources, identification of other potential sources, and corrective action following discovery of biological transport incidents through the Environmental Surveillance Program. In addition, Rockwell has initiated an interim stabilization program that results in clean surfaces on waste sites that can be properly monitored for biological intrusion. Rockwell also has an active program for decommissioning retired sites (such as the 204-S site) that will eliminate source terms forever.

As part of the Waste Management Program, the Environmental Surveillance Program monitors facilities and waste sites for biological intrusion. There is also a program of radiological surveys conducted over these sites. Radiation Protection Technologists have instructions to survey all signs of animal activity and all plants that have historically been biological transport problems, though others are monitored as well. Any sign of radioactivity is reported to the Environmental Surveillance and Control Group, who initiates corrective action before a problem similar to the 204-S or BC controlled area incidents can result. Future plans to eliminate all biological intrusion are under way. Possible solutions include exhumation of waste, or in situ disposal.

Past biological transport incidents in the 200 Area vicinity have taught that continuing waste management practices, especially environmental surveillance control activities, will be required until ultimate removal or isolation of radioactive waste from the reach of plants and animals is achieved. These incidents have also taught that any lapse in the herbicide application program may result in the recurrence of contaminated tumbleweed growth as previously discussed; and that a discontinuation of the interim stabilization program on contaminated sites may result in other adverse environmental conditions (e.g., the contamination of the environment or other stabilized sites).

The continuation of the interim stabilization and herbicide application programs, coupled with environmental surveillance, will ensure future minimum impact on the environment by biological transport of radioactive waste.

CONCLUSION

In order to minimize the impact of future intrusions, Rockwell has maintained a waste management policy of immediate initiation of corrective action following the discovery of biological intrusion. This policy operates as follows.

- Biological intrusion is discovered through a routine environmental surveillance program that includes inspections, radiological surveys, and sampling.
- The incident is investigated and reported to the responsible program.

- Corrective action is taken which may include decontamination, decommissioning the source, or surface stabilization of waste sites followed by routine selective herbicide application.
- Continuation of environmental surveillance ensures prevention of future incidents.

Significant progress is being made in eliminating biological transport sources and inhibiting future intrusion into other sites through the design of facilities to exclude animal and plant intrusion, and through an active environmental surveillance and control program.

REFERENCES

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