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EVALUATION OF REMEDIAL ALTERNATIVES FOR THE SOLAR PONDS PLUME, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Kelly Carter Hranac
Morrison Knudsen Corporation
Rocky Flats Environmental Tech. Site
P.O. Box 464
Golden, Colorado 80402-0464
(303)966-7400

F. Winchester Chromec, PhD; Robert Fiehweg
Rocky Mountain Remediation Services
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, Colorado 80402-0464
(303)966-4535, (303)966-7403

John Hopkins, PhD
Rocky Mountain Remediation Services
2237 Trinity Drive, Bldg 2
Los Alamos, New Mexico 87544
(505)662-1314

ABSTRACT

This paper describes the process used to select a remedial alternative for handling contaminated groundwater emanating from the Solar Evaporation Ponds (Solar Ponds) at the Rocky Flats Environmental Technology Site (RFETS) and prevent it from reaching the nearest surface water body, North Walnut Creek (Figure 1). Preliminary results of field investigations conducted to provide additional information for the alternatives analysis are also presented. The contaminated groundwater is referred to as the Solar Ponds Plume (SPP). The primary contaminants in the SPP are nitrate and uranium; however, some metals exceed the site action levels at several locations and volatile organic compounds, originating from other sources, also have been detected. Currently the SPP, local surface water runoff, and infiltrated precipitation are collected by a trench system located downgradient of the Solar Ponds and pumped to three storage tanks. The water (two to three million gallons annually) is then pumped to an on-site treatment plant for evaporation at an approximate cost of $7.57 per liter.

Due to the high cost of treatment and the need to implement a long-term remedy by the end of fiscal year 1999, a remedial alternatives analysis study was conducted in 1997. The current study further investigates three of the four retained remedial alternatives from the 1997 study: 1) Managed release of collected water to a pond on North Walnut Creek; 2) Treatment of collected water at a different on-site location by a less expensive process; and 3) Phytoremediation. The uranium activity in the SPP presents a complication in implementing a remedial action. Relatively high uranium activity has been identified in background groundwater wells at RFETS. In order to evaluate the size of the uranium plume associated with the Solar Ponds, an estimate of background uranium concentrations is required. Uranium isotope analyses of both SPP and background wells were conducted during this study and the ratios of the ^{234}U to ^{238}U activities and ^{238}U to ^{235}U masses were calculated. This data will be used to evaluate the size of the uranium component of the SPP.

I. INTRODUCTION

The source of the SPP is contaminated groundwater emanating from the Solar Ponds at RFETS (Figure 1). The primary contaminants are nitrate and uranium. Currently the SPP, local surface water runoff, and infiltrated precipitation are collected by an Interceptor Trench System (ITS) located in the hillslope to the north of the Solar Ponds. The two to three million gallons of groundwater collected each year by the ITS near North Walnut Creek is pumped to three 132,100-liter above-ground modular storage tanks (MSTs). The water is then piped to Building 374 for treatment by evaporation, at an approximate cost of $7.57 per liter.

The high cost of this treatment, in addition to the eventual demolition of the water treatment facilities at RFETS during site closure, drove the need for an alternative to the current treatment method. The Rocky Flats Cleanup Agreement (RFCA)[1], signed by the U.S. Department of Energy (DOE); U.S. Environmental Protection Agency, Region VIII (EPA); and the Colorado Department of Public Health and Environment (CDPHE) in 1996, set a milestone of fiscal year 1999 for implementation of a remedial action to control the SPP and prevent it from causing the nearby stream, North Walnut Creek, to exceed the state surface water standards. RFETS is scheduled for site closure in 2006.

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A. Geology and Hydrogeology

The Solar Ponds are located on level ground in the northeastern portion of the Industrial Area at RFETS. To the north of the Solar Ponds is a hillslope which descends to North Walnut Creek (Figure 1). The subsurface geology beneath the Solar Ponds and the SPP consists of surficial deposits underlain by weathered/fractured bedrock and competent bedrock. The surficial deposits consist of Rocky Flats Alluvium, landslide deposits, colluvium, valley fill alluvium, and artificial fill (referred to as "alluvium"). The alluvium thickness ranges from 0.3 to 6.9 meters in the vicinity of the SPP; the thickest alluvium is found to the northeast and southeast of the Solar Ponds. These materials unconformably overlie the bedrock.

The bedrock beneath the SPP is composed of claystone and silty claystone of the Arapahoe and Laramie Formations, with lenticular sandy siltstone and sandstone bodies. Claystone is the predominate lithology in the study area, although siltstone and sandstone bodies also subcrop[4]. The bedrock has been variably altered by weathering. Fractures have been identified in the claystones beneath the Solar Ponds, and to the north and northeast of the Solar Ponds. These fractures are a potential migration pathway for contaminants to leave the Solar Ponds area. A seismic refraction study was conducted in the Solar Ponds and North Walnut Creek areas[4] and analysis of these data indicated that the upper 3 to 9 meters of the claystone bedrock is weathered. The deepest weathering was found along the North Walnut Creek drainage.

Groundwater enters the Solar Ponds area from the west-southwest in the alluvium and weathered bedrock. Groundwater flows eastward beneath the Solar Ponds and then diverges to the north-northeast toward North Walnut Creek and to the east-southeast toward South Walnut Creek. This divergence in groundwater flow is caused by an east-west trending bedrock high beneath the Solar Ponds and natural topographic breaks in these directions[4].

The groundwater flow path is very complex due to the varying thickness of the alluvium and weathered bedrock units and the highly variable primary and secondary permeabilities of the two units. The combination of the variable alluvium thickness and seasonal water table fluctuations results in large areas of the alluvium becoming unsaturated during late fall and winter.

B. Operation of the Solar Ponds and ITS

The six original Solar Ponds were used to store and evaporate process wastes containing alcohol wash solutions; waste radiography solutions; leachate from the RFETS sanitary landfill; treated sanitary effluent; groundwater from the ITS; saltwater solutions; cyanide wastes; acid wastes; and other compounds such as sodium, cadmium, nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfate, hydrochloric acid, nitric acid, and hexavalent chromium from the 1950s to 1986. In addition, radioactively-contaminated aluminum scrap and a solution resulting from treatment of lithium metal with water were also placed in the Solar Ponds[4].

One Solar Pond was closed in 1962, prior to construction of a building in this location (Building 779, Figure 1). The contents of the pond, as well as the clay liner were removed. Cleanup activities at the five remaining Solar Ponds began in 1985 and sludge removal from the ponds was completed in 1995. Additional remediation activities to remove contaminated soils, equipment, and structures are proceeding concurrently with the SPP remediation, but as a separate project. Capping was selected as the ultimate remediation for the Solar Ponds and vicinity; and is expected to be completed in Fiscal Year 2005[2].

In 1971, seeps of high nitrate groundwater were noted on the hillslope downgradient (to the north) of the Solar Ponds. Also in 1971, RFETS installed a system of interceptor trenches in this hillslope to capture groundwater, infiltrating surface runoff, and any leakage from the Solar Ponds. These interceptor trenches dewatered the slope to provide slope stability and prevent the pond leakage from reaching North Walnut Creek, to the north of the slope. The system of trenches was abandoned and the current ITS was constructed in 1981 (Figure 1). ITS water was recycled to the SEPs until installation of the MSTs in 1993. Since 1993, water collected by the ITS has been pumped to the MSTs and from there to Building 374 for evaporation.

The ITS was installed primarily in the unconsolidated alluvium and the upper portion of the weathered bedrock. However, some portions of the ITS were not keyed to bedrock. The ITS effectively dewaters the alluvium in this area; however, some contaminated groundwater may pass beneath the ITS where it is not keyed to bedrock. This water may discharge to the alluvium in this area, discharge to North Walnut Creek, or remain in the bedrock.

II. REGULATORY FRAMEWORK

The RFCA[1] governs cleanup activities at RFETS. The primary goal of RFCA[1] is the protection of surface water, in this case North Walnut Creek. The RFCA[1] identified action level strategies for groundwater. The action levels, Tier I and Tier II, require RFETS to determine if action is necessary to prevent contaminants from exceeding surface water standards. Tier II action levels are the EPA Maximum

Contaminant Level (MCL) concentrations for each constituent, or other risk-based concentrations agreed to by all parties. Tier I action levels are 100 times the Tier II action level. Exceedance of a Tier II action level must be reported to the agencies and continued to be monitored. Exceedance of a Tier I action level requires RFETS to evaluate impacts to surface water.

The in-stream standard for nitrate in North Walnut Creek is 10 mg/L; however, RFETS has negotiated an interim nitrate in-stream standard of 100 milligrams per liter (mg/L) which applies during the site cleanup period of January 1, 1998 through site closure in 2006. The in-stream standard for total uranium isotopes is 10 picoCuries per liter (piC/L). The compliance point for these standards is currently the RFETS boundary. After 2006, the in-stream standard for nitrate will be 10 mg/L. Both the nitrate and total uranium isotope stream standards must be met at any point in North Walnut Creek within and downstream of RFETS after 2006. Available SPP data indicate that the nitrate concentrations exceed the original nitrate Tier I action level of 1000 mg/L near the Solar Ponds and SPP groundwater contaminated with nitrate and uranium has the potential to impact surface water via discharge to North Walnut Creek.

III. ALTERNATIVES EVALUATION

In 1997, RFETS undertook a study to evaluate alternatives for management and treatment of the water collected by the ITS[2]. The objective of the study was to find a less costly method of handling or treating the ITS water, as well as preventing contaminated SPP groundwater from impacting North Walnut Creek. The alternatives analysis focused primarily on dealing with the nitrate in the groundwater, although it was recognized that the uranium in the groundwater might also influence the selection of an alternative. However, the uranium plume had not been defined sufficiently to determine impacts to surface water.

Eleven alternatives were developed to address the Solar Ponds Plume. These alternatives are briefly summarized in Table 1 and the major elements of each alternative are shown on Table 2. The alternatives were evaluated based on the following elements:

- *Effectiveness:* Ability to protect human health and the environment and comply with surface water standards in North Walnut Creek.

- *Implementability:* Technical implementability (ease of construction and reliability of operation) and administrative implementability (ability to obtain necessary permits, licenses, availability of necessary equipment and workers).

- *Ability to Meet Specific Goals and Objectives:* The goals and objectives set for the ITS are: 1) Compliance with applicable surface water standards for nitrate and uranium, including the interim nitrate standard; 2) Consistency of an alternative's actions with the goals of RFCA[1], and the RFETS Site Vision and Site Closure Plan[3]; and 3) Significant reduction in costs over current ITS water management practices.

- *Cost Minimization:* Evaluation of existing equipment to be used by the alternative; alternatives requiring substantial new construction, particularly outside of the RFETS Industrial Area, were ranked lower.

- *Ease of Post Site-Closure Operations:* Evaluation of long-term operations and maintenance (O&M) requirements; specifically O&M requirements required after RFETS closure.

- *Regulatory Agency and Local Community Acceptance:* Evaluation of prospective acceptability to regulatory agencies and the local community, as well as alternative's ability to meet the terms and conditions of permits, regulations, and agreements.

Although data for Cost Minimization and Ease of Post Site-Closure Operations were compiled, these two criteria were not used in ranking the alternatives. A weighting factor was subjectively assigned to each criteria, based on its perceived importance in meeting the SPP goals and objectives. Each alternative was then assigned a value for each of the four evaluation criteria using a scale of 1 (poor) to 5 (excellent). The criterion "Ability to Meet Goals and Objectives" was considered the most important of the evaluation criteria.

A. Results of 1997 Study

After the initial screening, four remedial alternatives were retained for further study: 1) Treatment of ITS Water at Building 995; 2) Phytoremediation; 3) Managed Release of ITS Water; and 4) Enhanced Evaporation at the MSTs. The weighted totals for remedial alternatives 1 and 2 were the highest; the weighted totals for remedial alternatives 3 and 4 were the second highest.

1. Treatment of ITS Water at Building 995. ITS water would be pumped to the wastewater treatment plant (WWTP) at Building 995 rather than to the evaporators at Building 374. Redirection of the ITS water to Building 995 would involve very little modification to the Site's infrastructure, as most of the necessary components are in place and useable. The ITS water is not expected to have a major impact on operations at the facility, as it would make

up less than 4% of the normal influent volume of the WWTP under normal ITS flow conditions. Treatability studies to assess the impacts of the ITS water on the current operating process, as well as impacts to the proposed on/off aeration system for this building were suggested. Evaluation of the potential impact of the uranium in the ITS water on the possible future land application of WWTP biosolids was also suggested.

2. Phytoremediation. Phytoremediation is an emerging soil, groundwater, and wastewater remediation technology that makes use of designed plant systems to remove, contain, or change the form of metals, organic, and radioactive compounds. Phytoremediation systems can be active (irrigated with contaminated water) or passive (deep-rooted plants draw water directly from contaminated aquifer). Both active and passive systems were evaluated during the study; the passive system was selected for further study.

The passive system will focus on minimizing recharge of contaminated SPP groundwater to North Walnut Creek. This passive phytoremediation system will involve planting of deep-rooting native vegetation in the SPP upgradient of North Walnut Creek to intercept shallow groundwater. The Preble's Jumping Mouse (*Zapus hudsonicus preblei*), a species recently listed as threatened, lives in the riparian areas along North Walnut Creek. To protect the Preble's habitat, only native vegetation will be planted in any phytoremediation system implemented, and this will be outside of the designated Preble's habitat.

The selected vegetation will likely be native cottonwood trees (*Populus spp.*). Initially, the trees will be irrigated to establish the trees and train the root systems for maximum interception of plume flow. It is anticipated that four years will be required for the trees to become mature enough to survive without irrigation and provide control of the SPP. Review of published research indicates that phytoremediation using cottonwood trees will be highly effective in reducing nitrate concentrations in groundwater. The fate of the dissolved uranium in the groundwater after implementation of a phytoremediation system is unclear.

3. Managed Release of ITS Water. Under this scenario, untreated ITS water would be released to North Walnut Creek. During Phase I the interim nitrate surface water standard of 100 mg/L is in place. Pumping at the ITS pump house would cease and the ITS water would be allowed to overflow the pump house and enter North Walnut Creek. During Phase II, the ITS would be decommissioned by grouting after capping of the Solar Ponds in 2005. Technical evaluation of the impacts of Phase I on North Walnut Creek indicated that the nitrate and uranium surface water standards would be met on a seasonal basis. However, there would likely be times during low flow periods when the surface water standards of North Walnut Creek would not be met. The effectiveness of Phase II will be evaluated during the current groundwater assessment and modeling activities. It is suspected that North Walnut Creek would not meet the surface water standard for nitrate of 10 mg/L. The primary drawback to this remedial alternative, is its suspected inability to meet the surface water standards on a daily basis as required by RFCA.

4. Enhanced Evaporation. In this alternative, water would be collected by the ITS and stored in the MSTs. The MSTs would be equipped with spray nozzles to provide enhanced evaporation of the ITS water. This process would continue until site closure, and possibly continue for a period after site closure. This alternative has been eliminated from further study, due to concerns expressed by the CDPHE and the EPA regarding the potential spread of contamination due to overspray at the MSTs.

Although reducing the cost of treating the SPP water was the most immediate reason for identifying the treatment method, RFETS was also interested in a long-term solution/remediation for the SPP. The conclusion of the 1997 report was that phytoremediation was the most promising of the retained alternatives because of its relatively low initial and O&M costs, passive nature, and potential to provide long-term protection of the surface water in North Walnut Creek. However, selection of an alternative could not be made until additional information was gathered regarding the nature and extent of the SPP, the local hydrogeology, agronomic properties of the SPP soil, and uranium uptake by deep-rooting vegetation.

B. Current Activities

Evaluation of the retained alternatives, or a combination of the alternatives, required collection of additional data and a rigorous interpretation of the existing and newly-generated data. Currently, this data collection and interpretation is in progress, and includes the following tasks.

- Definition of current vertical and lateral extent of the SPP
- Refinement of the local (vicinity of the SPP) conceptual hydrogeological model
- Use of analytical models to simulate local groundwater flow and predict the concentrations of nitrate and uranium in the groundwater that will discharge to North Walnut Creek under various scenarios

- Evaluation of the uranium uptake of vegetation presently in the SPP and comparison of these data to background data
- Evaluation of agronomic properties of soils in the ITS area where a phytoremediation system may be placed
- Evaluation of uranium isotope ratios of groundwater samples from the SPP and background locations for identifying locations where uranium in groundwater can be attributed to leakage from the Solar Ponds
- Treatability studies of ITS water at Building 995 and evaluation of uranium content of biosolids

IV. RESULTS OF CURRENT ACTIVITIES

A discussion of the preliminary results of the plume characterization and the techniques being applied to evaluate background uranium activities in groundwater will be discussed below. The results of the phytoremediation evaluations, treatability studies at Building 995, and the selected alternative are not available at this writing, but will be presented at the conference. An additional paper, "Hydrogeologic Analysis of Remedial Alternatives for the Solar Ponds Plume, RFETS", was submitted in category 3.7 Site Remediation Case Studies; it describes the refined site conceptual hydrogeological model, the set up of the groundwater flow and contaminant transport models, and how these models will be used to evaluate the effectiveness of the retained alternatives.

A. Plume Characterization

A comprehensive groundwater sampling event was conducted during Fall 1997 and Winter 1998 to define the vertical and lateral extent of the nitrate and uranium in the SPP, as well as collect samples from selected background wells for uranium isotope analysis. Sixty-six wells in the SPP area and 18 background wells were selected for sampling. Fourteen of the selected wells did not contain enough water for sample collection. The wells for the initial sampling event were selected to spatially represent the alluvium, weathered bedrock, and competent bedrock in the SPP and background areas. This initial sampling event represents groundwater quality during the "low flow" season at RFETS. Two additional sampling events, of seven wells sampled during the first event, were or will be conducted to evaluate water quality during "high flow" season at RFETS.

The range of nitrate and uranium values in the alluvium and weathered bedrock units documented from this most recent sampling event were somewhat unexpected. Prior to this sampling event, the extent of the SPP had been based on a 1995 study which collected samples from a large number of wells but conducted field analyses of the samples for nitrate only. The distribution of total uranium isotopes exceeding 10 piC/L (the stream standard for North Walnut Creek) could not be reliably defined based on historical sampling events in the SPP area. In addition, most previous reports regarding the SPP had grouped the alluvium and weathered bedrock together as the "Upper Hydrostratigraphic Unit." Because it was suspected that some SPP groundwater was moving beneath the ITS in the weathered bedrock and flowing toward North Walnut Creek, this investigation focused on evaluating the nitrate and uranium plumes in the alluvium and weathered bedrock separately. Because the results of the Fall 1997/Winter 1998 groundwater sampling event have only been available for a short time, only general interpretations as to the lateral and vertical extent of the SPP are presented below.

1. Contaminant distribution in alluvial groundwater. High concentrations of nitrate, as well as high activity concentrations of uranium were detected in the alluvial groundwater. The nitrate concentrations ranged from non-detected to 3200 mg/L. Predictably, the highest concentrations were found in the area immediately adjacent to the SEPs (Figure 1). Nitrate concentrations in groundwater adjacent to North Walnut Creek range from 640 mg/L (well 1786) near the ITS pump house to 0.06 mg/L at the eastern-most well sampled (well 1386). The alluvial groundwater adjacent to North Walnut Creek exceeds the 100 mg/L surface water standard for nitrate for approximately 500 feet downstream of the ITS pump house.

The total uranium activities (sum of all uranium isotopes) in the alluvium ranged from 0.72 piC/L on the western edge of the western-most Solar Pond to 1605 piC/L on the eastern edge of this pond. The alluvial groundwater adjacent to North Walnut Creek exceeds the surface water standard of 10 piC/L in all wells sampled during this event, from B208789 just south of the MSTs to well 1386.

2. Contaminant distribution in weathered bedrock groundwater. Nitrate concentrations in the weathered bedrock wells ranged from 0.45 mg/L at well B208689, adjacent to North Walnut Creek, to 5400 mg/L, detected in well P209589 to the northeast of the northeastern Solar Pond. The 5400 mg/L detected at P209589 was the highest nitrate concentration detected in the SPP during this sampling event. Nitrate concentrations in weathered bedrock wells B210389 and B208689 adjacent to North Walnut Creek were 0.67 and 0.45 mg/L, respectively.

These very low concentrations occur in wells where the overlying alluvium has nitrate concentrations around 600 mg/L. It appears that some denitrification of the groundwater may be occurring in the weathered bedrock in this area.

The total uranium activities detected in groundwater in the, weathered bedrock during this sampling event ranged from 2.47 piC/L at well 76292 to the east of the Solar Ponds to 369 piC/L at well P209589 (where the highest nitrate concentration was detected). The total uranium activities in weathered bedrock wells B210389 and B208689 adjacent to North Walnut Creek are 104.73 and 13.96 piC/L, respectively. Comparison of the total uranium activities at these two wells with their nitrate concentrations, gives further evidence that denitrification of the groundwater may be occurring in this area.

B. Analysis of Uranium Isotope Data

The uranium activity of background groundwater in both the alluvium and weathered bedrock at RFETS varies greatly. Because of this, it is very difficult to arrive at a uranium activity for background groundwater in the alluvium or weathered bedrock which can be used for screening the SPP groundwater total uranium concentrations and identifying areas impacted by the Solar Ponds. Published studies have shown that the atom ratio of ^{238}U to ^{235}U *in naturally occurring uranium is 137.8.* This atom ratio can be used to separate the components of anthropogenic (enriched or depleted) uranium and naturally-occurring uranium. The ^{234}U to ^{238}U activity ratio has also been used to distinguish between natural and anthropogenic uranium. The activity ratios of ^{234}U to ^{238}U are approximately 0.09 in depleted uranium, 1.06 in natural uranium, 5.74 in power-reactor fuel, and higher for weapons-grade uranium[6]. The ^{234}U to ^{238}U activity ratio for uranium in natural waters usually ranges from 1 to 3; the higher activity of ^{234}U in natural waters appears to result from selective mobilization[7]. Ratios that are above 3.0 or below 1.0 suggest the presence of artificially enriched or depleted uranium.

Calculation of the ^{238}U to ^{235}U mass ratios and ^{234}U to ^{238}U activity ratios using the uranium isotope results for background and SPP wells collected during the recent sampling event did not show any consistent pattern that could distinguish naturally-occurring from anthropogenic uranium. The most likely reason that the ratios could not be used to distinguish between the sources of uranium in the groundwater is that the analytical error associated with the method by which the samples were analyzed (alpha spectroscopy) was too great (+/- 20%). To reduce the analytical error associated with uranium isotopic determination, 10 samples (seven from background wells and three SPP wells) will be analyzed for uranium isotopes by high-resolution Inductively Coupled Plasma/ Mass Spectroscopy (ICP/MS). The analytical error associated with uranium isotope determinations by this method are 1% to 2%. It is hoped that uranium isotopic ratios calculated from this data will help define naturally -occurring uranium in groundwater. Groundwater samples collected from the SPP wells during the second and third sampling events will also be analyzed for uranium isotopes by ICP/MS.

V. CONCLUSIONS

Analysis of groundwater samples and interpretation of the results are not yet complete. The results of these analyses and interpretations will be presented at the conference, in addition to the results of the phytoremediation studies, treatability studies, and modeled response of the hydrogeologic system to implementation of the retained alternatives.

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Table 1. Description of Remedial Alternatives Evaluated

Alternative	Description
1. Direct Release of ITS Water	Closure of the ITS and ITS pump house. Groundwater is allowed to flow into N. Walnut Creek.
2. Managed Release of ITS Water	Phased release of ITS water to North Walnut Creek without treatment. First phase requires use of MSTs.
3. Evaporation of ITS Water at Building 374	Continued use of ITS and MSTs with periodic treatment of collected water at Building 374 evaporators (or replacement facility).
4. Treatment of ITS Water at Building 995	Continued use of ITS and MSTs with periodic treatment of collected water at Building 995, the RFETS wastewater treatment plant.
5. Treatment at MSTs	Treatment for denitrification and uranium removal using the MSTs as process vessels. Requires continued use of ITS.
6. Constructed Wetlands	Use of appropriately-sized area with wetland-type plants to receive ITS water for denitrification and uranium retention. Requires continued use of ITS and MSTs.
7. Off-Channel Evaporation Pond	Use of an pond outside of the N. Walnut Creek drainage for evaporation of ITS water. MSTs would be closed.
8. Dispersion Field	Continued use of ITS and MSTs with distribution of ITS water in a leach field for denitrification and uranium retention.
9. Phytoremediation	Use of deep-rooted vegetation to passively intercept/treat SPP groundwater.
10. Iron/Peat Passive Treatment	Use of a passive zero-valent iron and peat moss system for uranium retention.
11. Enhanced Evaporation at MSTs	Continued use of ITS; use of spray evaporation system within the MSTs to evaporate ITS water.

Table 2. Major Element of Remedial Alternatives

Alternative	Continued Use of ITS	Continued Use of MSTs	Ex-Situ Treatment	Use of Existing Equipment	Use of Undisturbed Land Outside of SPP Area	Generation of Waste Solids Req. Future Action	Treated Water Discharge to Walnut Creek	Untreated Water Discharge to Walnut Creek	In Situ Treatment
1. Direct Release								✔	
2. Managed Release	✔	✔		✔				✔	
3. Evaporation at Bld. 374	✔	✔	✔	✔		✔	✔		
4. Treatment at Bld. 995	✔	✔	✔	✔		✔	✔		
5. Treatment at MSTs	✔	✔	✔	✔		✔	✔		
6. Constructed Wetland	✔	✔	✔	✔	✔	✔	✔		
7. Off-Channel Evaporation Pond	✔		✔	✔	✔	✔			
8. Dispersion Field	✔	✔	✔	✔	✔	✔			
9. Phytoremediation	✔ (shaded)	✔ (shaded)		✔ (shaded)			✔		✔
10. Iron/Peat Passive Treatment						✔	✔		✔
11. Enhanced Evaporation at MSTs	✔	✔	✔	✔		✔			

(Shaded) Continued use of ITS and MSTs for less than 3 years

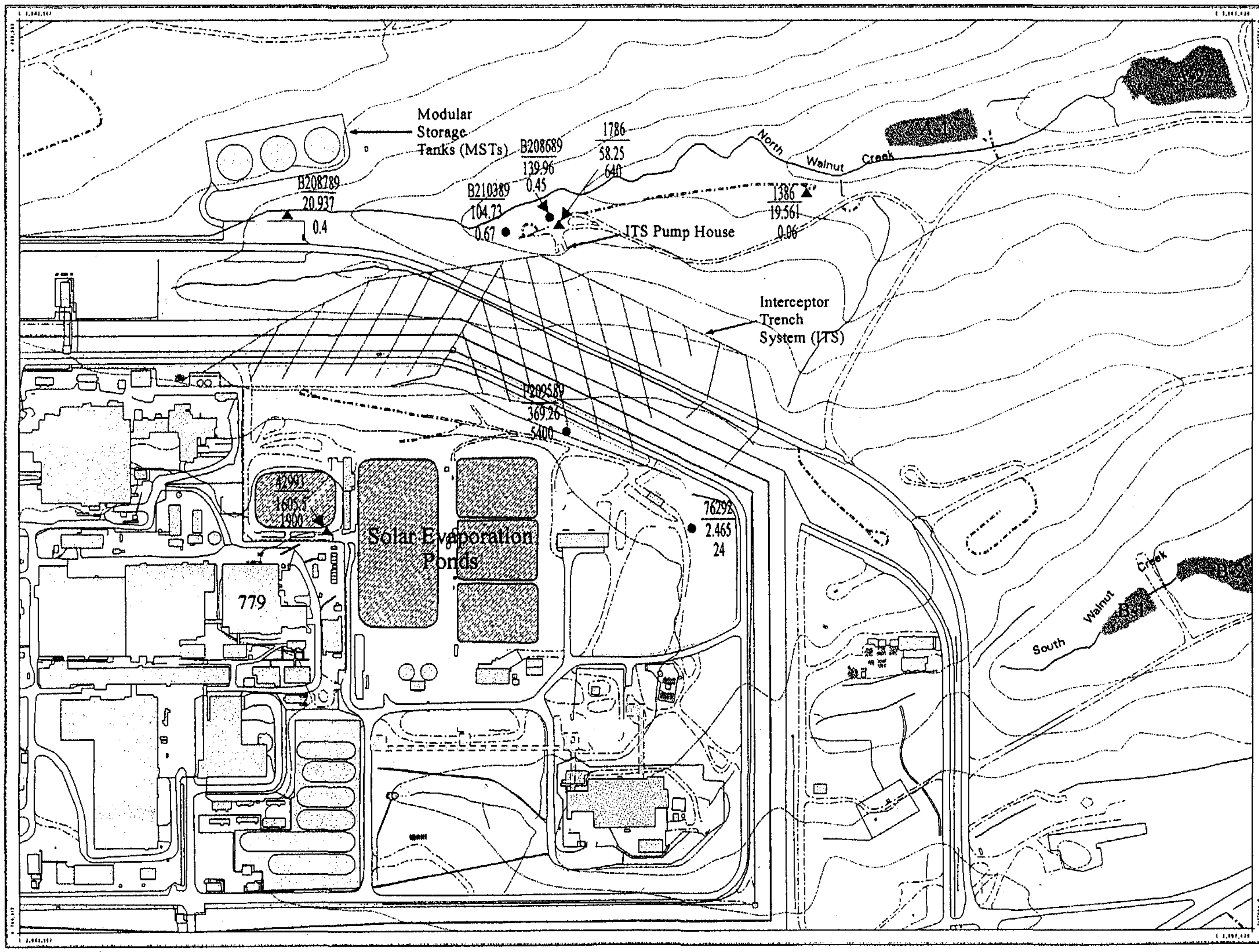

Figure 1
Solar Ponds Plume and Vicinity

Explanation

▲ Alluvial Monitoring Well
● Weathered Bedrock Monitoring Well

▲ 1386 Well Name
19.561 Total Uranium, piC/L
0.06 Nitrate, mg/L

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20 foot)
- Paved roads
- Dirt roads

100 0 200 400 ft

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Rocky Flats Environmental Technology Site

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