

Public Perceptions of a Radioactively Contaminated Site: Concerns, Remediation Preferences, and Desired Involvement

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A public attitudes survey was conducted in neighborhoods adjacent to a radioactively contaminated site whose remediation is now under the auspices of the U.S. Department of Energy's Formerly Utilized Sites Remedial Action Program (FUSRAP). The survey's purpose was to ascertain levels of actual and desired public involvement in the remediation process; to identify health, environmental, economic, and future land-use concerns associated with the site; and to solicit remediation strategy preferences. Surface water and groundwater contamination, desire for public involvement, and potential health risks were found to be the most highly ranked site concerns. Preferred remediation strategies included treatment of contaminated soil and excavation with off-site disposal. Among on-site remediation strategies, only institutional controls that leave the site undisturbed and do not require additional excavation of materials were viewed favorably. Cost of remediation appeared to influence remediation strategy preference; however, no strategy was viewed as a panacea. Respondents were also concerned with protecting future generations, better assessment of risks to health and the environment, and avoiding generation of additional contaminated materials. *Key words:* community, FUSRAP, public attitudes survey, radiological contamination, remediation. *Environ Health Perspect* 104:1344-1352 (1996)

Public aversion to plans by the U.S. Department of Energy (DOE) to remediate radionuclide-contaminated sites under its jurisdiction is due in large part to three factors: a lack of confidence in the ability of the DOE to manage these sites; the perception that the department pays insufficient attention to public health, the environment, and options for future land use; and previous DOE failure to elicit public opinions about the management and remediation of these sites. By eliciting public attitudes toward the remediation of one set of DOE sites in a large metropolitan area, this case study tries to gauge the relationship between public concerns about the site and attitudes regarding proposed remediation strategies. It also seeks to ascertain if and how the public wants to participate in the selection of remediation strategies.

Considerable research has been done on public perceptions of the risks associated with hazardous and radionuclide-contaminated sites (1-3). However, few studies have related these risk perceptions to public views toward remediation strategies. For example, do members of the affected public who view the site as a health risk prefer a certain type of remediation strategy?

The Formerly Utilized Sites Remedial Action Program (FUSRAP) in St. Louis, Missouri, provides a unique opportunity to explore these issues. Recently at this site, controversy has emerged over proposed remediation strategies that could leave considerable amounts of contaminated materials within the community. As a result of public opposition to these plans, the DOE

has decided to elicit public input into the process of selecting a remediation strategy so that the strategy that is chosen is durable and politically acceptable.

FUSRAP comprises a diverse array of private and government-owned sites in the continental United States that were used by two DOE predecessors—the Manhattan Engineer District (MED) from 1942 to 1946 and the U.S. Atomic Energy Commission (AEC) from 1946 to 1973. These agencies used the sites to process uranium and thorium ores and store radiological concentrates and residues. At one time, nearly 400 facilities nationwide were engaged in these activities, which were initially aimed at providing feed materials to other facilities responsible for developing nuclear weapons. Activities at these sites contaminated equipment, buildings, and soils with naturally occurring radionuclides (uranium-238, thorium-232, radium-226) and by-products of their decay (radon and thoron). As a result of health and environmental concerns, Congress initiated FUSRAP in 1974 to decontaminate and restore these sites to conditions suitable for human use. FUSRAP now encompasses 46 sites in 14 states.

The St. Louis FUSRAP site properties are primarily located downtown and near Lambert-St. Louis International Airport and are referred to as the downtown and airport properties, respectively. From 1942 to 1957, the Mallinckrodt Chemical Company in downtown St. Louis processed uranium ore under contract with the MED/AEC. During that time, radioactive residues from processing contaminated

the property and were released into the environment. In 1946, the MED acquired the airport properties and began storing Mallinckrodt residues there. At the end of AEC's contract with Mallinckrodt in 1957, the AEC decontaminated buildings on the downtown properties and released them for use without restrictions. Although the area had been cleaned to meet standards in effect at the time, radiation levels at Mallinckrodt now exceed current guidelines, which are far more stringent than in the 1950s.

Current guidelines for unrestricted use of contaminated DOE sites require that residual radionuclides remaining on a site have a concentration no greater than 5 pCi/g for surface soils and no greater than 15 pCi/g for subsurface soils. These guidelines, developed by the DOE, are designed to ensure that no member of the public receives a total dose commitment greater than 100 millirems/year—the current federal standard. For purposes of illustration, when the downtown properties were released for use by the AEC, some parcels had traces of radium-226 in the soil that exceeded 400 pCi/g (4). Moreover, the average concentration of this isotope over at least 10 acres of the downtown properties has been found to be 40 pCi/g. Radium is chemically similar to calcium and accumulates in bone, creating a risk for bone cancer as well as leukemia.

In 1973, the DOE razed on-site structures on the airport properties, buried their remains, and covered them with clean fill. At that time, surface radiation levels were within acceptable guidelines. In 1985, the DOE acquired properties adjacent to the airport to permanently dispose of contaminated materials. These properties have been monitored since 1986, and multiple radiological characterizations have determined the location and extent of contamination. In October 1989, the U.S. Environmental Protection Agency (EPA) placed the airport properties on the National Priorities List. This action required remediation to proceed under EPA authority and under guidelines established by the

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Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund").

In a nonbinding referendum held in St. Louis County in 1991, more than 80% of voters opposed the establishment of a permanent waste disposal site in the county (5). In early 1994, the DOE disclosed a proposed plan for the St. Louis site, which recommended that a permanent storage facility for consolidating all radioactive materials from Manhattan Project activities in St. Louis be located on the airport properties. The proposed plan introduced two options: adding more radioactive materials to those already located on the airport properties and placing a concrete cover over the storage area, or excavating the radioactive materials on the airport properties and constructing a bunker on-site to contain the materials. Both options met with vocal opposition from residents and local and state officials (6). The Missouri Department of Natural Resources criticized the plan, stating that the proposed bunker did not meet safety and environmental requirements (7,8). In short, this opposition underscores three issues associated with DOE's plans: 1) public distrust of the ability of DOE to vigorously implement remediation strategies; 2) public fears that property values may decline as a result of poor or untimely remediation; and 3) concerns over future uses for the site.

Partly as a result of these criticisms, in mid-1994, the DOE stated that any remediation strategy adopted for the St. Louis FUSRAP site must be publicly acceptable and economically and technically feasible. According to then-DOE Assistant Secretary for Environmental Management Thomas Grumbly, "Everything is on the table, and we will work with all of our stakeholders [to develop a] new strategy." Grumbly's comment reflected the DOE commitment to incorporating citizen input into the process of selecting a remediation strategy (9-11).

Methods

Our research into public attitudes toward remediation strategies at the St. Louis site began shortly after the DOE committed itself to incorporating stakeholder input into strategy selection. We launched our investigation by developing a survey that targeted the public in the vicinity of the site. The survey process comprised three parts: selection of the population sample, survey design and implementation, and data analysis.

Selection of the Population Sample

Identifying the potentially affected population for the St. Louis FUSRAP site was the

most difficult part of the survey because there is no clear consensus among policy analysts over what constitutes an affected area associated with hazardous and radioactive waste sites. The area encompassed by the survey was limited by the likely range of health and environmental impacts from the St. Louis FUSRAP site and the proximity to the site properties of the residents who are most likely to have the greatest concerns. We identified these impacts and concerns in two ways. First, we drew upon a DOE contractor-prepared baseline risk assessment and a feasibility study/environmental impact statement for the St. Louis FUSRAP site. These documents identify areas of possible airborne and waterborne exposure from contaminants as well as economic infrastructure and urban populations most likely to be affected by remediation strategies (4,13).

Second, we drew upon other studies that probed public attitudes toward remediation of contaminated sites and defined affected areas by political jurisdiction (e.g., a single county, several counties within a state, and areas defined by standard metropolitan statistical areas). This was done to circumscribe an area according to local authority for certain remediation issues (e.g., future land use) and to delimit the geographic scope of public interest (1-3,14-18).

As in previous studies, more distant communities were excluded for two reasons. First, while waterborne contaminants may be carried by the Mississippi River away from the St. Louis site, affecting downstream populations, these impacts are likely to be negligible (12). Second, these downstream populations have expressed negligible interest in these impacts and their level of knowledge of the St. Louis site is low.

In contrast to many of these studies, however, we delimited our study area to affected census tracts and population districts within the St. Louis City and County lines. "Affected," as noted above, meant subject to possible radionuclide exposure through airborne or waterborne pathways. Because the U.S. Census Bureau demarcates census tracts by political or well-established geographic boundaries (e.g., rivers, creeks), our selection of these tracts made for an effective compromise between political jurisdiction and geographic impact.

We selected 15 U.S. census bureau tracts for our survey; 6 are proximal to the St. Louis FUSRAP downtown properties and 9 are proximal to the St. Louis FUSRAP airport properties. The downtown site properties are located in an industrial area adjacent to the Mississippi River. All cen-

sus tracts selected in this area fall, at least in part, within a 1-mile radius of the downtown properties. The FUSRAP airport properties are located in St. Louis County, 15 miles from downtown St. Louis and immediately north of Lambert-St. Louis International Airport. Six of the census tracts selected in the airport area fall within a 1-mile radius of these FUSRAP properties. We selected 3 additional census tracts based on their proximity to Coldwater Creek, which flows through the airport properties and empties into the Missouri River. These 3 census tracts are located downstream from the airport properties. In all cases, the radius of sites was based, as noted earlier, on possible health impacts stemming from exposure to radionuclides from the FUSRAP site properties. We structured sample size to provide a 95% confidence level (i.e., an initial selection of 1,000 respondents). We developed the sample by first identifying streets within each census tract by review of city and county maps. We then randomly selected names from a marketing directory that listed residents by street.

Survey Design and Implementation

Prior to initial mailing, we evaluated the survey for construction defects in two ways. First, we submitted the survey for critical review by colleagues familiar with study objectives and by DOE and DOE contractor personnel familiar with the St. Louis FUSRAP site. The survey and letter accompanying the survey stated how participants were selected, noted that participant response was voluntary, and promised anonymity. Only aggregate, as opposed to individual survey results, were used in the analysis, and surveys were coded with a number corresponding to the addressee. Once received, surveys were identified only by that number when data was entered. These steps conformed to institutional human subjects review procedures.

We then pretested the survey by mailing it to a cross-section of St. Louis residents from which the survey population would be drawn. The survey was revised in response to the input provided by the evaluation.

In early 1995, we proceeded with an initial mailing of 1,000 surveys and a follow-up mailing to nonrespondents. To maximize response rate, we telephoned nonrespondents to prompt them to complete the survey or, if they preferred, to complete the survey by telephone. We provided no information different from that provided to telephone respondents.

Survey questions focused on 1) the types of activities related to site remediation that respondents had previously participated in,

as well as how frequently they participated (e.g., public hearings); 2) activities they would be interested in participating in if available (e.g., receiving a newsletter, participating in a site tour); 3) opinions about remediation strategies under consideration at the site; and 4) opinions on issues related to the site and its remediation (e.g., health effects, environmental quality, future land use, transportation of contaminated materials, and public involvement). For the questions related to topics 3 and 4, we employed a scale ranging from 1 (low support) to 5 (strong support). This method allowed respondents to rate more than one issue equally (e.g., to give each site issue a strong-support rating of 5). Finally, demographic questions included gender, education, employment status, length of residence, distance of a respondent's residence from the site's airport and downtown properties, and whether children reside in the household. We also asked respondents to identify their level of familiarity with the site and their sources of information (e.g., newspaper, radio, television).

Data Analysis

Statistical analysis included cross-tabulations between each of the following variables: site concerns, remediation preferences, demographic characteristics, and public participation. The Pearson chi-square test was applied to each of the cross-tabulations to test for variable independence. Strength of the associations was estimated using the Cramér's *V* statistic. Only bivariate analyses were performed because of the relatively low response rate. Histograms of respondent high ratings (4s and 5s) and low ratings (1s and 2s) were generated and rating scores were ranked by averages to depict and compare site concerns and remediation preferences.

Results of Survey Analysis

A total of 199 usable surveys were returned by mid-1995. Residents living in the nine targeted census tracts proximal to the airport properties were far more responsive to the survey than were those living in the six targeted census tracts proximal to the downtown properties. Twenty-three percent of those living in the targeted airport area census tracts responded, while only 10% of those living in the targeted downtown census tracts did so. The reason for the divergence of responses may be attributed to a more transient inner city population. This is supported by the high rate of surveys returned undeliverable from the downtown census tracts. Thus, the composition of the respondent sample is, in general, more reflective of the communities

adjacent to Lambert-St. Louis International Airport than of the downtown community.

Despite a limited response from the downtown community, we found that the respondents were demographically diverse along a number of dimensions. In regards to education, the respondents were slightly better educated than the average area resident (18). About 8.3% of the respondents had less than a high school education, 22.0% were high school graduates, 32.7% had some college, 20.0% graduated from college, and 12.7% were post-college graduates.

Relative to employment experience, 54.6% of the respondents were employed outside the home, while 32.3% were retired. Nearly twice as many men responded to the survey as women. This difference in response by gender is probably due to the fact that surveys were mailed to, and likely filled out by, heads of households. Finally, less than half of the respondents had children under 18 years of age living at home.

Site Concerns

Prior to the survey, a review of media coverage of the St. Louis FUSRAP site provided strong anecdotal evidence that local residents opposed adding radioactive materials to existing storage areas on the St. Louis site properties. The evidence also suggested that these residents wanted radioactive materials removed from residential neighborhoods because of concerns over public health, ecological quality, water contamination, and related concerns (19,20). As a result, we asked respondents to rate nine commonly cited concerns on a scale of 1 (little or no concern) to 5 (very concerned). These concerns included risks to human health, environmental risks to plants and animals, surface water and groundwater contamination, the effect of site remediation on local community image, the effect on property values, any future land-use restrictions, the transportation of contaminated soils, any remediation costs, and the degree of desirable public involvement in site remediation. The survey also invited respondents to name another issue and rate it, if they wished. We compared concerns about the site by the percentage of high ratings (4s and 5s) and low ratings (1s and 2s) and by ranking averaged rating scores. The results are depicted in Table 1.

We also cross-tabulated respondents' site concerns against their demographic characteristics to determine significant relationships. Data were grouped in the following manner. Each set of demographic responses (e.g., gender, distance from site), as well as site concerns (e.g., health, water contamination), was treated as an individ-

ual cohort of respondents. Each cohort was compared to all other relevant cohorts on a given issue. Thus, as shown by Table 2, for example, we were able to compare those who favored consolidation and capping as a remediation option (as well as those who most favored other remediation options) to respondents falling within different categories of educational level.

We only list those cross-tabulated cohorts that had a significant relationship, and we provide the cross-tabulation results in rank order of significance in Table 2. Overall, we found gender to be significantly associated with ratings on health risks and the need for public involvement. Female respondents generally rated these issues higher than did male respondents—as also shown in Table 1. Relative ratings of other issues were more reflective of the concerns of the total sample, regardless of gender. We did not find any statistically significant relationships between site concerns and level of education, work status, and whether children currently reside at home. We used a marketing directory that lists the number of years residents have maintained the same listed telephone number to indicate length of residence. We observed no significant associations between concerns about the site and individuals' period of residence in the community. However, we found a significant association between the distance of a respondent's residence from the airport properties and his or her perception of FUSRAP impacts on property values.

Overall, those concerns rated most important by respondents (4 or higher) are those directly related to public health, the environment, and public involvement. This is consistent with other studies that have examined public concerns surrounding the remediation of contaminated sites (3,14,21). The high rating given to public involvement, moreover, appears consistent with the findings of recent studies that contend that the public perceives many of the gravest threats to health and environmental well-being as attributable to a lack of political accountability, a need for direct citizen activism, and a high degree of distrust toward authorities perceived to be responsible for environmental hazards (14,22).

By contrast, community image and future use of land were less important to respondents. Respondents' written comments to the survey confirm this assessment. The most frequently cited additional areas of concern were the impact of sites on future generations, the need for greater public education about site hazards, the need for better assessment of the site's risks to health and the environment, and avoid-

ance of the generation of additional contaminated soils.

Consistent with overall public distrust, there were also concerns with assessing blame or responsibility for site contamination. Evidence for this concern was expressed throughout respondent comments on the survey to the effect that “the individuals/companies responsible for creating the waste should pay . . . for the cost of cleanup,” to “Those responsible for causing the problem should pay for the cleanup,” and “. . . lay the cost on the companies that cause [the problem].” Moreover, these comments arose despite the fact that the federal government assumes all costs for FUSRAP site remediation. For example, as two respondents stated, “Make the responsible party pay; whoever created the waste site should pay for the cleanup,” and “. . . As a mother I say, you make the mess, you clean it up. Parties who put it there are responsible.”

Discussion of Site Concerns

Cross-tabulations (including those between site concerns and remediation strategies) and respondent comments provide insight into why some concerns about the site were more important to respondents than others. The following section discusses these concerns in order of overall ranking.

Water contamination. Water contamination was particularly important to those

respondents who supported disposing of contaminated soils outside of St. Louis County. The high concern expressed on this issue would seem to confirm why on-site remediation strategies (institutional controls, on-site disposal, and consolidation and capping) were less preferred. Respondent comments included concerns with possible contamination of a creek adjacent to the airport properties and the need for ongoing monitoring of surface water and groundwater contaminant levels. Local media coverage was extensive on this issue, which may help explain the relative importance it was accorded.

Not only has this issue been frequently mentioned in news accounts, which we

tracked during the period in which the survey was administered, it is also related to other water-quality issues in the area. For instance, de-icer from Lambert-St. Louis International Airport allegedly mixed with radiation from the airport properties as it leached into the adjacent creek (23). Both sources of contamination have generated contention among the DOE, the local community, and the Missouri Department of Natural Resources. Moreover, Missouri officials have cited groundwater contamination as a concern on the FUSRAP airport properties. The Missouri Department of Natural Resources is opposed to consolidating materials on the airport properties,

Table 1. Summary of remediation concern findings

Issue	Most concerned ^a	Least concerned ^b	Mean (1–5 scale)	Level of concern ^c
Water contamination	66	5	4.4	Very high
Health risks	59	8	4.2	Very high
Public involvement	57	9	4.2	Very high
Environmental risks	53	12	3.9	Moderately high
Impact on local property values	53	18	3.8	Moderately high
Remediation costs	49	13	3.8	Moderately high
Future land-use restrictions	47	18	3.6	Moderate
Soil transport	42	14	3.7	Moderate
Community image	32	27	3.1	Low

^aViewed as major concern as determined by percentage of respondents choosing 4 or 5 on a 1–5 rating scale.

^bViewed as minimal concern as determined by percentage of respondents choosing 1 or 2 on a 1–5 rating scale.

^cVery high, a rating of 4–5 about 60% of the time; moderately high, a rating of 4–5 around 50% of the time; moderate, a 4–5 rating <50% of the time; low, a 4–5 rating <34% of the time; very low, a rating of 4–5 <25% of the time.

Table 2. Significant correlations among respondent site concerns, remediation strategy preferences, participation in site-related activities, and demographic characteristics

Significant correlations	Confidence level ^a	Strength of relationship ^b
Those with less formal education tended to favor consolidation and capping as a remediation strategy	99.9%	Moderately strong
Those who were less familiar with the FUSRAP site tended to be more concerned with public involvement	99.9%	Moderately strong
Those who were more concerned with image of the local community tended to favor treatment as a remediation strategy	99.8%	Moderately strong
Those who had participated in FUSRAP-related activities were more familiar with the St. Louis site prior to the survey	99.8%	Moderate
Female respondents tended to be more concerned with surface water and groundwater contamination than were male respondents	99.4%	Moderate
Those who had participated in FUSRAP-related activities tended to favor treatment as a remediation strategy	98.9%	Moderate
Those who reside closer to the airport properties (1–2 miles) tended to favor treatment as a remediation strategy more than those who lived farther from the airport properties (2–6 miles and >6 miles)	98.7%	Moderately strong
Female respondents tended to be more concerned with health risks than were male respondents	98.5%	Moderate
Those who were more concerned with future restrictions on land use tended to favor excavation and off-site disposal as a remediation strategy	98.4%	Moderately strong
Those who had participated in FUSRAP-related activities were less concerned with remediation costs	98.0%	Moderate
Those who were more concerned with community image tended to favor excavation and off-site disposal as a remediation strategy	97.5%	Moderate
Those who were more concerned with remediation costs tended to favor institutional controls as a remediation strategy	97.1%	Moderate
Those who were more concerned about future restrictions on land use tended to oppose institutional controls as a remediation strategy	96.9%	Moderately strong
Those who were more concerned about future restrictions on land use tended to oppose consolidation and capping as a remediation strategy	96.4%	Moderate
Those who were more concerned with remediation costs tended to oppose treatment as a remediation strategy	96.3%	Moderate
Those who were more concerned about the transport of contaminated soils from the site tended to favor institutional controls as a remediation strategy	96.0%	Moderate
Those who were more concerned with the site's health risk to community members tended to favor excavation and off-site disposal as a remediation strategy	95.9%	Moderate
Those who were more concerned with remediation costs tended to disfavor excavation and off-site disposal as a remediation strategy	95.7%	Moderate
Those who reside closer to the airport properties (1–2 miles) tended to be more concerned with local property values than those who lived farther from the properties (2–6 miles and >6 miles)	94.4%	Moderate
Those who were more concerned with surface water and groundwater contamination tended to favor excavation and off-site disposal as a remediation strategy	94.2%	Moderate

^aCalculated from the Pearson chi-square statistical test; only relationships with an approximate 95% confidence level were included in this table.

^bBased on Cramér's *V* measure of association: no relationship, 0; negligible, 0.01–0.05; weak, 0.06–0.14; moderate, 0.15–0.29; moderately strong, 0.30–0.49; strong, 0.5–0.69; very strong, 0.7–0.99.

in part, because of the possibility of further groundwater contamination (24).

Health risks and risks to the environment. Health risks appear to hold a primacy among the public and constitute a special test of fairness to many community stakeholders (3,25). For many who live near the FUSRAP site, radioactive contamination is perceived as posing a direct threat to their own and their childrens' well-being (26,27).

Some St. Louis area officials have expressed concern about potential health risks from the FUSRAP site, pointing to a cluster of leukemia cases in the area around Latty Avenue, which is adjacent to the airport where a number of FUSRAP properties are being remediated (7,28,29). Survey results suggest that members of the public are also concerned about this issue. Health risks to the community were of particular concern to those respondents who supported off-site disposal. Although women were generally more concerned with this issue than men, the high ratings given to health concerns indicate widespread consensus over the importance of possible contamination from the St. Louis FUSRAP site. Again, this finding is consistent with other site-specific studies of issues involving hazardous waste management (3,30).

Respondents cited anecdotal evidence of health problems, particularly those experienced by children, associated with possible exposure to radionuclides from the FUSRAP site. Respondents made fewer comments regarding risks to animals or plants. Meanwhile, some respondents tended toward the opposite extreme, exhibiting a high degree (greater than in other categories) of skepticism towards this issue and suggesting that they believed health risk was minimal if not nonexistent (e.g., comments to the effect that the sites pose no visible risk to public health). In short, despite the generally high ranking of concern toward the issue of health effects, comments among respondents indicate a sharp divergence over its importance.

Public involvement. Considerable research suggests that extensive dialogue between citizens and management agencies is necessary when siting new waste management facilities, remediating old ones, or selecting remediation strategies. This dialogue is needed to clearly identify public concerns, provide decision makers with the range of feasible remediation strategies that are acceptable to the public, and protect underlying societal values of popular sovereignty and political equality (17,31-33).

Moreover, the public generally wants to be contacted early and often about the remediation process, is concerned over dis-

ruption of normal economic activity, and wants contaminated materials to be quickly and effectively stabilized (34-36).

The DOE has mandated that its program offices work with communities to identify future-use options for contaminated sites undergoing remediation. This process should include designing a site-specific public participation process to evaluate the opportunities, constraints, and viewpoints associated with future use, remediation standards, and associated issues (37).

Aside from the legal requirements of conducting such exercises, there are other benefits of public involvement, including enhanced perception of fairness of the decision-making process, creation of joint responsibility for the mitigation of risk, reduced resistance to siting storage and disposal facilities, and acknowledgment that the public actually contributes to improving technical solutions (2,16,25,38).

Overall, women respondents generally favored involving the public in determining remediation strategies more than men. While 57% of male respondents rated public involvement as high (4 or 5 out of 5), 71% of women rated this issue high. Approximately one-third of respondents who offered comments on this issue expressed a desire for enhanced public involvement in the selection of remediation strategies to be brought about through: 1) provision of better scientific information to the general public; 2) full release of all relevant site information; and 3) referenda on specific remediation strategies "put to a vote at the community level," as one survey respondent phrased it. Justifications for public involvement ranged from the claim that people in the area need "to have their say in the matter" to the claim that there is a "failure on the part of government and the news media to inform [the] public about this whole situation."

Ironically, some respondents acknowledged that the public may not be knowledgeable enough to make decisions about the site and, in the words of one respondent, "they only know what [the] media and government tell them." Despite this assessment, lack of familiarity with FUSRAP appears instead to serve as a sort of incentive for public involvement in the eyes of some respondents. Cross-tabulation between support for public involvement and familiarity with the St. Louis FUSRAP site showed that the less familiar a survey respondent was with the site prior to the survey, the greater his or her support for public involvement, suggesting the belief that involvement might enhance public knowledge.

Remediation costs. Recent studies suggest that the general public is becoming

increasingly concerned about the potentially high costs of remediation of radionuclide-contaminated sites (2,39). Those respondents who opposed the two most costly remediation options (treatment and off-site disposal) rated cost as a primary concern. Moreover, cost of remediation was a highly rated concern among those respondents who supported the least expensive remediation strategy (maintaining the site). In addition, respondent comments suggested a widespread perception that money has not been wisely spent and that some has been used for, as several comments put it, irrelevant studies and bureaucratic delays in FUSRAP.

On the other hand, as we will discuss in the next section, respondents gave the two most expensive remediation strategies their highest overall ratings. This may be due to the perception that, while fiscal restraint is desirable, it should not be practiced at the expense of protecting human health. As two respondents stated, "My health is worth any cost," and "Consequences are more important than dollars."

Community image. Community image is affected by the concern that the presence of a contaminated site in a community may adversely affect the way in which outsiders, particularly potential job-creating firms or land developers, perceive a neighborhood. The perception of loss of future economic opportunities due to the belief that environmental legacies deter certain businesses from moving to a community or encourage others to leave can become stigma, which may include damage to a community's reputation or image as well as stress, pervasive dread, fear, and even anger from living in proximity to an environmental legacy. While stigma are difficult to quantify, some contend that stigma from hazardous or radioactive waste sites are likely to be associated with high public perceptions of risk to health and the environment, intense negative imagery of a community, and adverse effects on jobs and the local economy (1,40).

We found that the less respondents were concerned with community image, the less likely that they would support treatment or off-site disposal—probably because of the very high estimated costs of these two remediation strategies. In essence, there is little adverse perception among our sample of respondents. This is contrary to the opinion of some leaders in the St. Louis area, as reported by the media (41). One respondent reported that the image of contaminated materials in St. Louis imposing an "intolerable political burden . . . is greatly exaggerated."

Other explanations for the lack of perceived stigma associated with the presence of

the FUSRAP site lie in the fact that both the downtown and airport properties are located in industrial areas and, as one respondent reports, "the area is already blighted." Another respondent noted that the region is generally "painted in the worst possible light" by some environmental activists.

Property values and future land use. While there is considerable debate over the impact of contaminated sites on nearby property values, actual as well as perceived impacts are difficult to discern. In areas where land is in high demand, fears of contamination may be offset if lands are permitted to be sold at or near market values (4,42). Such an arrangement may be accomplished through special purchase agreements and long escrow periods covering the duration of remedial actions. As in other Superfund contexts, future-use options for such land is partly dependent upon the ability of the community and land owners to negotiate remediation standards with the state and federal governments (43-45).

We found that survey respondents did express concerns about how the St. Louis FUSRAP site may devalue adjacent properties and how the site may be used in the future. While the respondents did not rate the site's effects on property values as a major concern, we found a strong, discernible relationship between concern over the FUSRAP site's impact on property values and residence proximity to site properties. By cross-tabulating distance of respondent residence to the airport properties (1-2 miles, 2-6 miles, and >6 miles) and level of concern over property values (low, moderate, high), we found that the closer to the airport properties respondents reside, the greater their level of concern. Also, those who were more concerned with future land-use restrictions were less likely to support two of the on-site remediation options—consolidation and capping or maintaining the site—and more likely to support the disposal of contaminated materials off-site.

Respondent comments help explain the somewhat ambivalent rating given to concern over the effect of the FUSRAP site on property values. Over half of those respondents with comments on this issue reported that FUSRAP-related impacts on property value are largely inconsequential to them. Reasons cited by respondents included the fact that the FUSRAP site properties are located in industrial areas and that few residential areas are located near there. Moreover, as one respondent reported, lower property values translate into the benefit of lower rent for residents and lower land purchase prices for industries.

However, two respondents claimed that perceived health risks from the sites may have deleterious effects on property values when owners try to sell their property.

Likewise, comments on the issue of future land-use restrictions may also help to explain its relatively lower ratings. Some respondents reported that because some of the airport properties are owned by the Lambert-St. Louis International Airport, their future use is restricted anyway. Others reported that placing restrictions on the site for certain purposes (e.g., creation of a wildlife refuge or establishment of a commercial site with limited public access) may benefit the community.

Contaminated soil transport. Those most concerned with transport of contaminated soils off-site and disposal at some remote location tended to favor institutional controls and site maintenance as an appealing remediation strategy. This may be due to the fact that this is the one on-site management strategy that requires no additional excavation or hauling of radioactive materials. Although far more respondents favored off-site disposal than on-site management, written comments indicated a concern with exporting or transferring the problem elsewhere, ensuring the careful transport of contaminated soil and avoiding contamination of additional sites through transport. This ambivalence toward off-site disposal, despite an overall unfavorable reaction to on-site management strategies, may also explain the overall high ranking for treatment of contaminated soil.

Remediation Strategy Preferences

The St. Louis FUSRAP site is unusual insofar as the DOE has identified several possible remediation strategies but has yet to make a final selection. This provides a

unique opportunity to gauge public views toward remediation strategies before the DOE begins remediation.

Respondents were asked to rate their preferences toward five proposed remediation strategies for the St. Louis site. These strategies, taken from the DOE feasibility study for the St. Louis site, are provided in Table 3 in the exact form they appeared in the survey. We informed respondents that all strategies had been studied by the DOE for use, but none had been selected. As shown in Table 3, we also provided them with the DOE estimate of each remediation strategy's cost. These estimates were provided to gauge if cost of remediation would be a factor in public preference (2,3). Information on potential dose reduction was not provided simply because, under CERCLA, any remedy considered for potential use in cleaning up a FUSRAP site must meet the current radiation standards noted earlier.

We compared remediation strategy ratings by the percentage of high (4s and 5s) and low (1s and 2s) ratings and by ranking averaged rating scores (Table 4). We also cross-tabulated results against concerns about the site and respondent demographic characteristics to determine significant relationships among these variables (Table 2). Survey respondents regarded treatment and excavation in conjunction with off-site disposal most highly. These strategies received the greatest number of positive ratings and were among those drawing the fewest negative ratings. In contrast, excavation followed by on-site disposal in an above-ground bunker was the least favored strategy, garnering the fewest high ratings and the greatest number of low ratings. On-site management strategies (e.g., excavation followed by on-site disposal, consolidation

Table 3. Remediation strategies rated by survey respondents

Remediation strategies	Description	Estimated cost
Institutional controls and site maintenance	Use institutional controls such as deed restrictions to restrict public access to radioactively contaminated areas	\$90 million
Consolidation and capping	Excavate radioactively contaminated soils, consolidate the soil on the FUSRAP airport properties, and cover with a barrier	\$300 million
Excavation and on-site disposal	Excavate radioactively contaminated soils and dispose in an above-ground bunker built on the FUSRAP airport properties	\$475 million
Excavation and off-site disposal	Excavate radioactively contaminated soils and dispose at a facility located outside of St. Louis County	Disposal in-state, \$580 million; disposal out-of-state, \$920 million
Treatment of contaminated soils	Treat radioactively contaminated soils, reuse the clean soil, and dispose of contaminated residue at a commercial facility located outside of St. Louis County	\$1.3 billion

Table 4. Summary of remediation preference findings

Remediation strategies	Most favored ^a	Least favored ^b	Mean (1–5 scale)	Level of concern ^c
Treatment of contaminated soil	39	28	3.2	Moderate
Excavation and off-site disposal	32	35	3.0	Moderate
Institutional controls and site maintenance	31	32	2.9	Low
Consolidation and capping	18	44	2.3	Very low
Excavation and on-site disposal in an above-ground bunker	15	51	3.0	Very low

^aDetermined by percentage of respondents choosing 4 or 5 on a 1–5 rating scale.

^bDetermined by percentage of respondents choosing 1 or 2 on a 1–5 rating scale.

^cVery high, a rating of 4–5 about 60% of the time; moderately high, a rating of 4–5 around 50% of the time; moderate, a 4–5 rating <50% of the time; low, a 4–5 rating <34% of the time; very low, a rating of 4–5 <25% of the time.

and capping of contaminated materials) were generally viewed unfavorably. The notable exception to this trend is the option of institutional control and maintenance of the site, which was viewed more favorably than other on-site strategies. This option leaves the site undisturbed and does not involve additional excavation or hauling of contaminated materials.

The range of mean scores between the highest-regarded strategy (treatment) and lowest-regarded strategy (on-site disposal) is relatively modest (3.2–2.1). This may be explained by the fact that each of these potential remediation strategies was viewed as having serious problems. Respondents reported that their primary concerns, regardless of strategy selected, were the cost of site remediation, assurance of site safety after remediation is complete, and dependable, safe disposal of waste and residues. Fully one-third of respondents who provided written comments cited the cost of remediation as their major concern. One-sixth of respondents who provided comments reported that they wanted contaminated materials removed from St. Louis.

Discussion of Remediation Strategies

Treatment was highly favored by those who reside in proximity to the airport properties. This is probably because of opposition to on-site disposal or concern over the possibility of nearby spills of contaminants resulting from off-site transport of soils. Those who were more concerned with community image also tended to favor treatment. Respondents may have perceived this remediation strategy as an effective means of removing contaminated materials and associated community stigma; however, given that few respondents appeared concerned with community image, this factor probably had a limited influence on this option's high ratings.

Although treatment emerged as the most preferred strategy, criticisms of treatment included its alleged lack of cost-effectiveness and potential negative impacts

(e.g., concern over what to do with wash water from soil washing and how to reuse contaminated residue). Among those respondents who reported that cost was a major concern, treatment ranked low.

The strongest supporters of excavation and off-site disposal included those respondents who identified themselves as less likely to be concerned with remediation costs. This alternative is the second most expensive remediation strategy. Respondents who supported excavation and off-site disposal were also more likely to be concerned with health risk to community members and water contamination. Because this option is designed to remove contaminants, it may have been viewed as eliminating the source of potential exposure and water contamination. In addition, those who favored this remediation strategy were more likely to be concerned with future land-use restrictions. This finding is not surprising since the removal of on-site contamination would presumably allow for increased future land-use options. Those supporting this remediation strategy were also more likely to be concerned with community image, presumably because it might eliminate the adverse perceptions toward the community as a place to live and/or work that could be associated with retaining contaminants on-site.

Those opposed to excavation and off-site disposal gave as their reasons its enormous cost and the perception that it may "create more problems than it solves." Despite such criticisms, respondents tended to clearly favor excavation and off-site disposal over remediation strategies involving on-site management of contaminated soils.

Respondents who supported institutional controls and maintenance of the site tended to be more concerned with the cost of remediation, transportation of contaminated soils, and future land-use restrictions. Each of these concerns is understandable, given that this is the least expensive option that would not involve transporting soils off-site but would involve future land-use restric-

tions (e.g., deed restrictions, access controls).

In criticizing the use of institutional controls, respondents cited its relatively high cost, given the strategy's apparent simplicity. Some questioned the effectiveness of a perimeter fence in protecting the public, particularly children. Those favoring this option, on the other hand, cited the absence of perceived ill effects from the St. Louis FUSRAP site. They also alluded to the fact that the site has been radioactively contaminated for a long time with no apparent harm to the community.

Support for consolidation and capping seems to be most strongly associated with those having less formal education (high school, no college). Respondents who rated this option low appeared to be concerned with how this remediation strategy might limit future land-use options. Their concern was probably based on the assumption that because consolidation and capping is intended to contain rather than eliminate on-site contamination, land-use restrictions would be required. Most respondent comments were critical of this strategy. One respondent characterized it as a shotgun approach that will serve no positive end.

By far the least preferred strategy for remediation of the St. Louis site, excavation with on-site disposal of contaminated soil, received the greatest number of negative ratings and the fewest positive ratings. While there were very few comments on this strategy, those provided by respondents most frequently cited a concern for surface water and groundwater contamination (generally a highly ranked concern among respondents), claimed that it was inappropriate for disposing of contaminated materials in a densely populated area, and stated that on-site disposal may deny future use of a site or prevent returning a site to a pristine condition.

In short, no potential remediation strategy under consideration by the DOE at the St. Louis FUSRAP site was wholeheartedly endorsed by the public. Partly because every strategy has potential problems, we found that respondents wanted the public to be consulted on all activities designed to remediate the St. Louis site. Furthermore, we found that respondent concerns toward remediation efforts stemmed, in part, from the DOE ineffectively conveying to members of the public how proposed remediation strategies would resolve the concerns they harbor.

Previous Participation and Willingness to Become Involved

We found that the vast majority of respondents (78.5%) had not participated in any remediation-related activities (e.g., attend-

ed public meetings or workshops, visited the DOE information center) offered by the managers of the St. Louis FUSRAP. Respondents' reasons for not participating, as gauged by comments, included lack of knowledge and concern about the site and more important priorities.

Previous respondent participation in site activities was cross-tabulated against site concerns, remediation preferences, and demographic characteristics. Previous participation was significantly associated with one site concern—cost of remediation. We found that those respondents who had previously been involved in remediation-related activities were less concerned with the cost of site remediation. This is consistent with the finding that those who had previously participated in remediation-related activities were more supportive of the most expensive remediation option—treatment. There were no significant relationships between previous participation in remediation activities and residence distance to site properties, gender, education, employment status, or whether children reside in the household. Not surprisingly, we did find a significant relationship between past involvement in remediation activities and level of familiarity.

A variety of options to encourage public involvement are prescribed under CERCLA, including disseminating public information and holding public meetings. In the survey, respondents were provided with a selection of choices for involvement ranging from relatively passive actions (e.g., receiving a newsletter) to more progressively active measures (e.g., a telephone hotline, site tours, public meetings, and workshops). Seventy-six percent of the respondents indicated an interest in participating in some type of activity to "learn more about and/or express [their] views" on the St. Louis site.

Knowledge of Site

Respondents were asked to rate on a scale of 1–5 their familiarity with the St. Louis FUSRAP site prior to the completion of the survey (1, not familiar; 5, very familiar). The vast majority of respondents indicated little to no familiarity with the FUSRAP site prior to the survey (1s and 2s, 63%). Nine percent were somewhat familiar with the site (giving a rating of 3) and 11% were very familiar with the site (giving a rating of either 4 or 5).

Why were respondents willing to complete a survey and comment on the St. Louis FUSRAP site when the majority were unfamiliar with the site? One possible explanation may lie in the extensive media coverage that has been provided on hazardous waste and other contaminated sites in the community. From this volume of information,

which includes news stories that typically quote explicit opinions of various stakeholders, members of the public, particularly those who reside near waste sites, have developed their own set of concerns associated with contaminated materials.

Conclusions

Our case study of public concerns toward the remediation of the St. Louis FUSRAP site has produced five sets of findings, which may be useful in guiding future research into how remediation concerns explain perceptions toward proposed remediation strategies and vice versa. Our study also sheds light on how the public wants to be involved in remediation decision-making.

First, respondents' highest-ranked concerns were those regarded as most capable of directly affecting individual health and well-being (e.g., water contamination, health risk). Concerns perceived to be less important have less of an effect on individual health and well-being (e.g., community image, property values).

Second, treatment and excavation with off-site disposal were the two most highly regarded strategies because they were seen as addressing the respondents' greatest concerns (e.g., public health, water contamination).

Third, respondents least preferred the remediation strategies designed to provide on-site management of contaminated soils, with the exception of the strategy that leaves the site virtually undisturbed (i.e., institutional controls and site maintenance). In short, the respondents seemed to be saying that if the DOE intends to excavate contaminated soil, then the agency should either ship it out of the community or treat it and ship out the residues. Conversely, if contaminated soils are safe enough to be left under institutional control, then the DOE should not excavate this material.

Fourth, respondent comments associated with the most highly rated concerns appear applicable to other waste management issues across the United States, especially to waste management problems caused by previous activities at federal facilities (e.g., legacy issues). The most striking and consistent of these comments relate to protecting future generations; improving risk assessment; avoiding future problems; taking responsibility for past harm; and avoiding what some respondents referred to as unnecessary and wasteful expenditures to solve problems caused by what they labeled inappropriate, careless, or misguided waste management methods.

Finally, despite a lack of knowledge about the problems associated with remediation, respondents believed that the public

should be involved in the remediation process. This is problematic inasmuch as the risks associated with different remediation strategies need to be understood by members of the public if their input is to be constructively incorporated into the remediation process as dictated by environmental regulations, [i.e., CERCLA and National Environmental Policy Act (NEPA)].

Survey findings suggested that members of the public living adjacent to the St. Louis FUSRAP site harbor three general concerns that need to be encompassed in future efforts at site remediation: decisions should be transparent, sensible, and cost-effective. In addition, because we found that over half of the St. Louis residents living in proximity to the FUSRAP site properties were generally unaware of their presence, we recommend the following: the DOE should reevaluate its community relations program to ensure that 1) the public is informed about the presence of and activities at the site; 2) the public is effectively educated about the remediation process prescribed by CERCLA/NEPA; and 3) two-way communication is maintained between the DOE and members of the public. Clearly, decision makers must take their cues from the bottom up and understand that remediation strategies and concerns about the site are interrelated.

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