

SITING LOW-LEVEL RADIOACTIVE WASTE FACILITIES

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ABSTRACT

Siting of low-level radioactive waste (LLW) facilities poses a significant planning challenge—one that must be addressed under federal law by 1986. While the public is apprehensive about LLW, it shows no indication of stopping consumption of goods and services which generate it. The siting activity, possessing some unique complicating characteristics, falls within a class of activities defined by uncertain costs and both discreet localized and pervasive societal benefits. This article describes a siting process for LLW facilities. It addresses siting as a sociopolitical as well as a technical problem. Roles for a range of actors interested in siting are identified and stages in choosing sites are described. Degrees of involvement for each set of actors at each stage in siting are suggested. The process is conceptualized as one of state directed balancing under a large number of technical and social constraints. A central role for elected officials is developed and the need for identification of a managing “lead agency” is recognized; but the process relies on participation by all affected actors.

INTRODUCTION

We face an important set of land use decisions peculiar to the nuclear age. Each state must provide by 1986, either through interstate regional compacts or individually, the capacity to dispose its commercial low-level nuclear waste (LLW) materials. This article describes a siting process for LLW facilities.

BACKGROUND

Low-level nuclear waste is generated by hospitals, public and private educational and research institutions, manufacturers of radioactive compounds and sources for industrial uses (termed non-fuel cycle uses), in addition to nuclear power plants and makers of nuclear fuels (termed fuel cycle uses). The federal government has defined LLW as:

Radioactive waste not classified as high level radioactive waste or transuranic waste (elements with an atomic number of 92 or higher), spent nuclear fuel, or by product material as defined in the Atomic Energy Act of 1954.¹

Most LLW contains a relatively small amount of radioactive material in a large volume and therefore does not usually require shielding or heat removal (which are concerns in high-level waste storage). Shallow land burial is a sufficient strategy to isolate most LLW [1]. A small volume of these wastes require greater confinement because of higher activity; for this type of LLW deeper burial is required.

Low-level nuclear wastes can be in any physical form. They can be solids, liquids, or gases. The waste may be uranium and other special mining and milling waste, empty containers, gloves used in various processes, packaging, paper towels, protective clothing, ion exchange resins, biological wastes (such as animal carcasses), valves, and plumbing.²

Disposal facility performance must be maintained over the long-term in light of the inherent radiological hazard of the waste. The toxicity of radionuclides diminishes over time as the level of radioactivity decreases. The major isotopes

¹ Nuclear Waste Policy Act of 1982, 24 U.S.C. 10101(10). State law may supplement this definition. For example, Chapter 1177 of the 1983 California Statutes distinguishes low-level waste from 1. *high level wastes* which are "(1) irradiated reactor fuel, (2) liquid waste resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted" and from 2. *transuranic waste* which "includes any waste containing more than 100 nanocuries of alpha-emitting transuranic elements per gram of waste material." (A nanocurie is one billionth of a curie and a curie is the standard unit for measuring radioactivity, equal to 37 billion nuclear transformations per second or the radioactivity contained in one gram of radium.)

² Before LLW may be transported or buried, liquids and gases must be converted to solid form by absorption onto resins or solidified with cement (10 CFR 61). Throughout, 10 CFR 61 refers to Code of Federal Regulations, Title 10, Part 61. The solid waste going to land burial is usually highly compacted to minimize volume (and thereby reduce burial costs). Typically, wastes are shipped for burial in thirty or fifty-five gallon drums, less commonly in crates, boxes, and cans. The containers are intended to hold the waste only through transportation and emplacement. Long-term container integrity is not required: the burial hole or "trench" is relied upon for this function. (For class B & C wastes as defined in 10 CFR 61, stability and waste form requirements may be met by high integrity containers.)

of concern in LLW have half-lives of less than thirty years. The quantities of longer lived isotopes likely to be present at a typical LLW disposal site require that the interred waste remain covered and safe from intrusion for several hundred years. Federal regulations require 100 years of institutional control, the period of greatest potential hazard; however, the design lifetime of a burial facility is generally considered to be 500 years.³

In comparison with other wastes, the volume of LLW produced is not great. A significant fraction of hospitals, medical laboratories, and research facilities produces low-level wastes in small amounts [2]. Estimates of the volume of the problem are offered by EG&G Idaho [3], 106,766 m³ of waste containing 332,845 curies of radioactivity disposed in 1980 at commercial sites; and EG&G Idaho [4], 87,789 m³ containing 279,863 curies in 1981. To add a graspable perspective this latter volume would cover a football field to a depth of sixty-five feet [4].

However, these numbers do not adequately describe the LLW siting challenge. Although produced in significantly smaller quantities than domestic solid waste and hazardous wastes, the radioactive property of LLW is not chemically or biologically degradable to the extent of these other waste types. Incineration and chemical treatment may greatly decrease the volume of LLW.⁴ More importantly, low-level wastes, by virtue of their inclusion under the "radioactive" rubric are considered more dangerous than other wastes by the lay public [5] and oftentimes by the planners and policymakers who ultimately will decide where and how the waste should be treated.

Yet many within the waste disposal industry and in businesses that generate wastes consider the LLW challenge to be less significant than that of other disposal problems involving toxics or hazardous wastes—in part because LLW decays to non-hazardous levels over the short-term (hundreds of years) and the volumes are much smaller.⁵ Furthermore, unlike hazardous wastes, nuclear materials have always been controlled, users are relatively few in number, and they are licensed by federal and state agencies. Thus, waste production and location is more exactly known. "Midnight dumping" of LLW has not been observed. Finally, only a single LLW disposal site is needed for most compacts or even the largest of states. In combination, these characteristics allow the formulation of a siting process that allows greater participation of elected officials and less reliance on administrative agency decision-makers.

³ 10 CFR 61.

⁴ In contrast, the hazard of organic chemical compounds such as polychlorinated biphenyls (PCB's) may be neutralized by incineration which breaks down the toxic molecular association.

⁵ A draft report prepared by The State of California Governor's Hazardous Substances Task Force estimated the volume of toxic waste on the order of tens of millions of tons each year. *Toxic Management in California* (October, 1983).

The Government Response

Recognizing that a satisfactory response to LLW siting was unlikely if states were individually relied upon, the federal government adopted legislation that addresses both positive and negative incentives to cooperation. The “Low Level Radioactive Waste Policy Act of 1980” legislates that “each State is responsible for providing for the availability of capacity either within or outside the State for the disposal of low-level radioactive waste generated within its borders . . . ” and the philosophy that “low-level radioactive waste can be most safely and efficiently managed on a regional basis.” [Sec. 4. (a) (1)] The Act provides for the development of federally approved interstate compacts for the regional disposal of waste and a strong action forcing provision: “(a)fter January 1, 1986, any such compact may restrict the use of the regional disposal facilities under the compact to the disposal of low-level radioactive waste generated within the region.”⁶ [Id. (B)] The federal government is mandated to provide information about regional needs, including transportation needs and the “capability of the low-level radioactive waste disposal facilities owned and operated by the Department of Energy to provide interim storage for commercially generated low-level waste and estimates of the costs associated with such interim storage.” [(b) (1) (D)]

Congress thus set a policy which acknowledged several complex issues of LLW management:

1. The relatively low volume, inherent hazard, and high cost of disposal do not warrant individual burial sites in each state. From a national perspective, proliferation of sites is undesirable;
2. States desire the right to exclude wastes generated outside their borders; and
3. States perceive the LLW problem as urgent but require near-term deadlines to spur them to be responsible for their own wastes rather than to shift responsibility to the present host states.

Table 1 lists the states’ responses to the LLW Policy Act. Several regional compacts have been formulated and several states have been excluded from or have elected not to join a compact. These states either generate so much LLW that they are not attractive as compact members, or they feel it is inevitable that they will have to host the disposal facility for the compact and would

⁶ Recently the United States Supreme Court let stand lower court opinions which preclude states from presently barring facilities from accepting wastes from other states. The court declined to review two opinions which were based on the interstate commerce and supremacy clauses of the United States Constitution. One case involved California shipments to Illinois of high-level wastes (*Hartigan v. GE*, #82-648). The other involved shipments of LLW to Washington. In the latter situation Washington State residents had adopted an initiative which banned both storage and transportation of wastes that were produced outside of the state (*Don’t Waste Washington v. Washington*, #82-841).

Table 1. Compact Groupings and Legislative Status as of April 17, 1985*

Northwest (IH/IS)	Rocky Mountain (IS)	Midwest	Central States (IH)	Southeast (IH/IS)	Northeast
Alaska (R)	Colorado (R)	Indiana (R)	Arkansas (R)	Alabama (R)	Connecticut (R)
Hawaii (R)	Nevada (R)	Iowa (R)	Kansas (R)	Florida (R)	Delaware (R) ^a
Idaho (R)	New Mexico (R)	Michigan (R)	Louisiana (R)	Georgia (R)	Maine ^a
Montana (R)	Wyoming (R)	Minnesota (R)	Nebraska (R)	Mississippi (R)	Maryland (R) ^a
Oregon (R)		Missouri (R)	Oklahoma (R)	N. Carolina (R)	Massachusetts ^d
Utah (R)		Ohio (R)		S. Carolina (R)	New Hampshire ^a
Washington (R)		Wisconsin (R)		Tennessee (R)	New Jersey (R)
				Virginia (R)	New York (R)
					Rhode Island
					Vermont ^a
Western	Dakotas	Central Midwest	Appalachian	Northern New England	
Arizona (R)	N. Dakota (R)	Illinois (R)	Delaware ^{a,f}	Maine ^a	
California (PS/IH)	S. Dakota (R) ^b	Kentucky ^c	Maryland ^{a,f}	New Hampshire ^a	
			Pennsylvania (IS)	Vermont ^a	
			West Virginia (R)		

Legend: State Legislative Status: Introduced in the House (IH); Introduced in the Senate (IS); Passed in House (PH); Passed in Senate (PS); Ratified, Signed by Governor (R). Congressional Legislative Status is indicated in **bold** using the same legend.

- ^a Denotes states participating in more than one region.
- ^b Pending state general referendum approval in November 1985.
- ^c By the Governor's executive order.
- ^d The New York Governor has forwarded a LLW siting bill to the NY legislature. No action has been taken on a compact.
- ^e The Massachusetts LLW Commission developed a "working draft" compact and presented it to the Governor. The NE Compact was rejected.
- ^f Maryland and Delaware were parties to developing the Appalachian Compact and are likely to join it, as long as they are not required to take on host state responsibility. Under the Appalachian Compact, Pennsylvania is to host the LLW disposal site.

Note: Texas continues to pursue an independent course of action. D.C., Puerto Rico, and the U.S. Virgin Islands are not listed as eligible states in the remaining viable compacts.

* Reprinted, after authors' modifications, from *The Radioactive Exchange*, 4:6, p. 8, April 17, 1985.

rather exclude wastes from other states (i.e., “go it alone”). Texas is among this class. Exclusive use of the compact site must be authorized by Congress. Legislation establishing several LLW compacts has been introduced in Congress, but no bill has gone past committee consideration.⁷

The federal government has also promulgated regulations on siting criteria for low-level waste, commonly referred to as 10 CFR 61. These provide licensing procedures, performance objectives, and technical criteria for shallow land burial and take into consideration both the short-term operational phase and long-term concerns of inadvertent intrusion, public health, and site stability to estimate ongoing maintenance post-closure. The regulations present prescriptive requirements which are aimed at insuring that performance objectives are met. They address characterizability of the site, potential land resource use, disposal site stability, natural disposal site characteristics, natural resources at the disposal site, groundwater discharge, surface geologic processes, financial liability, and other factors of relevance to site selection.

Nonetheless, no siting process has been mandated or generally accepted. Bills creating compacts refer to siting in only the most skeletal way. They do establish commissions as independent legal entities to direct the LLW enterprise, but they do not address siting process or elaborate or prioritize criteria. State laws which require site selection within specified periods are similarly silent on the approach to siting.⁸ The present work can feed into these generally articulated federal and state programs.

Siting History and Lessons from Other Siting Experiences

The nature of the siting problem for low-level waste facilities is suggested by the history of the nation’s difficulties in states which have hosted sites. Three commercial low-level sites are now in operation in the United States. U.S. Ecology operates sites in Hanford, Washington and Beatty, Nevada. Chem Nuclear, which is owned by Waste Management, operates a facility in Barnwell, South Carolina. In response to a variety of political pressures, each of the host state governments has attempted in the last five years to close its site to waste generated outside the state borders. Nevada chose to close its site altogether and continues to legally attempt closure of the Beatty facility. (The present operator’s license has not been renewed). South Carolina, defeated in its attempt to exclude outside waste, elected to limit the amount of waste it will accept each year. All of the host states have tightened waste acceptance standards and have instituted surcharges.

⁷ H.R. 3777, 98th Congress, 1st Session (Southeast Compact); H.R. 1012, 98th Congress, 1st Session (Northwest Compact); H.R. 3002, 98th Congress, 1st Session (Central Compact); and companion Senate Bills.

⁸ See Senate Bill 342, California (August 30, 1983).

All sites were shut down by host state governor's executive orders in Fall 1979 due to concerns about safe packaging for transportation. They were reopened after the states received assurances from the United States Department of Transportation and the Nuclear Regulatory Commission that enforcement of existing regulations would be increased. Also in 1979, Washington's Governor Dixie Lee Ray closed the Hanford site because of deficiencies in packaging discovered in incoming shipments. Governor Ray List of Nevada ordered closure of the Beatty site after it was discovered that contaminated tools and other materials were being salvaged and sold to locals by employees. South Carolina Governor Richard Riley, concerned about the burden of outside waste that his state received, ordered input to be reduced to 50 percent; later the legislature limited receipts to about one-third of pre-1979 levels. All sites were eventually reopened. Regulations governing packaging and handling were tightened, and burial fees were increased.

The low-level waste siting problem has both *sui generis* and quite generalizable aspects. Low-level waste facilities fall within that class of activities that have been colorfully described as "lulu's," locally undesirable land uses [6]. Sites can have considerable economic benefits to some groups in society, and generalized benefits are enjoyed by many, including those who consume products whose manufacture, use, or disposal generate LLW. But localized costs can be significant or perceived as significant.

While the immediate challenge to siting of LLW facilities is new, siting controversial, nondesirable land uses is not. Planners have faced problems with locating freeways, municipal waste disposal facilities, correctional facilities, and several other uses. Perhaps the experience which has the most lessons to offer is that involving hazardous waste disposal facilities.

With the discoveries of the potential health effects of exposure to hazardous waste and of the large number of disposal activities that were not properly sited, a major concern has arisen over proper siting. This concern has been reflected in literature which summarizes the activities of states in the hazardous waste area and offers alternatives to extant state action.

The voluminous literature converges on three major factors: the composition of the body that has the lead role in siting; the nature of the powers lodged in that group and in bodies with which it must interact; and the procedures that are employed by the entity that either implement or supplement those powers.

The appropriate "lead agency" in the siting of hazardous waste facilities has been variously described as an independent siting board, a corporate governmental entity, an existing administrative agency, or the legislature or executive [7]. Siting boards are of varying composition in Massachusetts, Ohio, Indiana, Connecticut, New York, Maryland, and Michigan among other states [8]. They may be small and composed primarily of representatives of existing administrative or regulatory agencies or large and represent both technical skills needed in siting and citizen interests, including the local level. The benefits of a

siting board are said to include the isolation of the participants from political influence that is certain to arise in siting decisions; but the composition of boards does not always reflect this alleged strength.

More important than the identity of the group that makes siting decisions (or makes major recommendations in the siting process) is the nature of the powers lodged in the lead group. Again the experience of the states and the literature offer considerable variety. The powers of those with the major siting responsibility may be to do no more than master planning: to inventory the needs of a state and select potential candidate sites. A somewhat stronger variation of this process is to plan and mandate consistency between local governmental zoning and regulatory action and the master plan for siting of facilities [7].

On the other side of the continuum of the use of political influence by the lead entity are the powers to condemn land and use it for facility construction or to substitute state-wide judgments for those of locals. Ultimately the state has the right and the obligation to use its police power to site facilities if that is deemed essential to the public health, welfare, and safety. The state power may come either in the form of preempting local government activity relating to siting of facilities or as an override of local government decisions that do not reflect compliance with statewide goals. The Model State Hazardous Waste Management Act of 1977 contains an override of local veto provision [8]. A version of the override requires that local governments enter into binding arbitration with the state entity; the aim is to insure that local interests are heard but to prevent them from precluding siting in their regions.

More significant practically than the theoretical powers of the siting entity are the procedures for making use of the siting power acceptable. Among the most often discussed are negotiation between local and regional or state interests and compensation of local interests [9, 10]. The use of compensation has been called a "bribe" [11]; perhaps it is more fairly described as an economic incentive to influence locals to consider the siting of facilities which incur costs to an area. The negotiation notion takes several forms including: mediation, siting juries [12], and a variety of types of public participation that go beyond the public hearing format [7]. The overall rationales are to recognize legitimate local interests and to concede powerful local influence in ultimate outcomes.

The leading recommendation for siting hazardous facilities consists of a siting board composed of experts and representatives of concerned interest groups. The board has the power to recommend sites to the state government or to use the police power of the state itself to override opposition to sites recommended by private developers or state planners. The better thinking concludes that, realistically, negotiations with locals are desirable and probably essential to any successful siting attempt [9].

Despite the careful articulation of hazardous waste facility siting approaches and their theoretical attractiveness, the fact remains that none of the suggested forms has been so successful as to suggest full-scale application to the LLW arena. Very few if any hazardous waste facilities have been sited in recent years [13]; and the preemption power, while available, has been used only rarely [11]. Negotiations with locals, if in a form that treats local interests on a par with statewide or regional needs, often result in obstruction of the siting process. (In Minnesota a \$3.7 million demonstration project funded by EPA as a model for site selection identified sixteen sites within the state but each was successfully opposed by local interests [14].)

The use of economic incentives to improve the record of siting of locally undesirable land uses—while an intriguing idea—is also unproven. Tarlock is skeptical [11, p. 6]:

The success of bribes as an alternative to regulatory mechanisms that address the preemption issues is not assured. Cities are relatively immune to bribery on this issue because the risks are unquantifiable and no substantial economic return is immediately forthcoming. As the authors of a study of the Massachusetts law concluded: “Whether the combined efforts of the educational campaign and incentives offered through the negotiation process are sufficient to overcome local opposition remains to be seen. . . .”

The hazardous waste siting experience thus offers some suggestions for policies for siting other land uses (reliance on the state police power, involvement and support of local interests, and statewide or regional inventorying and planning); but no one clearly superior model results for siting LLW facilities. In addition the urgency of siting LLW facilities leads us to suggest an approach that requires legislative involvement and recognizes the need for public participation in the articulation of values and the development of factors that will direct the siting process—but locates the ultimate responsibility for siting at the state level.

SITING APPROACH

The Nature of the Task

The proposed process recognizes that the siting challenge is both sociopolitical and technical. Siting is a process challenge: The technical analysis of the problem has been thoroughly studied and parameters are suggested for seismic, meteorologic, geologic, and environmental dimensions [15, 16]. Technical assistance including computer-assisted siting packages, are available. However, these produce different outcomes as differentially employed. Citizen groups may emphasize socioeconomic factors more fully than agency representatives. They may have different risk assessment calculations than

those who will not live near the sites [17]. They will have different evaluations of property affected by the chosen site—both as measured in price demanded in compensatory schemes and in the psychological costs of living near an LLW facility. Furthermore, technically trained participants may select differentially within the range of parameters on a given factor—emphasizing the importance of the area they know best.

We recognize that government officials try to avoid accountability for decisions on siting. Responsibility for site selection is neither sought nor desired. Nevertheless, ultimate accountability must rest with elected officials, and siting decisions should be observable by the public. Accountability does not equate with management of the process, so implementation is left to an administrative agency: the paper lays out considerations for the choice of lead agency.

We recognize also that any siting model will confront dynamics of policymaking that act to counter a rational, objective process. We offer here a pure type, and argue that the process is worth seeking because: 1) siting approaches which are overly responsive to special interests can produce outcomes which are unacceptable from both the perspectives of public health and citizen satisfaction; 2) resources are sufficiently generous and wastes are hazardous enough to allow for ambitious approaches; and 3) societal goals as presented in the LLW Policy Act and in state law are sufficiently specific that responsibility for selection has already been constrained; this can protect elected officials at the state level from some of the criticism which is predictable no matter what the ultimate choice of site.

The process begins with identification of legal requirements for siting. This is followed by an inventory of social and technical criteria and an evaluation of the compatibility of the objectives of those interested in the siting outcome. Following a scoping process, criteria are weighted and prioritized prior to a regional screening based on the results. A more focused activity follows with ultimate selection of one site subsequent to in-depth studies of a small number of alternative sites.

By spelling out activities and by differentiating among interests that will demand to be heard we make explicit whether each activity is descriptive, analytical, or decision-taking and how resolution is to be reached at each stage of siting. Classifications are based on determinations of whether each actor offers legal authority, accountability and responsibility, or technical or other types of information (i.e., preferences and needs), and influence. Table 2 summarizes the involvement of each set of actors at each stage in the process.

The actors — Involving the interests that seek to participate is crucial to a successful siting process. Local citizens groups (including Indian tribes as explicitly noted in 10 CFR 61); local business interests; technical experts

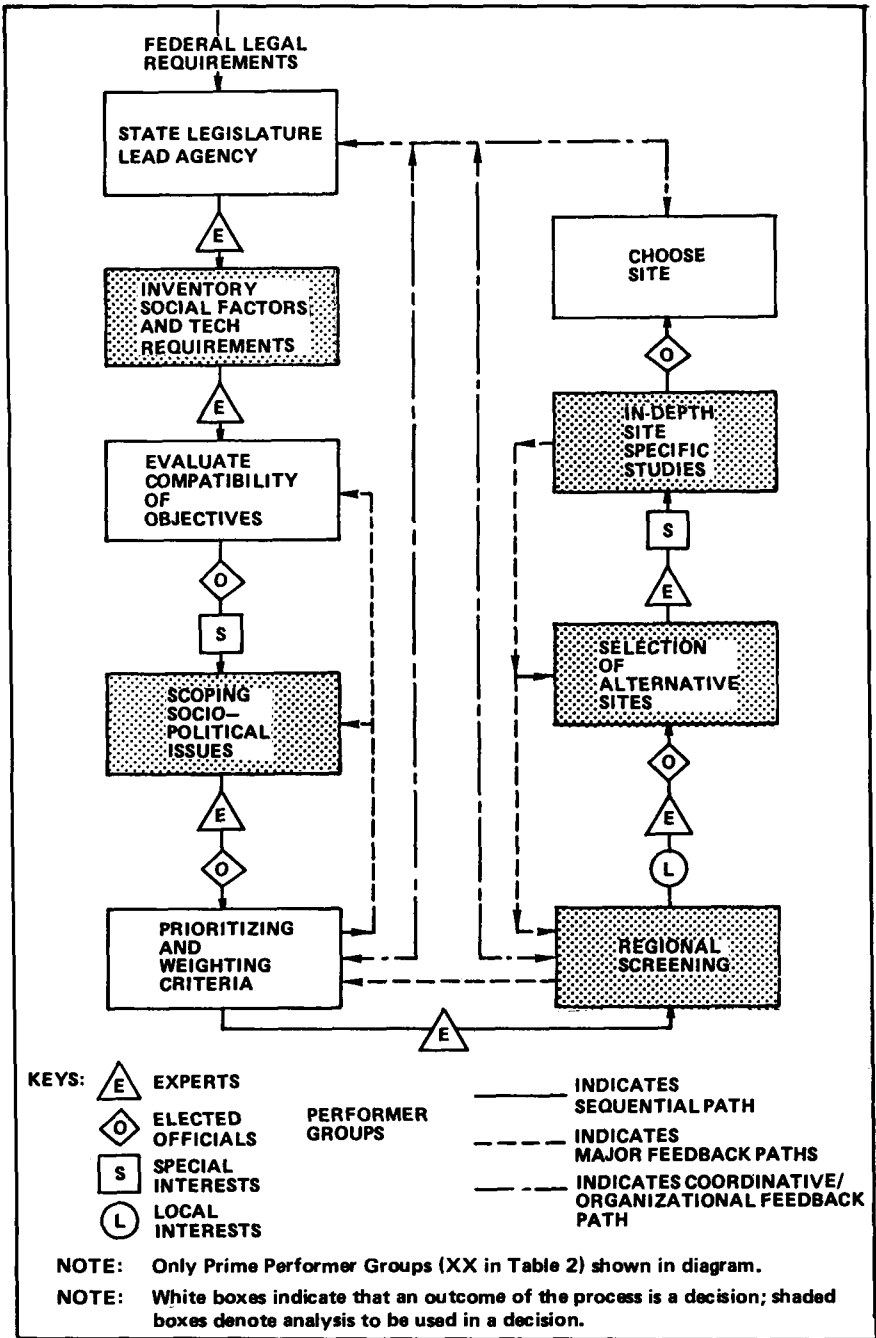


Figure 1. Sequence of Site Selection.

Table 2. Functions and Performers for Siting of Low-Level Radioactive Waste Facilities

Activity	<i>"Expert" Group</i>			<i>Elected Officials</i>	
	<i>Administrative Agencies (A)</i>	<i>Technical Experts (B)</i>	<i>Process Experts (C)</i>	<i>Local Elected Officials (D)</i>	<i>State Elected Officials (E)</i>
1. Establish Legal Requirements					
2. Inventory Social Factors and Technical Requirements	XX	XX		X	XX
3. Evaluate Compatibility of Objectives	XX	X	X		
4. Scope Sociopolitical Issues			X	XX	
5. Prioritize and Weight Criteria	XX				XX
6. Undertake Regional Screening	XX	XX	XX	X	X
7. Select Alternate Sites	XX	XX	XX	XX	
8. Perform In-depth Site Specific Studies	<i>a</i>	XX		X	
9. Choose Site	<i>a</i>				XX

^a The Nuclear Regulatory Commission and the host state health department must review all data submitted with the site application and must license the site.

including wildlife ecologists, geologists, hydrologists, demographers, anthropologists, transportation planners, engineers, public health experts, and meteorologists will be involved. There is a role for generalists including planners and other expeditors. Operators of existing facilities are also invited to participate in certain stages. We recognize a special need to manage the contributions of interest groups so that they do not distort the siting process. However, any process that attempts to exclude them out of fear of disproportionate influence risks being undermined or being declared irrelevant.

Table 2. (Cont'd.)

<i>Elected Officials</i>	<i>Special Interests</i>			<i>Local Interests</i>			
	<i>Special Interests— Industry (F) (G)</i>	<i>Special Interests— Environmental (H)</i>	<i>Potential Developers (I)</i>	<i>Local Citizens (J)</i>	<i>Regional Government (K)</i>	<i>Local Business (L)</i>	<i>Site Operators (M)</i>
XX							
	X	X	X		X		
X	X	X					
	XX	XX					
X					X		
X	X	X	X				
X	X	X	X	XX	XX	X	
<i>a</i>			XX				
<i>a</i>							X

The role of elected officials – The inherently controversial nature of siting makes it the type of decision that is commonly delegated to an administrative agency with only general directions or loose standards. Legislators do not wish to be associated with outcomes that will likely disappoint or alienate constituencies. Experience demonstrates that in the LLW siting field consideration of implementing details in legislative bodies is likely to be avoided.⁹

⁹ According to *The Radioactive Exchange*, for example, legislators in the Midwest compact “were not at all enthusiastic about amending the compact (as proposed by a state senator) and having to face legislative ratification a second time” [18].

Nonetheless, in the described process a central role is designed for elected officials. Deadlines for choice of sites for facilities and the highly emotional nature of decisions associated with nuclear materials demand legislative consideration. Delegation should be done only after the legislature has specified the weight that should be given to various objectives, and the final site choice itself should not be delegated. In addition, legislators should be cognizant of the fact that final siting decisions will be acceptable only if those affected conclude that the decision was made in a forum that was open, accessible, and representative [18].

Siting boards are sometimes used in the hazardous waste siting process. The political value of these boards is that they remove potentially unpopular choices from intense public scrutiny. But this is also their weakness: they diffuse accountability and remove from public view a decision which must reflect a great degree of participation and serious attempts at consensus, but one which is ultimately a use of the police power. A working group of the legislature may be operationally desirable in crucial stages of siting; it may wish to call in the assistance of non-elected officials; and it may refer to itself as a siting committee or board—but this is a different use of the term than that prevailing in hazardous waste siting.

Uniquely sensitive issues are raised when a legislator is required to contribute to a decision when a candidate site is in his or her district. We offer two responses to this challenge. First, some candidate sites may actively seek LLW facilities—making the representative’s task more simple.¹⁰ Perhaps more probable is the situation where constituents in potential site regions are generally opposed to locating facilities in their districts. In this case representatives may be able to fulfill responsibilities by vigorously representing their district interest; a decision rule on choice can be created to override local opposition only with large majorities of the elected bodies—such as two-thirds or even three-fourths of the legislature.

Some actors pose difficult challenges. For example, present operators of disposal sites possess invaluable information from their business experience. They have developed facilities, worked with them for years, evaluated alternative means to their management and control and have had to make changes in their systems. Yet they can be overly influential in early stages of siting. Objective assessments of their performance are difficult to make. They have a vested

¹⁰ Local officials in the North Central part of Texas have informed the Texas Low Level Radioactive Authority that “they would welcome a LLW facility in their area” [20].

The extreme of this situation can occur when a developer or other interested actor seeks special legislation to favor one site or preclude siting in a region [21]. Abuses of legislative influence are always possible; in the present case they may be countered by efforts to make decisionmaking more visible and by having legislative representation cross regional and other lines.

interest in having the technologies that they have employed classified as the best available for the job. It can be in their interest to counter technology forcing (i.e., assert that the procedures and technologies they employ are state of the art). “Capture” of the process by this group, as that term is used in the administrative sciences, may be subtle [22]. In the present scheme, they are involved in an active role only after regional choices are made. Similarly, users of the disposal service, including universities, electric utility companies and hospitals, need to be satisfied with siting process or they will lobby against its outcome. They are involved early on, but in some stages their roles are limited.

Process characteristics – The process we describe is characterized as participatory in generation of data and representative in the utilization of that data. Information necessary to reach an acceptable siting outcome is lodged among several actors and comes in a variety of forms. Some is highly technical and, in fact, outside of the ordinary knowledge of many who will be affected by a final siting choice. Other data are decentralized and include information about human responses to siting choices, local characteristics [23], means of collectively responding to difficult land use choices, and a variety of economic impacts.

Consensus need not be imminent for participatory modes of generating information to be valuable. Indeed we recognize the possibility that consensus about site selection may not materialize. Nealey and Hebert have concluded: “there is little likelihood that government policy-makers can bring much consensus behind any conceivable waste management plan” [5]. This conclusion is based upon a review of public attitude surveys conducted on the nuclear energy and waste issues. Four factors were specified as preventing the development of a consensus on waste management strategies: uncertainties regarding long-term storage and concomitant division of opinion about risk between the experts and the informed public; diversity of basic life values among the public; unbalanced “education” of the public through the media; and the poor correlation between knowledge about the nuclear issue and values. Those researchers have also found the public and the technical community differently rate short- and long-term safety concerns, accident detection, and cost. Others conclude that consensus will result through education when participants attend to available technical analyses. In the proposed approach consensus, while desirable, is not a prerequisite to site selection.

We aim through participatory mechanisms to enhance knowledge and understanding among the actors about effects and perceived effects on others; the process is designed to avoid some of the problems associated with centralized, hierarchical and agency-oriented forms of decision-making that rely on narrow definitions of appropriate expertise. Yet responsibility remains with elected officials and the process must be professionally managed.

Selection of lead agency – Despite the important function played by legislative bodies in articulating and balancing interests to be addressed in siting, the daily management of the process of site selection will not be done by elected officials. Responsibility for directing the process through inventorying social and technical requirements and criteria selection is lodged in a body with the resources and expertise to move the decision back to elected officials for final selection.

Choice of a lead agency for these operational tasks is not a trivial activity. Selection should be made with an understanding that it affects substantively the nature of candidate sites—no matter how specific the legislature is on criteria for selection. Whether management is lodged in a department of environmental protection, energy, or health will influence the areas of expertise that will inevitably, to some degree, set the context for various stages of siting. Control by engineers, physicists, public health officials, or ecologists in daily management, regardless of how rationalized and how participatory are the remaining stages of selection, will affect, sometimes subtly and sometimes egregiously, emphases and interpretations. The legislature needs to decide which societal objectives will take priority. Agencies have different traditional stakeholders and these will have differential access to administrators.

In view of the federal concern with health protection and because of the extensive public apprehension about health issues associated with nuclear wastes, the lodging of management responsibility in a state department of public health or health services is proposed. This recommendation is supported by a close to general consensus that the environmental impacts of LLW facilities will not be significant if accepted criteria for siting are employed; this makes the reliance on an environmental quality agency less important than might otherwise be the case. (If performance objectives mandate siting away from populated areas, the legislature may choose to delegate managerial control to an environmental agency in order to maximize protection of natural resources and wildlife.)

After information has been collected, shared and applied the siting choice is made. In the neutral sense of the term it is a political choice to be made by state elected officials. This siting scheme thus rejects the position, common in what political scientists have called interest group liberalism [24], that administrative expertise is capable of making societally acceptable decisions in areas where a pluralism of values reigns. As well, we distinguish decision-makers (which include planners) from decision-takers (which include elected officials) [25]. The proposed process is not one of environmental mediation. Participation is aimed at providing valuable new information and recognizing legitimate citizen interests. It does not assume that consensus will be reached through involvement of all the actors recognized. Decision-takers must have the ultimate responsibility for site selection. As Ducsik has noted for power plant siting [23, p. 161]:

Collaboration does not necessarily connote a truly joint effort. What seems most important is that the public not be totally insulated from the technical work, because a lack of understanding of the thought processes followed and judgments made by planners can easily give rise to a perception that the weak or questionable aspects of various alternatives are being concealed in technical jargon.

Siting LLW Facilities

Several activities constitute the process from the establishment of federal legal requirements for LLW siting through the selection of a site in the state or region (Table 2).

Establish Federal legal requirements – Performance objectives are a constraint under which all actors will work. Performance objectives emanate from a variety of sources and their development may be dynamic. Even the LLW federal regulations are not static. They can be changed based on expressed dissatisfaction of even a small number of political actors. However, at some stage in the process the regulations are considered a given. It is at that point that the presently described process begins.

Factor inventory – Two inventory activities are essential. To determine social factors of relevance to the compact—those that may have been given little or insufficient attention at the federal level—representatives of communities and tribes who are residents of areas that are among the likely choices for sites need to be involved. At this stage details about local conditions can be described and the need for compensation to those who live near sites may be considered. By making it clear early in the process that compensation is (or is not) available, an item of uncertainty in the decisions of localities on LLW siting is removed. Compensation need not be thought of in only a monetary sense (such as user and property taxes). Rather it can more broadly include the ability of local communities to impose permit conditions and otherwise regulate, e.g., through special monitoring requirements or the right to periodic citizen inspection. By acknowledging the “strategic importance of compensation” [10], an incentive is created for locals to maintain involvement from early in the siting process to ultimate site selection.

An argument against initially specifying compensation is that other economic incentives which are identifiable by locals may make compensatory schemes unnecessary; compensation may only make the siting process avoidably costly. The decision on whether and when to determine a compensation package may best be left to the lead agency after it has received initial indications of the “market for sites.” A competing stage for determining compensation may be at the selection of alternate sites when impacts on locals become more readily identifiable and salient.

Both industry and environmentally-oriented special interest groups participate at this stage.¹¹ They are invited to contribute to the development of performance objectives and prescriptive requirements. Potential site developers are asked to express their views on factors that should be considered in siting, but this input is constrained because developers are likely to have a proprietary interest in the final version of the criteria. Regional governments are participants: they may possess data on area conditions and local preferences.

An active role is required for technical experts to insure that state and compact characteristics which will affect the performance of a chosen site are adequately addressed. Again, the role is not dominant; social factors may be equally important in ultimate site selection. One may need to make tradeoffs between ideal sites from a technical perspective and those that reflect dominance of social considerations. In this function both local and state elected officials play an important role.

This mix of technical experts, those who have expertise in other areas, and those who have a stake in the outcome of this process is critical. Clearly, differences will exist within and across expert groups. Consensus may not result; however interactive procedures will assist in identifying issues over which there is disagreement and for which a political decision is necessary. In this process uncertainties are made known and differing interpretations made explicit.

An example of this exchange is offered in consideration of whether a site should be located near population centers. A variety of experts has addressed this question. Many would opt for siting as far as practicable from occupied areas. But in most siting criteria discussions, proximity to population centers does not preclude siting. A site meeting the minimum technical requirements of federal regulations could be located near population centers: no federal standards define "high population density." Distancing of facilities from population centers may minimize interference with the expansion of urban areas and decrease the likelihood of human intrusions after institutional controls have ended. Locating away from large expanding populations may limit the economic impact of long-term land commitments to waste disposal since site land costs could be low. But economic impact needs to be addressed by a range of interests represented in the siting process, as benefits to one group of actors may be seen as costs to another. Some jurisdictions may seek new industries and be relatively unconcerned about risks associated with LLW, and transportation costs may be prohibitive for some sites which are ideal in other ways.

Discussion of this factor will involve other considerations as well. Demographic projections over fifty to one-hundred years need to be supplied

¹¹ Choice of representatives for the interests which will participate in the siting stages is not a simple task. Problems reportedly have surfaced in EPA's "Regulation Negotiation" project on LLW disposal rules. Because our process is not one of mediation, and consensus is not essential, choice is less problematic under the proposed siting scheme.

by technical experts, and physiographic characteristics of the state's or compact's region need to be described. Growth in tourism or recreational use after institutional controls have ended should be projected by government agencies and perhaps user groups. So, too, information needs to be supplied on presently available technologies including those that act to buffer surrounding areas from the wastes, and "best guesses" need to be made on distances from the site which will be adequate to protect population centers. (This task will be revised later in the process because "best guesses" will be site specific: protection is a function of several factors including the quantities of various radionuclides and chemical and physical forms to be emplaced in the trenches, the depth of burial, the thickness of the backfill and of geological strata. Nonetheless, some models have been developed which allow for the prediction of potential releases to the environment from a "reference" disposal facility [26].) In this manner criteria for standards are systematically addressed.

Evaluation of compatibility of objectives – The primary role at this stage is assumed by administrative officials who identify areas of fit and compatibility among criteria and areas in which integrating criteria is technically impossible or very difficult.

All actors have opinions on incompatibility, but the siting process can be expedited if a preliminary analysis is made by policy analysts in the managing or lead agency. Again, the identity of the lead agency (public health, environment, energy orientation) may preclude a truly objective analysis of compatibility. If other participants are dissatisfied with the choice made by the managing bureaucracy or with the agency's performance on this task, it may be necessary to more fully air the views of special interests.

Objectivity of actors—including policy analysts—will not be achieved everywhere, so visibility of decision-making is sought. An important function can be played by the media in reporting processes and outcomes at various junctures in the siting scheme. By providing timely news along the way to final site selection, the media can limit a factor that is related to differential power in siting: differential access to information. And it can highlight abuses of power which are likely to be concomitant with less visible decision processes.

Increasingly the media are assuming significant roles in interpreting environmental issues. Cable television and the greater decentralization of broadcast journalism offer opportunities to fully inform those interested in LLW siting. Focuses can be on both technical factors and on the dynamics of resolving differences among actors at each stage. Whether media representatives will assume this highly responsible role of communicator remains to be seen. The prevailing alternative appears to be periodic reporting of only the most newsworthy (and perhaps sensational) aspects of LLW issues—in ways that stop short of educating viewers about complexities and tradeoffs in the environmental arena. Indeed citizen risk assessments of new technologies and alternative

public policies are often determined by television and newspaper analyses in ways that lead to exaggeration of potential dangers [27].

Roles for environmental and industrial representatives are recognized at this stage: involvement may be demanded and should be recognized. But if the process is designed to be and is considered fundamentally technical, and if actors conclude that they will be able to assess the objectivity of this task at a subsequent stage—that of scoping—recognition of the usefulness of independent policy analysis is likely.

State officials may actively solicit the assistance of experts in cases where factors are imprecisely defined, are beyond analysts' expertise, or where conclusions could benefit from validation. For example, social scientists might address the ability to both address psychological impacts of living near a disposal facility and meet service needs of workers.

Scoping of socio-political issues — Scoping, a process innovation that was first utilized in environmental controversies in the 1970's, brings together those who are interested in the outcome of a policy choice or regulation in an attempt to identify the significant concerns of each. The process is critical in LLW facility siting. In it participants articulate, with assistance of the available technical data and information, the salient impacts of siting. We would expect to reveal most of the perceived adverse consequences of siting at this stage. Involved are self identified locals, special interest groups and elected officials from local governments that are potential siting areas. Scoping is most successful when facilitated by actors without a strong interest in articulation of the final set of issues, so process expeditors are involved. Individuals without predetermined positions and/or economic interests on LLW issues need to be located—including those with planning skills that include technical understandings.

Prioritizing and weighing of criteria — To this point extensive technical information has been provided and analysis of interest group positions has been offered. Conflicts and incompatibilities in siting criteria are clear, and no approach to optimizing will give equal weight to all criteria. Remaining is a difficult political choice: how to organize the criteria to assist in the next, more mechanical, stages. Elected officials undertake this task, either directly or through a commission established for the purpose. The central point is that the decision is not one reached through objective processes. It involves value judgments and tradeoffs of the kind that are best made in a highly visible forum by those who are responsible for health, safety, and welfare concerns.

Technical assistance may be required at this stage. It can be provided by state administrative agency personnel and regional governments.

Regional screen — Once this crucial step is passed, the function of elected officials is limited until a site is chosen. The focus shifts to application of criteria, and emphasis is on technical analysis guided by performance

objectives. For example, areas with considerable precipitation are rejected; those with stable land characteristics are considered; seismic, physiographic, economic, land use, and demographic considerations act to sort the compact's candidates. Various analytical devices are available for screening, ranging from the highly sophisticated computer-assisted graphics to simple but accurate overlays of potentially limiting factors [28, 29]. As Table 2 notes, dominant at this stage are the technical and process experts within state government and elsewhere. Assistance can be provided by industrial and environmental groups if they possess new information. (Allowing participation when nonredundant information may be made available and precluding it otherwise is efficient and has precedent in administrative law.) Other actors would be allowed to provide technical assistance. Potential site developers now are active. They respond to requests for proposals that were generated independent of their influence. Resulting are nominations of regions of the state or compact in which siting is feasible.

Conflicts may arise if the search is limited to areas in which the political climate is sympathetic or for which there are good data. Information sources such as water resource maps, climate and rainfall maps, and geologic surveys may be incomplete for some regions that are excellent site locations. Conversely, conflict can be limited with a legislative conclusion that search activities will be limited to public lands.

Initial exclusionary criteria may eliminate all areas within a region of interest. This situation would require reconsideration of prioritizing and weighing of criteria (see feedback loop in Figure 1).

Alternate site selection – At this stage the focus sharpens on the leading candidate sites within the regions and rational siting procedures face a dilemma. On the one hand, parochial interests can undermine the siting process by concentrating on impacts within specified areas and failing to concede the need to optimize under a variety of constraints. On the other hand, these interests may possess data on sites within the candidate regions that were not available previously or that attain relevance only at this level of resolution. A variant of the decision rule used in the prior activity stage applies: if the information is nonredundant, it will be admitted to the process being undertaken. Also, local interests in areas under consideration will carry a presumption that their new information is of value. Nonetheless, planners or others who do not represent local interests (those labeled process expeditors in Table 2) have the dominant function in matching available data to screening criteria to generate a small number of potential sites.

Site specific studies – In-depth studies will be performed of remaining candidate sites. These can take over a year in part because of the need to characterize seasonal variations in factors of importance and in part because of the naturally determined periods needed to quantify such parameters as ground

water flow rates [30]. Federal regulations require a minimum of one year for site characterization.

The emphasis is on technical contributions. Studies are commissioned by state or regional administrators. Potential site developers and their consultants play active roles. Now information of a general nature is validated or improved through test drilling, analyses of climate, soils, hydrology, wildlife and flora. Local elected officials are consulted for greater detail on socioeconomic considerations such as population impacts related to growth inducing construction of roads, services, and the facilities themselves. Data will be used to support the license application to the Nuclear Regulatory Commission.

Site chosen – This is the selection step. Elected officials again assume a critical role. Officials from each state involved in a compact, under procedures established for the compact, choose the facility location. They do so with access to the information generated in the site-specific analyses; for this task they are fully briefed by the managing or lead agency administrators. In addition to the veto power over an individual site which is lodged in the elected officials of the participating states, NRC approval of the site is required under 10 CFR 61 in “nonagreement” states. As a practical matter elected officials in a host state may be given final say on ultimate location of the facility.

CONCLUSION

The siting of low-level radioactive waste facilities poses a challenging planning problem. The decision on siting requires significant technical expertise. Knowledge about characteristics of LLW and about safe places to treat and store it resides among a variety of specialists. Yet, siting is a challenge like many others faced by the concerned public and by its urban and regional planners. LLW facilities are associated with tangible benefits to many and yet are considered suspect if not dangerous by some who reside near a potential site or who are concerned about people who live near the sites now or may in the future.

The siting challenge requires involvement by those who are to be affected by a decision. Yet to lodge ultimate decision-making authority among all those who possess some interest in the outcome would be unworkable. The process offered here is thus participatory in input and representative in outcome.

This ideal siting process is offered with the knowledge that it requires interest group behavior that is nontypical of involvement in many environmental and land use decisions. We have attempted to address what we consider to be a unique set of land use problems. The states are required to decide within a relatively short period where to site wastes facilities. Non-normative behavior is required. The alternative to the described siting procedure may be centralized decision-making which will have to override individual interests without learning of the perspectives and data they offer.

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