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B. Document Number HNF-SA-3215 - FP

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Root Cause Analysis of Contaminated Vegetation at Low-Level Burial Grounds on the Hanford Site

D. Internet Address

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G. Complete for a Presentation

. Title for Conference or Meeting Paper was originally prepared for presentation at Session 66 of the 1998 Waste Management Symposia. However, the paper was not presented.

. Group Sponsoring N/A

. Date of Conference N/A

4. City/State N/A

. Will Information be Published in Proceedings? [ ] No [x] Yes *

6. Will Material be Handed Out? [x] No [ ] Yes

1. ~~Author~~/Requestor

E. Eileen White E. Eileen White
(Print and Sign)

Responsible Manager

P. B. Brannan
(Print and Sign)

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HNF-SA-3215-FP
Revision 0

Root Cause Analysis of Contaminated Vegetation at Low-Level Burial Grounds on the Hanford Site

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Hanford
P.O. Box 1000
Richland, Washington

Contractor for the U.S. Department of Energy
Richland Operations Office under Contract DE-AC06-96RL13200

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E.J. Millikin
Fluor Federal Services of Hanford

P.B. Brannan
Duratek Federal Services of Hanford, Inc

August 2002

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Hanford
P.O. Box 1000
Richland, Washington

Contractor for the U.S. Department of Energy
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EDC-	FMP-
EDT-	ECN-
Project No.:	Division:
Document Type	Page Count:

Abstract		Summary		Full Paper	X	Visual Aid	

Conference Name:	
Conference Date:	November 5, 1997
Conference Location:	
Conference Sponsor	
Published in:	
Publication Date:	

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11/5/97

ROOT CAUSE ANALYSIS OF CONTAMINATED VEGETATION AT LOW-LEVEL BURIAL GROUNDS ON THE HANFORD SITE

Emily J. Millikin and Patrick B. Brannan
Waste Management Federal Services of Hanford

INTRODUCTION

Historically, control of contaminated vegetation has been a problem in the 200 East and West Areas of the Hanford Site. Contamination events associated with the long roots of plants such as tumbleweeds penetrating into buried radioactive waste have been identified since the late 60's and early 70's (DOE, 1996). Since development of the tracking system for Radiological Problem Reports (RPRs), contaminated vegetation has been reported within Solid Waste Projects (SWP) burial grounds and across the Hanford Site. The first RPR related to contaminated vegetation on the Hanford Site was reported on February 12, 1993, at the 216-U-10 Pond in the 200 West Area (Barajas, 1997). Tumbleweeds were found with direct contamination to 35,000 disintegration per minute beta/gamma[a]. Since that time, numerous incidents of contaminated vegetation have been reported and documented.

On February 10, 1997, SWP of Waste Management Federal Services of Hanford (WMH) was notified that a trend had been identified of increasing contaminated vegetation at the 200 Area Burial Grounds (RFSHRC-97-002). It was documented that over the last 17 months (FY 1996 and FY 1997) 24 RPRs were written due to contaminated vegetation. Seventy-five percent of the reports identified contamination on or near the 218-W-3A Burial Ground. The contamination was found in one of three matrices:

- Tumbleweeds still attached to the root;
- Windblown tumbleweeds, fully intact; and
- Fragments or seeds from windblown tumbleweeds.

Although contaminated tumbleweeds are not considered a violation of Title 10, Code of Federal Regulation (CFR) Part 835, Section 835.404(b), the trend of contamination being outside a posted area (lack of contamination control) could be viewed as a potential for future noncompliance if not addressed.

In response to the Notification of Potential Trend report, RFSHRC-97-002, SWP directed the root cause of contaminated vegetation be addressed and corrective actions be identified to resolve the problem. This report documents the results of a root cause analysis performed for contaminated vegetation, specifically tumbleweeds, and presents recommended corrective actions for WMH.

[a] Contamination values reported in 1993 did not include unit area.

PURPOSE AND SCOPE

The purpose of the analysis was to identify causal factors of contaminated vegetation, specifically tumbleweeds, in the 200 Area Burial Grounds and recommend corrective action(s). The recommendations were to encompass both immediate and long-term actions. The outcome of the analysis was to provide management with recommendations to develop a Plan of Action. The analysis focused on the 218-W-3A Burial Ground, assuming corrective actions identified to resolve the problem in the 218-W-3A Burial Ground may be applicable to the 200 East and West Burial Grounds, and possibly across the Hanford Site.

200 AREA BURIAL GROUNDS

The 200 Area Burial Grounds are classified as a landfill and cover a total area of approximately 518 acres (DOE, 1988a) . The landfill is divided into eight burial grounds. Each burial ground is comprised of a number of trenches. Figure 1.0 depicts a typical burial ground on the Hanford Site. Two burial grounds are located in the 200 East Area: 218-E-10 (13 trenches) and 218-E-12B Burial Grounds (40 trenches). The following burial grounds are located in the 200 West Area:

- 218-W-3A Burial Ground, 57 trenches
- 218-W-3AE Burial Ground, 8 trenches
- 218-W-4B Burial Ground, 14 trenches
- 218-W-4C Burial Ground, 15 trenches
- 218-W-5 Burial Ground, 13 trenches
- 218-W-6 Burial Ground, no trenches

Solid waste, designated low-level, low-level mixed, transuranic, or transuranic mixed waste, has been disposed of in shallow, unlined trenches in the burial grounds since 1960. The burial grounds have accepted radioactive waste generated at various facilities, on and off the Hanford Site.

Two basic types of trenches have been used for disposal in the burial grounds--V-trenches and industrial trenches. Typically, the trenches are backfilled following disposal of waste. The primary purpose of backfilling trenches is to provide an environmental barrier. Backfill for an industrial trench consists of soil with a minimum depth of 8 feet for disposed waste and 4 feet for retrievably stored waste. Waste placed in V-trenches is backfilled with a minimum of 8 feet of soil. This barrier is designed to isolate the waste from animals and humans and minimize the intrusion of long-rooted plants.

Figure 1.0 Typical Burial Ground on the Hanford Site.

From the time of startup of the burial grounds until 1965, waste was disposed below grade at depths from about 18 inches to 4 feet. By 1965, the soil depth was 4 feet. In 1972 it was determined that the long-rooted plants were still penetrating the radioactive waste resulting in 'hot' tumbleweeds. As a result, a decision was made to backfill all wastes with a minimum of 8 feet of soil. This additional soil cover resulted in a much cleaner operation (DOE, 1996).

Before 1970, no attempt was made to segregate the waste by type or level of radioactivity. Since 1970, solid waste designated or suspected to be transuranic waste has been segregated from other radioactive waste and placed in retrievable storage units. Since 1985, steel drums containing radioactive organic liquid waste (mixed waste) also were placed in retrievable storage. Since 1987, mixed waste burial has been halted except for the disposal of mixed waste containers with a dose rate greater than 200 mrem/hour at the container surface and special-case wastes (e.g., submarine reactor compartments).

PHYSICAL CHARACTERISTICS AND MANAGEMENT OF TUMBLEWEEDS

Tumbleweeds are considered an aggressive weed that is not indigenous to Southeastern Washington. Tumbleweeds are thought to have originated from the Ukraine (Malady, 1997). More than one biospecies of tumbleweeds has been found on the Hanford Site. However, the most common biospecies is the Salsola Kali, (Russian Thistle).

The tumbleweed is a summer annual plant, which seeds itself every year. Approximately 10,000 seeds may originate from one tumbleweed, and it is thought that approximately 80 percent of the seeds germinate and reach maturity. The seeds are released from the parent tumbleweed after the tumbleweed has died. The seeds may be dormant for up to 20 years, depending upon the amount of soil movement (e.g., back scrapping, wind blowing, placement of clean soil).

Studies have shown that tumbleweed seed will germinate with the addition of water within 6 hours (Malady, 1997). Their roots grow as deep as 20 feet underground in the vertical direction in search of water. Tumbleweed roots can readily penetrate thin plastic barriers by finding small holes where water has seeped through. In addition, a tumbleweed root will follow the path of least resistance for seeking water and will grow through cracks in wooden and/or concrete burial boxes.

Research on contaminated tumbleweeds indicates that radionuclides such as Strontium-90 and Cesium-137 are concentrated in the crown of the root (Malady, 1997). Tumbleweeds see these radionuclides much like fertilizer and actually seek them out. It is suspected that seeds from radiologically contaminated tumbleweeds may be contaminated (Malady, 1997). Radioactivity in contaminated tumbleweeds is fixed within the body of the plant. The radioactivity is not readily removable; however, the plant itself is highly mobile. Therefore, the primary potential health hazard from tumbleweeds on the Hanford Site is external radiation.

Historical management of tumbleweeds at SWP, and throughout the Hanford Site has included one or more of the following:

- Spraying of herbicides that selectively kills tumbleweeds;
- Identifying, removing, and verifying the tumbleweed is contaminated by either manual (personnel) or physical methods (heavy equipment);
- Planting of other vegetation;
- Use of snow fencing to redirect the path a tumbleweed travels.
- Placing clean fill over an area of contaminated tumbleweeds and/or the applying of soil cement; and
- Covering contaminated soil with cobbles and stones and applying herbicides.

ROOT CAUSE ANALYSIS

The root cause analysis process consisted of assembling a team, determining the appropriate root cause methodology to be used in the analysis process, gathering and reviewing information related to contaminated vegetation events, identifying and evaluating root causes of the problem, and determining the causal event. Each of these areas are further discussed below.

Root Cause Methodology and Assembled Team

A team comprised of five individuals, each representing an organization within SWP, was assembled. The individuals represented Facilities Support, Operations, Facility Engineering, and Radiological Control. In addition, an independent facilitator was present to assist in the root cause process. The methodology for the root cause analysis was the Event and Causal Factor Charting. Figure 2.0 presents the overall root cause process pertaining to contaminated tumbleweeds. The causal event was identified as radiologically contaminated tumbleweeds found outside a posted contamination area (CA).

Subject matter experts, M. I. Wood, Principal Scientist, and M. B. Malady, Environmental Management, were interviewed and provided information on characteristics of tumbleweeds, site geology, and the performance assessment for the 200 Area Burial Grounds. Historical information on vegetation management, RPRs, Occurrence Reports, Internal Memorandums related to remediation of the 218-W-3A Burial Grounds, and burial ground maps were used in the root cause process.

Two causes were identified that allowed for the continued growth of contaminated tumbleweeds: past and present waste disposal practices, and less-than-adequate vegetation management of noncontaminated tumbleweeds. The two causes can be classified as 8A, Legacy Contamination, employing the root cause codes in DOE Order 232.1, *Occurrence Reporting and Processing of Operations Information* (DOE, 1995). Each of these causes are further discussed below.

Past and Present Waste Disposal Practices

Past and present waste disposal practices consist of burying waste in cardboard boxes, wooden boxes, steel drums, bulk form (such as soil or asphalt), and other waste forms (such as submarine reactor compartments, railroad cars, plastic wraps, etc.) in the burial grounds. The waste packages were designed to provide containment during transportation and handling of the waste only, not containment during storage and disposal of radioactive waste.

Boxes have been designed to crush upon addition of soil to reduce void space and minimize subsidence problems. Waste packages were placed in unlined trenches and backfilled with soil when either the burial trench was full or radiological conditions were such that backfilling was required. The level to which the waste was backfilled varied depending upon the waste type (e.g. low-level, transuranic) and the year of disposal. The condition of the waste packages and depth to which the waste was buried provided an environment for vegetation to be in direct contact with radioactive contaminants.

Vegetation Management of Noncontaminated Tumbleweeds

For several years a vegetation management program has been in place for noncontaminated tumbleweeds. The program consists primarily of applying herbicides to kill tumbleweeds, sterilization of select areas, and planting of additional stabilization vegetation, such as Crested Wheat Grass. The program has achieved a success rate of killing approximately 80 to 85 percent of the tumbleweeds in the 200 Area Burial Grounds; however, the remaining 10 to 15 percent of live tumbleweeds have been found to grow roots into waste buried in the burial grounds and transport the contamination throughout the plant. Dead tumbleweeds have been found to be contaminated and spreading contamination within and around the burial grounds, including the 218-W-3A Burial Ground.

Because buried radioactive contamination is in contact with the soil and the high germination rate of the tumbleweed plant, an effective vegetation management program needs to achieve close to 100 percent sterilization to be considered effective. Past corrective actions associated with management of contaminated tumbleweeds have been found to be repetitive and not adequately revaluated to determine their effectiveness.

Mitigating Factors

Several factors were identified that were found not to be root causes, but actually contributed to the causal event of contamination being found outside of posted CAs. These factors included:

- Transportation of the dead contaminated tumbleweeds through natural phenomenon (e.g., wind).

- A general change of culture on the Hanford Site caused by a change in mission (e.g., production versus cleanup) and regulatory and contractual requirements (as noted in 10 CFR, Part 835.404(b)).

- The accidental identification of contaminated tumbleweeds through routine radiological surveys and radiation zone reduction efforts.

- No radiological routines were established for surveying underground radiological material areas (URMAs).

- Delayed funding of herbicide application.

Alternatives Identified Requiring Further Investigation for Resolving Causal Event

Various alternatives were identified for resolving the causal event at the 218-W-3A Burial Grounds and are identified in Table 1.0. The alternatives were classified into three major categories: Growth Prevention and Containment, Engineered Root Barriers, and Waste Packaging. Alternatives were identified that included engineering controls, with additional alternatives expected to be identified during an indepth engineering review to be conducted at a later date. In addition, contamination control techniques were addressed.. The alternatives were qualitatively evaluated by the root cause analysis team and encompassed both existing vegetation management methods, as well as nontraditional methods for managing contamination control .

RECOMMENDED CORRECTIVE ACTIONS

Recommended corrective actions for resolving the trend of contaminated vegetation in the 218-W-3A Burial Ground, and potentially throughout the 200 Area Burial Grounds, were organized as either immediate- (within FY 1997) or long-term corrective actions (FY 1998 and beyond). Immediate corrective actions included the following:

- Develop an aggressive plan for identifying the extent of contaminated tumbleweeds at the 218-W-3A burial ground and surrounding areas (e.g., 218-W-6 Burial Ground).

- Continue the application of herbicide for killing tumbleweeds.

- Develop an aggressive housekeeping program for the collection of tumbleweeds.

- Implement temporary containment methods (e.g., straw bales, fencing)..

- Reevaluate the practice of scraping soil contaminated with tumbleweeds (activity releases seed from the plant encouraging propagation).

- Continue to selectively plant competitive vegetation such as native grasses to eventually replace the tumbleweed.

Table 1.0 Alternatives for Resolving Causal Event

Alternative Category	Description of Alternative
Growth Prevention and Containment	Containment of tumbleweeds
Growth Prevention and Containment	Plant stabilization using alternative vegetation
Growth Prevention and Containment	Seasonal and maintenance application of herbicides
Growth Prevention and Containment	Weed removal via physical or mechanical methods
Growth Prevention and Containment	Soil cement (or other fixative)
Growth Prevention and Containment	Increase soil depth over waste
Growth Prevention and Containment	Perform investigative surveys to determine extent of contamination
Growth Prevention and Containment	Aggressive housekeeping for tumbleweed disposal
Engineered Barrier	Capillary barrier
Engineered Barrier	Chemical saturation layer
Engineered Barrier	Root pruning layer with chemically treated net
Engineered Barrier	Waste liner
Waste Packaging	Remove waste packages from problem trenches and repackage
Waste Packaging	Alternative waste packaging which prevents root penetration and provides adequate containment of waste

Recommended long-term actions included the following:

- Develop a long-term plan for investigation of radiological surveys at the 200 East and 200 West burial grounds, specifically targeting URMAs.

- Identify, evaluate, and test an engineered root barrier to prevent roots from reaching the buried waste.

- Continue the application of herbicides for vegetation maintenance (secondary method for control rather than primary).

- Investigate the feasibility of developing and implementing alternative waste packaging.

Alternatives Not Recommended As Corrective Actions

Several alternatives previously listed were not recommended as corrective actions for a variety of reasons. These actions are presented below, along with an explanation of why the alternative(s) was discounted.

- Weed removal via physical or mechanical methods at 218-W-3A and surrounding burial grounds - The control method for preventing the growth of tumbleweeds is ineffective. Because the roots of tumbleweeds may grow down approximately 20 feet and the large quality of contaminated tumbleweeds that may be present at 218-W-3A, this alternative is not considered to be practical nor technically sound.

- Application of clean soil fill and soil cement as a temporary barrier - The average life expectancy of soil cement is approximately 6 months to a year in the burial grounds. The application of soil cement does not affect the root of the tumbleweed nor prevent seeds from germinating underneath the cement barrier (Wood, 1997). In addition, the application of clean soil fill would enhance the growth of tumbleweeds and act as a transport vehicle for tumbleweed seeds that may have been dormant in the clean fill.

- Removing radioactive waste from trenches that would exhibit the highest potential for contamination migration - Not enough information is available to determine which trenches would exhibit the highest potential for contamination migration. Although the type of waste buried is documented, the condition of the buried packages varies among burial grounds and is not readily known.

ADDITIONAL ISSUES TO CONSIDER

Throughout the root cause process two issues were identified as potential items that warranted attention by management: the identification and management of contaminated vegetation across the Hanford Site, and.

During the root cause analysis, It became obvious that contaminated tumbleweeds are a Hanford Site problem and should be addressed from a site-wide perspective. Since 1993 there have been approximately 120 RPRs relating to contaminated tumbleweeds (Barajas, 1997). No one specific location can be identified where an increased amount of contaminated tumbleweeds may be located. The RPR database did not indicate that contaminated tumbleweeds are any more of a problem in the burial grounds than at other areas on the Hanford Site. In addition, it was recognized that corrective actions should be focused from a site-wide perspective rather than by one organization in order to achieve maximum effectiveness in minimizing the migration of contaminated tumbleweeds.

The second issue was the lack of research that has been conducted to date with respect to assessing the risks of onsite and offsite exposures from contaminated tumbleweeds. There was little information available and documented on potential risks to workers and the public from radioactive contamination fixed in a plant matrix, particularly tumbleweeds. Without a clear understanding of a quantitative risk value associated with exposure to contaminated tumbleweeds, a final decision as to a cost-effective method for managing tumbleweeds cannot be determined.

REFERENCES

Barajas, 1997. Site Wide Radiological Problem Report from the Site Wide Database. Fluor Daniel Hanford, Inc.

DOE, 1988a. *Low-Level Burial Grounds Dangerous Waste Permit Application.* DOE/RL 88-20. U.S. Department of Energy, Richland Field Office. Richland, Washington.

DOE, 1988b. Radioactive Waste Management. DOE Order 5820.2a. U.S. Department of Energy, Washington, D.C.

DOE, 1995. *Occurrence Reporting and Processing of Operations Information.* DOE Order 232.1. U. S. Department of Energy, Washington, D.C.

DOE, 1996. *The History of the 200 Area Burial Ground Facilities.* WHC-EP-0912. U. S. Department of Energy, Richland Field Office. Richland, Washington.

Malady, 1997. Conversation with M. B.Malady. Environmental Management Inc. Rust Federal Services Northwest.

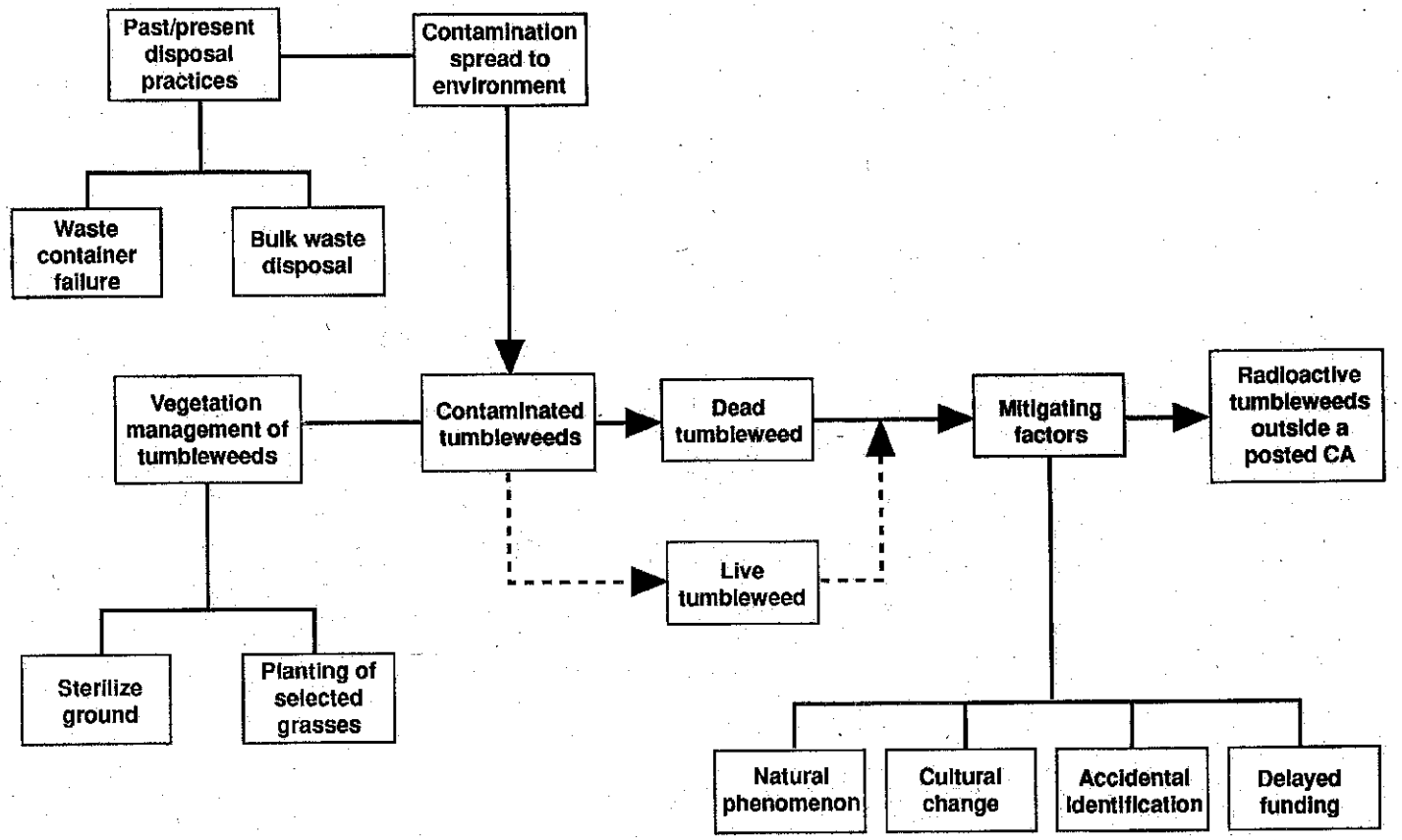
Wood, 1997. Conversation with M. I. Wood, Principle Scientist. Rust Federal Services of Hanford.

RFSH, 1997. Notification of Potential Trend. RFSHRC-97-002. Rust Federal Services of Hanford.

Event and Causal Chart Charting

RCA of Radiologically Contaminated Tumbleweeds

Figure 1.0



March 14, 1997