ASSESSMENT OF CANDIDATE SITES FOR DISPOSAL OF TREATED EFFLUENTS AT THE HANFORD SITE, WASHINGTON

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ABSTRACT

A rigidly defined evaluation process was used to recommend a preferred location to dispose of treated effluents from facilities in the 200 Areas of the U.S. Department of Energy's Hanford Site in Washington State. First, siting constraints were defined based on functional design considerations and siting guidelines. Then, criteria for selecting a preferred site from among several candidates were identified and their relative importance defined. Finally, the weighted criteria were applied and a site was selected for detailed characterization by subsurface investigations.

INTRODUCTION

Past waste disposal practices at the Hanford Site included the discharge of untreated effluents directly to ponds and trenches that infiltrated the effluents into thick, unconsolidated sediments overlying basalt bedrock. This practice was accepted at the time because the area was isolated from major population centers and had low precipitation, a deep water table, and favorable ion-exchange properties of the sediments. In accordance with the Hanford Federal Facility Agreement and Consent Order, by June 1995 these effluents will either receive treatment by the best available technology prior to their discharge or the discharge will be eliminated.

The treated effluents will be discharged to a land-based disposal facility chosen in accordance with the requirements of the U.S. Department of Energy (DOE) Order RL 4320.2C (1). The order requires that functional design requirements to protect human health and the environment be met while also considering cost and land-use planning factors. The facility will be designed to facilitate infiltration of the treated effluent into the sediments in compliance with a State Waste Discharge Permit. The terms and conditions of the permit will be negotiated in accordance with the requirements of Washington State Administrative Code (WAC) Chapter 173-216. The purpose of permits issued under the auspices of the administrative code is to comply with Section 307 of the Federal Water Pollution Control Act (33 U.S.C., §1251).

FUNCTIONAL DESIGN CONSIDERATIONS

Several design considerations (2) helped constrain the areas that could be considered for construction of the effluent disposal facility:

- Minimum average effluent flow rate of ~5677 l/m (1500 g/m)
- Thirty-year design life
- Berms sloped to facilitate escape of animals or fenced to inhibit entry
- A perimeter road for inspection and maintenance
- Underground effluent supply pipe protected from freezing.

The first two considerations required an area sufficient to accommodate infiltration of the effluent for the planned rate and duration. The remaining considerations required that the effluent disposal facility be located in terrain suitable for minimizing environmental disturbances, occupational hazards, and the risk of failures.

Rates of infiltration of effluent at the Hanford Site have been found to be highly dependent on both the hydrologic characteristics of the location and the chemistry of the effluent. Nevertheless, based on site-specific experience for infiltration ponds (Fig. 1), higher equilibrium rates of infiltration can generally be expected for paired-basin designs that operate in alternating cycles. The alternate wetting and drying cycles inhibit the growth of algae and permit periodic removal of fine-grained siltation or precipitation products that, within a relatively short time, can appreciably reduce the infiltration rate due to clogging of the pore space in the bottom of the pond. The required infiltration area was established by the following equation:

$$A = \frac{F}{I} \quad \text{(Eq. 1)}$$

where:

A = area required
F = rate of effluent influx
I = infiltration capacity.

For paired-basin designs, site-specific experience suggests that infiltration rates on the order of ~814 l/d/m^2 (20 g/d/ft^2) may be expected. For designs that do not facilitate cyclic operation (Fig. 2), experience suggests that an infiltration rate of 407 l/d/m^2 (10 g/d/f^2) may be appropriate for facility sizing. Assuming a rate of effluent discharge of ~5677 l/m (1500 gpm) and an infiltration rate of ~814 l/d/m^2 (20 g/d/ft^2), a minimum of ~6.13 hectares (2.48 acres) would be needed. Consequently, a minimum of ~12.26 hectares (5 acres) would be needed for a facility that could be operated either with or without alternate wetting and drying cycles.

To minimize the risks of effluent supply pipeline rupture, leaks or spills, a location relatively near the retention basin that is the effluent source was considered desirable. Evaluation of currently available geologic, hydrologic, land-use, and contaminant location information suggested that environmentally acceptable candidate sites were likely present within 3.2 km (2 miles) of the effluent source. Consequently, an arbitrary maximum distance from the source of 3.2 km (2 miles) was chosen to focus the evaluation on nearby areas to reduce the risks likely to be associated with more distant sites.

The nature of the local topography was a prime factor in eliminating areas from further consideration. Areas with relatively steep slopes and high local relief would require significantly more cut-and-fill for berm construction and could pose

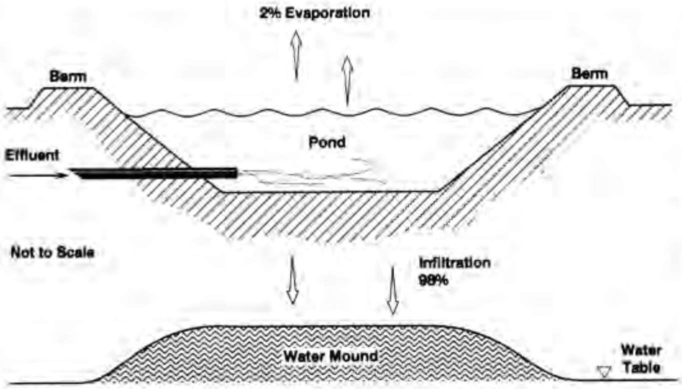

Fig. 1. Pond designed for infiltration of treated effluent.

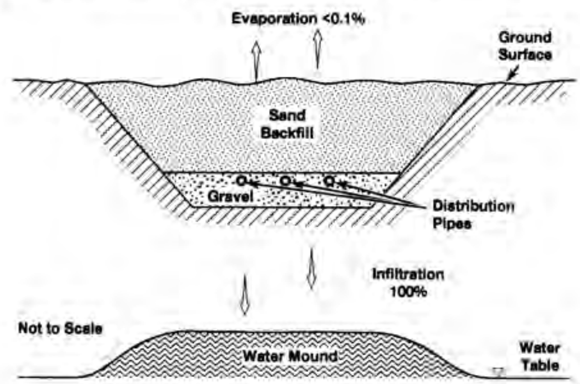

Fig. 2. Crib-like structure designed for infiltration of treated effluent.

appreciably greater risk of containment structure failure than those with more gentle slopes and low relief. For these reasons, gently sloping surfaces with relatively low topographic relief were preferred and a constraint of ≤2% maximum slope was used to screen unsuitable areas from further consideration. For the general area of interest within 3.2 km (2 miles) of the effluent source, a more gentle maximum slope criterion was judged to be needlessly constraining; steeper slopes were judged to pose unnecessary risks. Figure 3 shows areas available for consideration within 3.2 km (2 miles) of the effluent retention basin that slope ≤2%.

SCREENING CRITERIA

Screening criteria derived from DOE guidelines [DOE-RL Order 4320.2C, Site Selection, (1) and DOE Order 6430.1A, General Design Criteria, §200-1 (3)] were used to determine whether the areas constrained by the functional design considerations were suitable candidate sites. These screening criteria were:

- Conflict with current land use
- Negative effect on RCRA or CERCLA sites
- Negative effect on historical or archaeological sites
- Negative effect on threatened or endangered species.

These criteria provided the means to decide whether areas within 3.2 km (2 miles) of the effluent source with a slope of ≤2%, and that contain a minimum of ~12.26 hectares (5 acres) were worthy of further consideration. Areas that passed these screening criteria were subsequently ranked for relative merit; those that failed were dropped from further consideration.

Information needed to apply the criteria were obtained by a survey of site planning personnel, and facility reports and maps. Ground-based surveys were made that verified the absence of sites of historical or archaeological interest, or threatened or endangered species. Areas known to have surface or subsurface contamination were precluded because of the potential for contaminant remobilization by the treated effluent. The result of applying the four screening criteria is shown by Fig. 4.

The area remaining for consideration was arbitrarily subdivided into four candidate areas, "A," "B," "C," and "D" (Fig. 4). The objective of the subdivision was to provide several choices from which to select a preferred candidate site. A reference candidate site was located within each candidate area based on the reference site's proximity to (a) well-based hydrologic data, (b) the effluent retention basin, and (c) relative lack of interference with roads, rail lines, and other Hanford Site infrastructure or facilities.

CANDIDATE RANKING CRITERIA

Five ranking criteria provided the means to evaluate the relative merits of areas that complied with all of the functional design considerations and all of the screening criteria. The criteria were judged not to be of equal importance. Consequently, each ranking criterion was assigned a numerical weighting that reflected its relative importance. Selection of the preferred site for the effluent disposal facility was based on determination of which candidate scored highest, overall. Two types of criteria were judged as needed to evaluate the relative merits of candidate sites:

1. Safety and environmental protection (60% weight)
   a. Health and safety during construction and operation (30% of criterion 1)
   b. Potential to enhance or impede contaminant migration (70% of criterion 1)
2. Design, construction, and operation (40% weight)
   a. Obstructions between candidate site and effluent source (25% of criterion 2)
   b. Interference with the operation of other facilities (25% of criterion 2.
   c. Availability of adjacent land for expansion (50% of criterion 2).

The first criterion was considered to be of overriding importance. Criterion 1a was applied by using a philosophy of reducing the exposure of workers to radiation and hazardous substances and conditions to as low as reasonably achievable (ALARA). For example, a candidate area judged likely to have less risk to workers excavating and laying an effluent supply pipeline because it had the least potential for intersecting an area of contamination would be ranked higher than a candidate site with a longer effluent supply pipeline or one that would cross an area with known contamination.

The purpose of Criterion 1b was to ensure that the relative potential for either positive or negative effects on the migration of known contamination in the vicinity of the candidate sites was accounted for in assessing the merits of alternative candidate sites. Adverse effects were defined as follows:

- Treated effluent is likely to cause significant reduction of the projected travel time or increase the flux

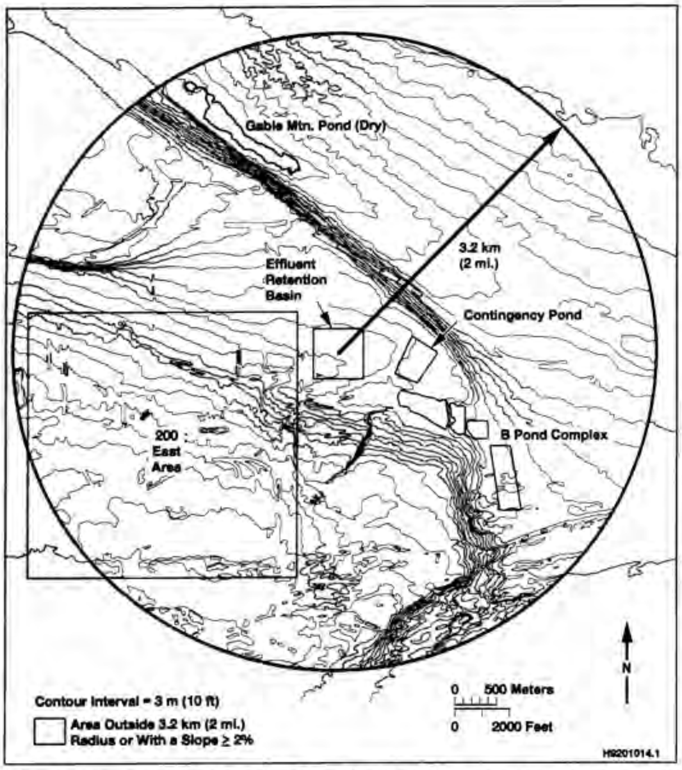

Fig. 3. Areas within 3.2 km (2 miles) of the retention basin with a slope of ≤2%.

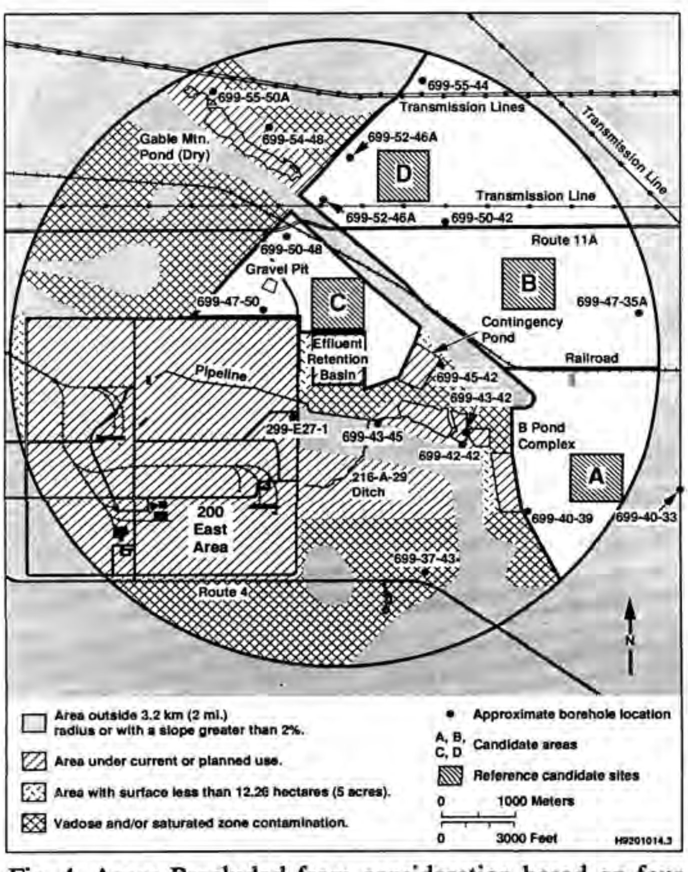

Fig. 4. Areas Precluded from consideration based on four screening criteria.

of contaminants to the Columbia River or other publicly accessible source of drinking water

- The operation of a RCRA site would be hindered or the remediation of a RCRA or CERCLA site would be made more difficult or less effective.

This criterion was applied to ensure that candidate areas which are relatively distant or down-gradient from known contamination are ranked higher than those that are closer to, or up-gradient from, contaminated areas. This criterion was also used to enhance the rankings of candidate areas where a rise in the water table down-gradient of known contamination would likely reduce or reverse the existing gradient between the contamination and the Columbia River, causing an increase in the contaminant travel time and/or lengthening of the contaminant migration path to the river -- both of which would be beneficial effects.

The potential for these effects was evaluated by computer simulations of the consequence of infiltrating the projected volume of effluent in each candidate area. Conceptual models based on current geologic and hydrologic knowledge of the candidate areas were used to numerically simulate the effects of the effluent infiltration. The three-dimensional, finite difference software, "MODFLOW," (4) was used for the simulations. If analysis of the information provided by the simulations suggested that effluent disposal at a candidate area had the potential to remobilize nearby vadose zone contamination, then that candidate was ranked lower. Similarly, if the results suggested a potential to significantly shorten the travel time or increase the flux of contaminants known to be present nearby in the unconfined aquifer, then that site was ranked lower.

The design, construction, and operation criteria were subordinate to the safety and environmental protection considerations. Criterion 2a was applied to rank the number and magnitude of such features as piping and power supply lines, roads, and the areas of contamination requiring remedial action between the effluent retention basin and the candidate areas that could obstruct construction of the infiltration facility. Criterion 2b was used to evaluate the potential for interference of effluent disposal with current operations in the vicinity of the candidate sites -- for example, due to a rise in the water table. Candidate areas with the least potential for interference were preferred. Because the capacity of the effluent disposal facility may need to be increased, Criterion 2c was used to evaluate the relative availability of adjacent land for expansion. Candidate areas with at least 50 acres of adjacent land available for facility expansion were preferred.

SITE SELECTION

The candidate sites shown in Fig. 4 were screened and ranked by individuals with demonstrable expertise and experience in land-use planning, regulatory permit application, ground water hydrology, geological and civil engineering, environmental sciences, archaeology, occupational health and safety, and facility design and construction. Participants were asked to judge the suitability of an area as a candidate site and to rank the candidate sites by means of the criteria and weighting system. They applied only those criteria that pertained to their fields of expertise. The raw and weighted scores were computed for each criterion of relative merit. The scores were summed, and the candidate sites were ranked accordingly.

Figure 5 summarizes the scores achieved by the four candidate sites using the five ranking criteria. Raw and weighted scores are given in the two columns at the right side of the figure. The weighted scores are normalized to 100. Reference candidate site "A" is clearly the preferred site because of its potentially positive effect on ground water flow and contamination associated with the B Pond complex (Fig. 6). The relatively high ranking is based on the site's potential to provide a hydraulic barrier or impediment by locally reducing or reversing the regional hydraulic gradient between contamination associated with the B Pond complex and the Columbia River.

Candidate site "A" is ranked somewhat lower than candidate sites "B" and "D" and the same as candidate site "C" for occupational health and safety. Its lower ranking results from the necessity to construct an effluent supply pipeline through an area that may contain slight subsurface contamination. All four candidate sites are ranked equal in terms of the availability of adjacent land for facility expansion. No obstructions to construction of an effluent supply pipeline are envisioned for sites "A" and "C." The supply pipeline for candidate site "B" would have to cross a railroad; that for candidate site "D" would have to cross a railroad, a four-lane divided highway, and the right-of-way for electric power transmission lines. No interference with the operation of other facilities is anticipated for candidate sites "A," "B," and "D." Site "C" is downgraded because of the potential for interference of an elevated water table at this site with the deep trench excavated for burial of naval submarine reactor compartments in the northeast corner of the 200 East Area.

Detailed characterization and assessment of the environmental effects of effluent disposal at candidate site "A" will be required to confirm the site's environmental acceptability. Plans for work to accomplish this confirmation have been completed and currently are undergoing review and approval.

REFERENCES

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	Safety and Environmental Protection Criteria (60%)					Design and Construction Criteria (40%)								Score Totals	
	Potential Effect on Groundwater and Existing Contamination (70%)			Potential Effect on Occupational Health and Safety (30%)		Availability of Adjacent Land for Expansion (50%)		Obstructions Between Retention Basin and Disposal Site (25%)			Interference with Operations of Other Facilities (25%)			Raw	Weighted & Normalized to 100 %
	Negative	Neutral	Positive	Elevated Risk	Minor Risk	No	Yes	Substantial	Some	None	Substantial	Some	None		
	Ranking Score														
Candidate Site	0	40	70	15	30	0	50	0	10	25	0	10	25		
A			X	X			X			X			X	185	91
B		X			X		X		X				X	155	76
C	X			X			X			X		X		100	43
D		X			X		X	X					X	145	72

Fig. 5. Ranking of candidate sites.

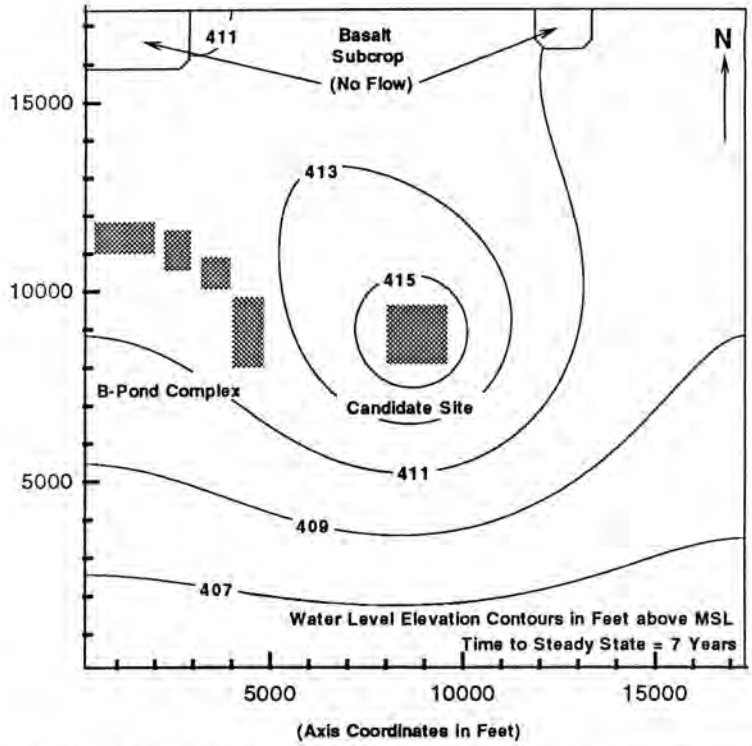

Fig. 6. Mounding of the water table beneath Site "A" simulated by MODFLOW.