WASH-1503

MASTER

ENVIRONMENTAL STATEMENT
RADIOACTIVE WASTE REPOSITORY

LYONS, KANSAS

JUNE 1971

UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON, D. C. 20545

RESPONSIBLE OFFICIAL:

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DISCLAIMER

WASH-1502

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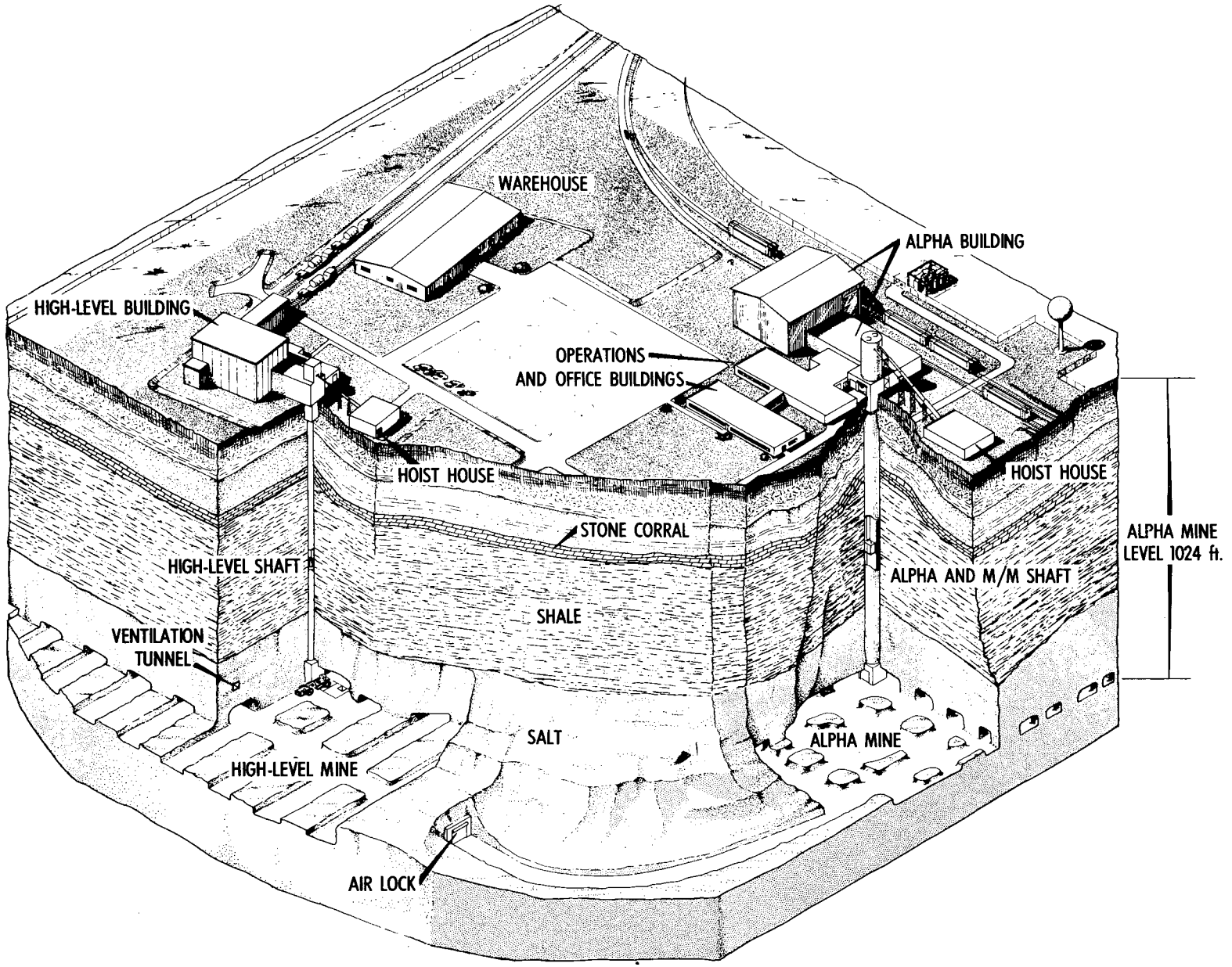


FEDERAL REPOSITORY

I. SUMMARY

As nuclear power assumes an increasingly important role in meeting the nation's requirements for electrical energy, the quantity of radioactive wastes will also increase. The wastes of primary concern - designated "high-level" and "alpha" wastes - contain radioactive nuclides that decay so slowly as to require that they be isolated from the biosphere for thousands of years. This statement describes the initial measures to be taken as a part of the Commission's overall waste management policy and program for the permanent disposal of these wastes. The proposed facility will safely contain these wastes for the required period of time without any significant impact on the environment. This policy has, in part, been established with publication in the Federal Register on November 14, 1970, of Appendix F to 10 CFR 50 which requires that industry solidify their high-level liquid wastes and transfer these wastes to a federal repository. This policy was first proposed on June 3, 1969, when it was issued for public comment.

These wastes can be described as follows. High-level wastes, principally the fission product "ashes" that are separated in the reprocessing of spent reactor fuel, are characterized by long lived beta and gamma radiation and high thermal power. Alpha wastes, principally solid materials contaminated with small quantities of plutonium and other transuranic isotopes, are generated in the course of operations involving nuclear fuel materials. These wastes are characterized by the presence of short range alpha particle emitters and low heat generation rates.

Up to the present time, high-level wastes have been stored on a temporary basis as liquids or solids in tanks, while alpha wastes have

been stored as solids in shallow land burial grounds. Recognizing that a truly permanent solution of this problem is required, the AEC in consultation with the National Academy of Sciences and members of the geologic community has, over the last 15 years, sponsored research and development work to examine the suitability of bedded salt formations as a final repository for these materials.

On the basis of these studies, and in accordance with the recommendations of the National Academy of Sciences, the Atomic Energy Commission proposes to construct a demonstration repository for solid radioactive wastes in the underground bedded salt formations of central Kansas. Although it is anticipated that this facility will ultimately be designated as the Federal Waste Repository, it will be initially operated as a demonstration facility. Subject to confirmatory geohydrologic studies, the AEC has tentatively selected a site near Lyons, Kansas, for this purpose. The proposed repository will utilize an existing, 200-acre nonproducing salt mine for emplacement of alpha wastes which meet storage criteria; an adjacent 800-acre section of the salt bed will be mined for emplacement of high-level waste; and surface facilities will be constructed for receipt and handling of the waste packages. Table 0 presents an estimate of the utilization of the high-level portion of this facility over its active life. Only wastes which meet the criteria which will be developed in the course of facility design will be stored in the repository. Certain criteria have already been established for both the high-level and alpha wastes. Wastes must be in solid form; explosive or inflammable materials will not be accepted for storage.

Environmental Impact - By establishing this facility, radioactive wastes of the type previously described will be permanently isolated from man's biosphere,

thus providing a direct and lasting benefit to the environment. No significant impact on the environment resulting from either the construction or operation of the proposed repository is anticipated. Minor environmental effects anticipated on or below the 1000-acre proposed site as well as those beyond the site boundaries are described below.

Thermal Impact - The decay of the radioactive isotopes in the waste material in the mine about 1000 feet below the land surface is expected to cause an upward heat flux calculated to produce a maximum temperature rise of less than 1°F at the surface of the site approximately 800 years after waste burial, and then gradually subside to natural levels. Subsurface salt and mineral rights would be acquired for a distance of approximately 1700 feet around the perimeter of the surface area of the site to assure that thermal effects do not inhibit subsurface activities of other land owners beyond the area owned and controlled by the Government and to prevent intrusions by drilling which might adversely affect the integrity of the salt formation.

An aquifer of minor productivity 100 feet below the site surface may experience a maximum temperature rise of about 14°F after 800 years, assuming that the aquifer is stagnant and will not dissipate heat by flow. Another minor aquifer at a depth of about 285 feet below the site surface may experience a maximum temperature rise of 32°F after 800 years.

None of these thermal effects should limit productive use of either of these aquifers or the surface land above the mine. More exacting heat flow calculations involving three dimensional models and using thermal property data obtained from core samples of the site will be used to further refine these estimates.

Radiological and Physiological Effects - During the normal operation of the repository very small quantities of radioactivity will be released to the atmosphere through the ventilation system, principally the naturally occurring radon released from the salt during mining. The design features and operating characteristics of the facility will be such that the resulting off-site concentrations of radioactivity and hence the potential physiological consequences will be only a small fraction of that resulting from natural background radiation. It is estimated that the average annual off-site concentrations will be no more than 0.1% of the permissible concentrations as defined in Title 10, Code of Federal Regulations, Part 20 (10 CFR 20).

The naturally occurring separation of the salt bed from circulating groundwaters will assure the long-term containment of these wastes, preventing their entry into man's biosphere.

Other nonradioactive materials will be released from the facility in small concentrations in the ventilation exhaust. These materials will include helium, hydrogen, diesel exhaust fumes, airborne salt particles, and chlorine (or HCl). The concentrations of these materials, in both the working mine areas as well as above ground locations, will be below all applicable air quality standards.

Geophysical Effects - The impact of this facility on the geophysical environment will be evidenced in the form of (1) bulk expansion of significant quantities of rock above and below the disposal plane due to the introduction of heat into the salt and (2) slow subsidence of the surface due to the convergence of the roof and floor of the mine. The latter effect is common to most mining activities. Available evidence

suggests that the subsurface rock layers will adjust to these deformations without deleterious effects so that the net effect will be a shallow surface depression amounting to about 4 feet, which will occur after a period of several hundred years. This subsidence is not expected to interfere with land use either above or adjacent to the mine or impair the integrity of the salt bed. Sophisticated models will be developed to predict the mechanical response of the rock column based on physical data obtained from core samples.

Ecological - About one thousand acres of land growing wheat, sorgum, soybeans, and pasture may be removed from agricultural production during the period of operation of the repository (perhaps 25 to 50 years). Approximately one-third of the land is not now in production because of USDA acreage restrictions. Since there will be no significant increase in soil temperature in excess of average annual variations or in the concentration of airborne materials, there should be no change in the character of the grassland community or the fauna.

Sociological Effects - The projected full-scale operation of the repository will require perhaps 200 employees. It is expected that some of these, with their families, would be additions to the Lyons community. The repository will not be offensive with respect to sprawl, noise, waste effluents, large utility usage, or conspicuous engineered features. It is possible that the presence of the repository may attract other commercial or nuclear related activities to this area.

Transportation - Solid wastes, meeting the criteria for storage, will be shipped to the repository from many points within the United States.

Shipments during initial years of operation are expected to be by rail; truck shipment may be authorized later. Shipment systems which will provide for the safe containment of these wastes during transport are generally available. Shipments of highly radioactive materials have routinely been carried out for over 25 years. All shipments will conform to applicable regulations of the Department of Transportation (49 CFR 173.389 through 173.399) and the Atomic Energy Commission (AEC Manual Chapter 0529 and 10 CFR 71).

Monitoring Programs - A detailed effluent and environmental monitoring program will be carried out as required by AEC Manual Chapter 0524 and 10 CFR 50. Additionally, long-term, post-operational environmental surveillance programs will be developed to assure maintenance of the permanent integrity of the salt bed.

Value Assessment of Short-Term Uses and Long-Term Consequences - The repository is expected to be in operation for a minimum of about 25 years. During this period of operation portions of the surface area could be put to beneficial use such as a site for an industrial park or might be revegetated to natural prairie. Following the decommissioning of the repository and sealing of the mine, essentially all of the surface could be returned to virtually unrestricted use subject, of course, to restrictions on deep drilling activities. It is planned that the site will be maintained in the perpetual care of the Federal Government to provide for continuity of the post-operational monitoring program, and to maintain the integrity of the underground workings thereby assuring the continued isolation of these wastes from the biosphere.

Table 0

Estimated Schedule of Alpha and High-Level Wastes To Be Buried at the Repository

Calendar Year	Volume of Alpha Waste[a] (10^6 ft^3)	High-level Solidified Wastes	
		Number of Containers[b]	Area of Salt Used[c] (net acres)
1975	0.350	-	-
1976	0.350	88	0.2
1977	0.350	184	0.4
1978	0.350	329	0.8
1979	0.350	561	1.3
1980	0.350	819	1.9
1981	0.700	1240	2.9
1982	0.700	2220	4.0
1983	0.700	2720	5.2
1984	0.700	2880	6.7
1985	0.700	3660	8.4
1986	0.700	4580	10.5
1987	1.000	5530	12.7
1988	1.000	6470	14.8
1989	1.000	7490	17.0
1990	1.000	8600	19.5
1991	1.000	9690	21.9
1992	1.000	10,900	24.6
1993	1.000	12,000	27.2
1994	1.000	13,200	29.8
1995	1.000	14,600	32.7
1996	1.000	15,800	35.5
1997	1.000	17,200	38.6
1998	1.000	18,400	41.4
1999	1.000	19,800	44.4
2000		21,300	47.7
Total	19.300	199,261	450.

[a] Assumes waste has been compacted by factors of 3 to 10.

[b] Containers are 6 in. in diameter and contain 1.6 ft^3 of solidified waste each. Half of the waste is aged 5 years and half is aged 10 years at the time of its receipt at the Repository.

[c] "Net" acres can be converted to "gross" acres by dividing by 0.5.

Irreversible Commitments of Resources - In view of the vast rock salt deposits existing in the United States, 60 trillion tons (plus larger ocean reserves), it is unlikely that the few million tons of salt that would be irreversibly committed to retaining the radioactive wastes at the repository would have any measurable effect on the reserves of this resource. Recent drilling activities confirm that oil and gas reserves underlying the site are quite small. The removal of 1000 acres from agricultural uses should cause no detrimental impact on local production or national needs.

II. BACKGROUND OF PROPOSED ACTION

The advantages of producing electrical power by nuclear energy are manyfold. Among the more prominent of these is the fact that nuclear power has the potential for providing an almost limitless source of energy while producing a minimum impact on our environment.

A key element in the Commission's nuclear power program has been the development of methods which will provide for the safe handling of the waste products from this industry. In some industries, waste products are normally discharged to and diluted by the environment. The Commission's high-level waste management programs have proceeded in a different direction, that is, towards providing complete isolation of these waste materials from man's biosphere in a manner as free of the requirement for human surveillance as possible.

The possibilities for approaching this ideal within a realistic administrative, technical and economic framework have been under discussion and study for more than 15 years by persons of many scientific and technical disciplines, both within and outside the nuclear energy community.

In 1955, at the request of the Commission, a committee of geologists and geophysicists was established by the National Academy of Sciences -- National Research Council (NAS-NRC) to consider the disposal of high-level radioactive wastes in geologic formations within the United States. This committee proposed storage in natural salt formations as the most promising method for the near future. This recommendation has been

endorsed by subsequent committees of the Academy after several reviews of on-going Commission-sponsored research and development programs.

The following comments by these Committees are noteworthy:

1957 - ". . . the most promising method of disposal of high-level waste at the present time seems to be in salt deposits."

1961 - ". . . that experience both in the field and in the laboratory on disposal of wastes in salt have been very productive, well-conceived; and that plans for the future are very promising."

1966 - "The Committee is favorably impressed with the whole solidification program, because it promises relief from the problems of storing and disposing of high-level liquid wastes at present sites where disposal into the ground anywhere near the fresh water aquifers would be intolerable. We are especially hopeful about the glass or ceramic products, because they may be safe from serious leaching, and thus, from release of hazardous radionuclides, for periods of many centuries. . . . The emplacement of such hazardous solids in salt vaults after a suitable cooling period would appear to be an obvious requirement."

These statements constitute a strong and continued endorsement of the basic principles of the Commission's waste management research and development programs. For these and other reasons, we believe that disposal in salt represents the best approach presently available for the long term handling of the radioactive wastes generated in the civilian nuclear power industry.

The recommendations of the Academy were based on a number of characteristics which make salt particularly attractive for this purpose. The following advantages were noted in the 1970 NAS Committee Report:

"1. A highly radioactive source separated from the environment by a thickness of good-quality bedded salt in an area of tectonic stability is effectively isolated from that environment for at least 1,000 years and probably for significantly longer.

"2. Bedded salt has a high compressive strength but flows plastically at relatively low temperatures and pressures. This will relieve stress concentrations produced by the mining operation or by the heat generated by the radioactive waste.

"3. Fractures that might develop in bedded salt are 'self-healing.' This is indicated in part by the absence of solution cavities in the rock salt that has been studied.

"4. The natural plasticity of the salt at the temperature imposed by the highly radioactive waste will effectively seal the remnants of the containers in cells of crystalline salt. Should man, for a now unforeseen reason, have to remove the buried radioactive waste, it could be accomplished with specialized mining equipment, albeit with considerable difficulty and effort.

"5. Bedded salt permits the dissipation of larger quantities of heat than is possible in other types of rock.

"6. Rock salt is approximately equal to concrete for gamma-ray shielding. Experimental radiation exposure has caused very little detectable radiolytic change in rock salt.

"7. The loss of our salt resources would be negligible. There is a great abundance of bedded salt in the United States (particularly in Kansas) that is of satisfactory quality and in suitable geological environments that can be used for the burial of specified radioactive wastes produced by the nuclear plants that are anticipated in the United States over the next two or three decades.

"8. The burial of the radioactive wastes under consideration in deep-bedded salt greatly reduces chances for release by accidental or malicious acts in both the near and distant future."

The 1970 Report of The National Academy of Sciences also noted that:

> "The Committee judges that a sound case has been made for burial of highly radioactive solidified wastes in bedded salt. Sites correctly chosen with respect to design criteria . . . . offer a satisfactory method for waste disposal in terms of present technology."
>
> "Presently accomplished research, development, and design . . . . are at such a state that the Committee can see no objection to proceeding with the plans for a demonstration facility for both types of wastes."

The Committee concluded that "The use of bedded salt for the disposal of radioactive wastes is satisfactory. In addition, it is the safest choice now available. . . ."

Project Salt Vault - An important factor in the Academy's recommendation was Project Salt Vault. This was a field-scale experiment carried out at an abandoned salt mine at Lyons, Kansas, to demonstrate the feasibility and safety of disposal-in-salt concept, to demonstrate the equipment and techniques for handling packages of highly radioactive solids, and to secure data for the design of an actual disposal facility. The experimental facilities at the mine (Fig. 1) consisted of five rooms (three 30 ft wide and two 40 ft wide) off a 30-ft-wide corridor, all newly excavated at a level about 15 ft above the existing mine. Two rooms contained arrays of seven holes, 5 ft apart and 12 ft deep. Fourteen irradiated fuel assemblies from the Engineering Test Reactor, two each in seven containers, were used to simulate actual solidified wastes. These were placed in one of the arrays, while electrical heat only was applied to the other as a control. In the other two rooms, electrical heaters were used to raise the temperature of a large quantity of salt in the central pillar in order to obtain information on its insitu deformational properties. The fifth room provided access to the lower end of a 20-in.-diam shaft from the surface.

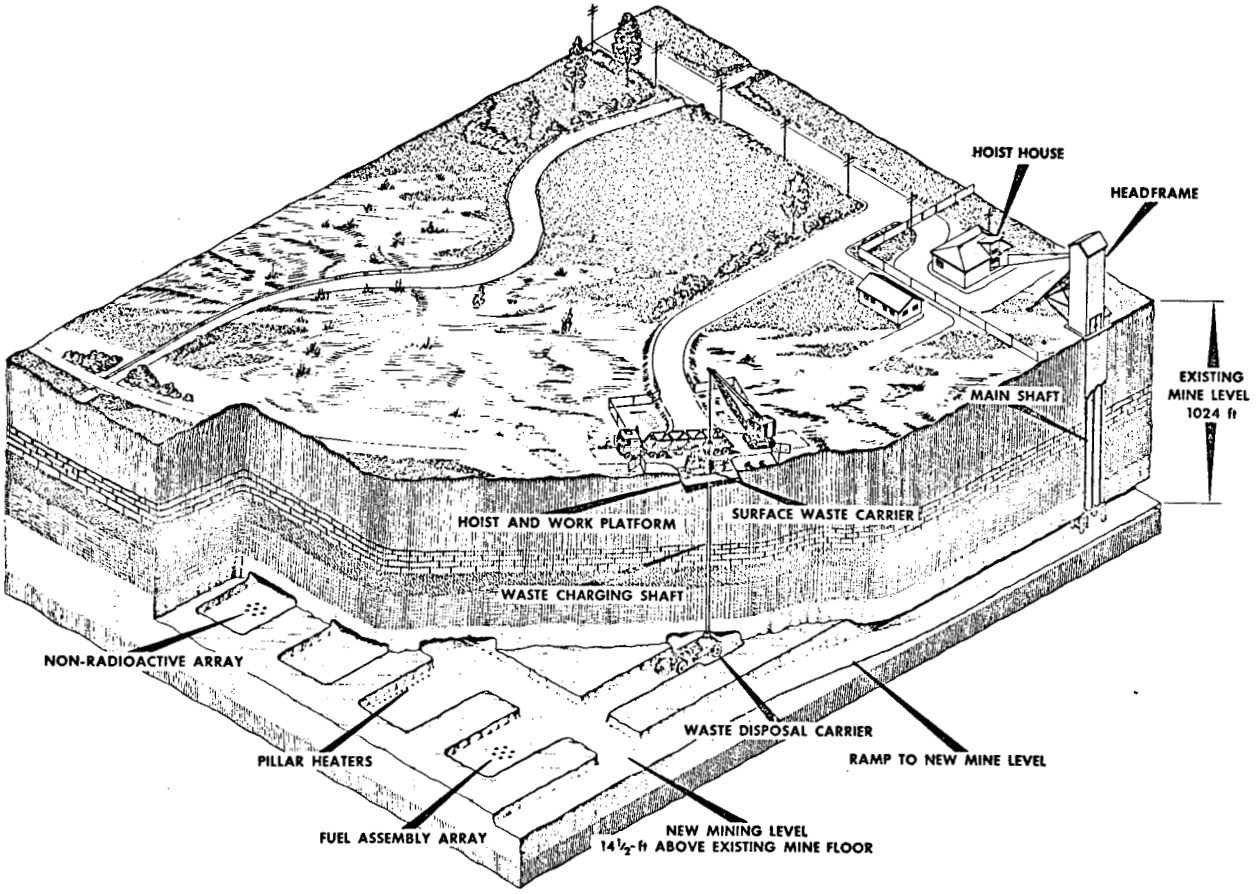
There were three basic steps in the operation of the experiment which ran from 1965 to 1967: (1) encapsulation of the fuel assemblies into canisters and loading of the canisters into the shipping cask, which was carried out in hot-cell facilities at NRTS; (2) shipment of the 30-ton cask and its forced-cooling equipment to the mine by truck; and (3) transfer of the containers into the mine. At the mine, the shipping cask was placed

over the small shaft and the canisters lowered one at a time into an underground transporter. This transporter then maneuvered over one of the specially lined storage holes and the canister lowered into it by remote control.

This experiment was very successful in all respects. A total of about 4 million curies of fission-product activity, in 21 containers, was handled both into and out of the mine without incident. The maximum personnel radiation exposure during any quarter was about 200 millirems to the head and hands. During the 19-month course of the experiment, the average dose delivered to the salt at the walls of the array holes was about 8×10^8 rads with a peak dose of 10^9 rads. In spite of these high doses, there were no measurable radiolytic or structural effects in the salt. In addition to the radiation, a considerable quantity of heat (both decay and electrical) was deposited in the salt. Around the arrays a circular ellipsoidal volume of salt of about 1400 ft^3 was heated to between 100°C and 200°C. Under the center (heated) pillar, a volume of salt of about 30,000 ft^3 was heated to temperatures greater than 60°C. These elevated temperatures produced a rapid acceleration in the rate of closure of the mine by modification of the plastic properties of the salt and also altered the pattern of deformations by the imposition of thermal stresses.

Bibliography - A bibliography of reports relating to the development of the salt mine project and related research and development reports is presented in Section X.

FIGURE 1



DEMONSTRATION OF RADIOACTIVE SOLIDS DISPOSAL IN SALT

III. WASTE CHARACTERISTICS

The wastes which the Commission proposes to bury vary widely in their physical, chemical and radiation characteristics depending on their origin and previous history of treatment.

High-Level Wastes - The source of virtually all the high-level wastes is the reprocessing plants that recover the uranium and plutonium from spent reactor fuels. As generated, these wastes are nitric acid solutions containing fission products and smaller quantities of uranium, plutonium, and other heavy elements, and they can be generally characterized by their very intense, penetrating radiation and their high heat-generation rates. The radiation characteristics of a typical waste and the identity of the significant radionuclides are presented in Tables 1, 2 and 3.

Four processes have been developed for converting these liquid wastes to solid forms which we believe can be shipped and stored safely in salt. Table 4 summarizes the characteristics of these solid products which average about 3 ft^3 in volume per ton of fuel processed. The solids can be described as calcine cake from the pot calcination process, glass from the phosphate glass process, sand-like granules from the fluidized-bed calciner and a ceramic from the spray calciner.

The acceptance criteria for the Repository specify (Appendix F, 10 CFR 50) that the dry, solid high-level waste shall be chemically, thermally and radiolytically stable, and shall be packaged in containers that will maintain their integrity for at least 90 days after receipt at the repository.

Alpha Wastes - Alpha wastes arise principally from the preparation of reactor fuels and from other AEC production operations. They consist of a wide assortment of solid materials contaminated with plutonium and other transuranium elements in amounts ranging from trace concentrations to several grams per cubic foot. Alpha wastes are packaged in tightly-sealed metal drums and crates, and since they are virtually free of penetrating radiation and evolve only a few hundredths of a watt per cubic foot, they may be handled by direct handling techniques.

Packages of alpha wastes that are known to contain liquids, potentially explosive chemicals, pyrophoric materials, oxidants (other than air), or sealed containers filled with gas under pressure will not be accepted at the Repository. Stringent administrative procedures will be implemented to assure that these criteria will be satisfied.

Table 1 Radioactivity and Thermal Power of Typical High-Level Waste as a Function of Time Since Processing[a,b]

Time Since Processing (years)	Radioactivity (Ci/metric ton of fuel charged to the reactor)			Thermal Power (W/metric ton of fuel charged to the reactor)		
	Fission Products	Actinides	Total	Fission Products	Actinides	Total
0	4,380,000	22,700	4,440,000	19,300	811	20,100
0.5	2,390,000	12,100	2,400,000	10,800	421	11,200
1	1,680,000	7170	1,690,000	7540	240	7780
2	1,000,000	3800	1,000,000	4400	117	4520
3	691,000	3010	694,000	2890	89	2980
4	533,000	2770	536,000	2110	81	2190
5	448,000	2640	451,000	1680	77	1760
7	365,000	2460	367,000	1260	72	1330
10	311,000	2210	313,000	1010	65	1080
11	300,000	2140	302,000	959	63	1020
12	289,000	2070	291,000	919	61	980
15	264,000	1870	266,000	828	55	883
17	250,000	1750	252,000	781	52	833
20	231,000	1590	233,000	720	47	767
25	204,000	1350	205,000	634	41	675
30	181,000	1160	182,000	560	35	595
35	160,000	1010	161,000	495	30	525
40	142,000	875	143,000	438	27	465
50	112,000	679	113,000	344	21	365
75	61,500	417	61,900	188	13	201
100	34,100	309	34,400	103	9	112

[a]The fuel from a light water reactor with an initial uranium enrichment of 3.3% is assumed to have been irradiated at an average specific power of 30 MW/metric ton to an exposure of 33,000 MWd/metric ton. The waste consists of all fission products plus the actinides remaining after removal of 99.5% of the uranium and plutonium following a postirradiation decay period of 150 days.

[b]A typical container of solidified waste having inside diameter of 6 in. and an active height of 8 ft contains waste from 0.476 metric ton of fuel charged to the reactor.

Table 2 Radioactivity and Mass of Radionuclides in Typical High-Level Waste as a Function of Time Since Processing[a,b]

Nuclide	Radioactivity (Ci/metric ton of fuel charged to the reactor) After: 1 year	3 years	5 years	10 years
^{239}Np	18	18	18	18
^{238}Pu	91	110	109	105
^{239}Pu	2	2	2	2
^{240}Pu	3	3	3	4
^{241}Pu	488	444	404	318
^{241}Am	154	155	156	157
^{243}Am	18	18	18	18
^{242}Cm	4160	189	12	3
^{244}Cm	2220	2060	1910	1580
^{90}Sr	74,700	71,100	67,700	59,900
^{90}Y	74,800	71,200	67,700	59,900
^{95}Zr	5610	2	0	0
^{95}Nb	11,900	5	0	0
^{99}Tc	14	14	14	14
^{106}Ru	205,000	51,600	13,000	413
^{106}Rh	205,000	51,600	13,000	413
^{125}Sb	6280	3760	2250	623
^{125m}Te	2590	1560	934	258
^{127m}Te	604	6	0	0
^{127}Te	597	6	0	0
^{134}Cs	153,000	77,600	39,400	7270
^{137}Cs	104,000	99,300	94,900	84,500
^{137m}Ba	97,300	92,900	88,700	79,000
^{144}Ce	316,000	53,100	8930	104
^{144}Pr	316,000	53,100	8930	104
^{147}Pm	76,000	44,800	26,400	7030
^{151}Sm	1140	1120	1100	1060
^{154}Eu	6550	6000	5510	4430
^{155}Eu	4350	2020	939	138
Total[c]	1,690,000	694,000	451,000	313,000
	Mass (g in waste per metric ton of fuel charged to the reactor)			
Fission products	28,900	28,900	28,900	28,900
U	4780	4780	4780	4780
Np	486	486	487	487
Pu	50	53	54	56
Am	140	140	140	141
Cm	29	26	24	20
Total[c]	40,500	40,500	40,500	40,500

[a] The fuel from a light water reactor with an initial uranium enrichment of 3.3% is assumed to have been irradiated at an average specific power of 30 MW/metric ton to an exposure of 33,000 MWd/metric ton. The waste consists of all fission products plus the actinides remaining after removal of 99.5% of the uranium and plutonium following a postirradiation decay period of 150 days.

[b] A typical container of solidified waste having inside diameter of 6 in. and active height of 8 ft contains waste from 0.476 metric ton of fuel charged to the reactor.

[c] Total includes all radionuclides.

Table 3 Photon and Neutron Source Strength of Typical High-Level Waste as a Function of Time Since Processing[a,b]

	Photons/sec or Neutrons/sec per Metric Ton of Fuel Charged to the Reactor			
	1 year	3 years	5 years	10 years
Photons				
0.30 MeV	3.55×10^{15}	9.06×10^{14}	3.65×10^{14}	1.87×10^{14}
0.63 MeV	2.20×10^{16}	1.16×10^{16}	7.20×10^{15}	3.59×10^{15}
1.10 MeV	1.50×10^{15}	5.56×10^{14}	2.87×10^{14}	1.45×10^{14}
1.55 MeV	4.87×10^{14}	1.91×10^{14}	8.71×10^{13}	2.04×10^{13}
1.99 MeV	1.95×10^{14}	3.81×10^{13}	7.76×10^{12}	2.00×10^{11}
2.38 MeV	5.49×10^{13}	1.38×10^{13}	3.46×10^{12}	1.10×10^{11}
2.75 MeV	1.78×10^{12}	4.48×10^{11}	1.13×10^{11}	3.57×10^{9}
3.25 MeV	3.23×10^{10}	8.12×10^{9}	2.04×10^{9}	6.49×10^{7}
Neutrons	3.98×10^{8}	3.35×10^{8}	3.12×10^{8}	2.58×10^{8}

[a]The fuel from a light water reactor with an initial uranium enrichment of 3.3% is assumed to have been irradiated at an average specific power of 30 MW/metric ton to an exposure of 33,000 MWd/metric ton. The waste consists of all fission products plus the actinides remaining after removal of 99.5% of the uranium and plutonium following a postirradiation decay period of 150 days.

[b]A typical container of solidified waste having inside diameter of 6 in. and active height of 8 ft contains waste from 0.476 metric ton of fuel charged to the reactor.

Table 4 Characteristics of Solidified High-Level Wastes

	Pot Calcine	Spray Melt	Phosphate Glass	Fluidized-Bed Calcine
Form	Calcine cake	Monolithic	Monolithic	Granular
Description	Scale	Microcrystalline[a]	Glass	Amorphous[b]
Chemical composition, mole %				
Fission product oxides	15 to ~ 80	5 to 30	5 to 25	5 to 50[c]
Inert metal oxides	10 to 50	40 to 50	10 to 30	10 to > 90
Sulfur oxides (if in waste)	0 to 40	0 to 40	0	0 to 40
Phosphorus oxides	~ 0	25 to 40	~ 60	~ 0
Bulk density, g/ml	1.1 to 1.5	2.7 to 3.3	2.7 to 3.0	1.0 to 1.7
Thermal conductivity, Btu hr^{-1} ft^{-1} $°F^{-1}$	0.15 to 0.25	0.4 to 1.0	0.4 to 1.0	0.10 to 0.25
Maximum allowable thermal power, W/liter of solid[d]	85	205	190	70
Leachability in cold water, g cm^{-2} day^{-1}	10^{-1} to 10^{-2}	10^{-3} to 10^{-6}	10^{-4} to 10^{-7}	10^{-1} to 10^{-2}
Hardness	Soft	Hard	Very hard	Moderate
Friability	Crumbly	Tough	Brittle	Moderate
Residual nitrate, wt % of product	≤ 0.05	≤ 0.005	≤ 0.005	≤ 4.0
Volume, liters/1000 MWd (thermal)	1 to 2.5	1.2 to 3	1.5 to 5	1.5 to 5
Maximum stable temperature, °C	~ 900	Phase separation at ~ 900	Devitrifies at ~ 500	~ 600
Container material	Stainless steel	Mild steel or stainless steel	Mild steel or stainless steel	Mild steel or stainless steel

[a]Glassy products can also be made with some difficulty.

[b]Microcrystalline products can also be made.

[c]Composition ranges for fluidized bed are also for Purex waste and are estimated.

[d]Approximate values for storage in air in 8-in.-diam cylindrical pots to maintain pot center-line temperatures at less than 900°C and pot wall temperatures at less than 425°C. Average k values were used.

IV. SITE SELECTION

In selection of a site for the initial demonstration waste repository, certain geologic criteria were established consistent with considerations of long-term isolation and efficiency of operations. These requirements should not necessarily be considered applicable to the siting of future repositories. As more information and experience are gained, some of these criteria may be relaxed and perhaps new ones added. The criteria are as follows:

1. The salt formation should be of the bedded type, approximately horizontal, and relatively undisturbed structurally.

2. The formation should have a considerable horizontal extent, amounting to at least several tens of miles to provide adequate isolation of the disposal area.

3. The formation should not be less than 500 ft. deep and not less than 200 ft. thick to provide for adequate heat dissipation as well as to provide a margin of isolation above and below the disposal plane.

4. The depth of the formation should not be greater than 2000 ft. because of both the increased cost and the increased difficulty of operating at greater depths.

5. The formation should not be associated with, or be in the immediate vicinity of, potentially valuable reserves of petroleum or other mineral resources.

6. The site should be situated in a zone of tectonic stability.

Salt deposits are quite extensive in the continental United States, underlying approximately 500,000 square miles in portions of 23 states (see Fig. 2). The application of these site criteria limited consideration to four areas. These areas were: (a) a 10,000-square-mile region of central Kansas; (b) a smaller (about 1000 square miles) area in west-central New York; (c) a similar area in southeastern Michigan, in general underlying metropolitan Detroit; and (d) a small area in northern Michigan. This last area was excluded from further consideration, because there have never been any salt mines in the area and (partially as a consequence of this) sufficient detailed geologic information for a rational analysis of the area was not available.

Based on available information, an evaluation of the geologic aspects of these sites indicates that, although the three sites might be suitable, the Kansas area is, on balance, the most favorable. The advantages that can be attributed to central Kansas are that the depth to the salt disposal horizon is generally less than the other sites; the thickness and areal extent of the deposit are greater; the area is in Seismic Risk Zone I (zone of minor expected earthquake damage); and, by virtue of having performed extensive experimental work there, information concerning the nature and properties of the salt in this area is presently available.

Additionally, the Lyons, Kansas, mine of the Carey Salt Company appears to make this site unique in that it is the only available, accessible, nonproducing mine in any of the three acceptable areas, thus making productive use of an abandoned facility and providing a means for reducing overall facility costs.

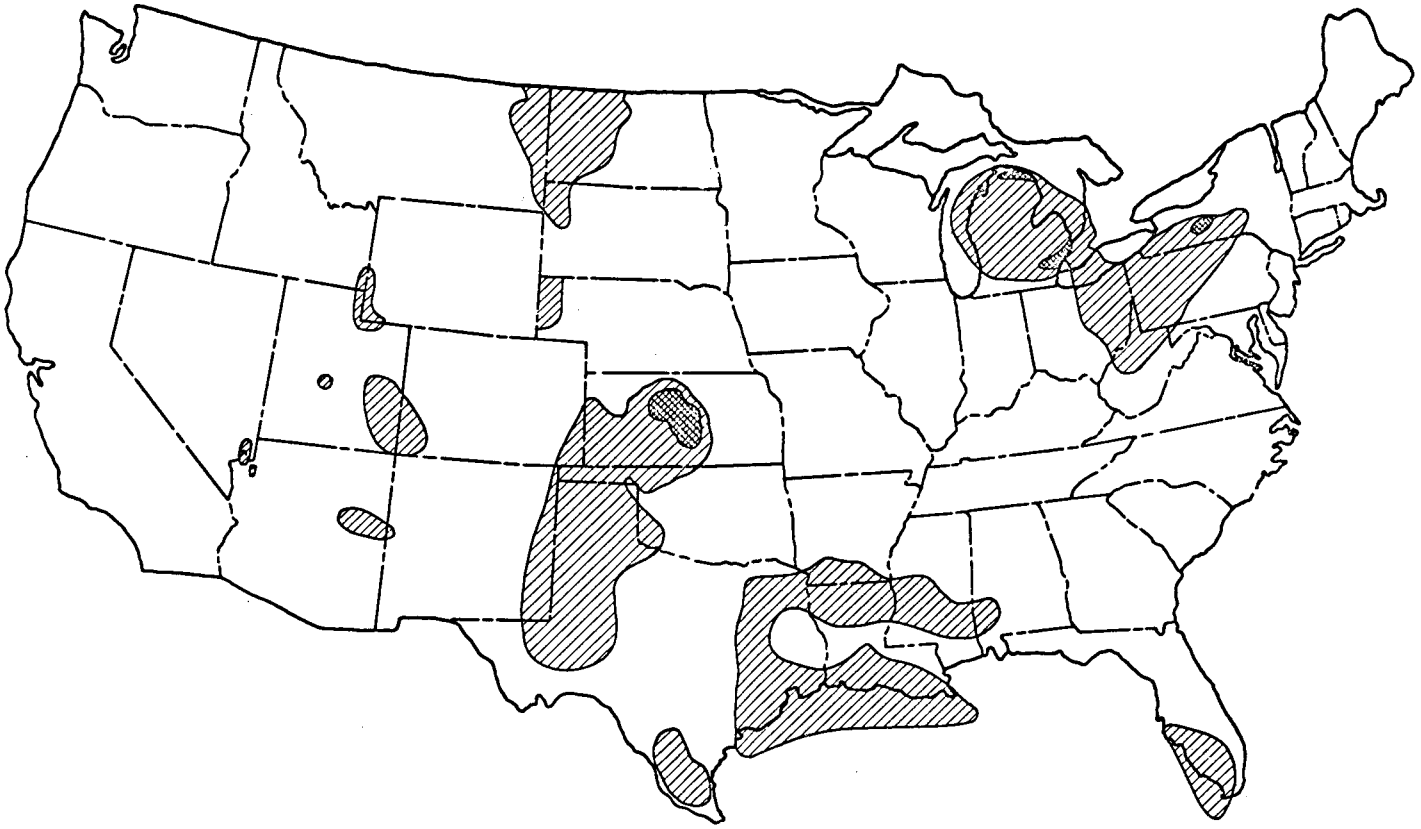
It is probable that other sites or other salt structures such as domes or anticlines may be acceptable for this purpose. However, in view of the magnitude and complexity of the studies necessary to confirm the hydrologic structural and tectonic stability of domes and anticlines and the increased cost of mining at greater depths it appears that the salt beds of the central Kansas area are most favorable at least for this initial repository.

Additionally, the Panel on Salt Disposal of the Committee on Radioactive Waste Management of the National Academy of Sciences in its 1970 report reviewed the selection of the Lyons site and concluded the Lyons site was satisfactory subject to additional confirmatory studies and data. The report also noted:

> ". . . the Lyons, Kansas, site offers a reasonable choice for such an initial demonstration project. Other sites such as those on the Gulf Coast, in Michigan, and in western New York should be considered for future use.
>
> "The Committee recommends that additional studies and investigations, . . ., be undertaken concurrently with planning and site acquisition. If these studies and investigations reveal problems or conditions that would jeopardize the safety and integrity of the storage site, the project should be reconsidered. However, based on research and development performed to date the Committee does not anticipate any insurmountable problem."

These investigations will be carried out as part of the site evaluation studies.

FIGURE 2



ROCK SALT DEPOSITS IN THE UNITED STATES (AFTER PIERCE AND RICH, U.S.G.S. BULL. 1148)

SALT DEPOSITS HAVING THICKNESS OF AT LEAST 200 ft AND LYING WITHIN 2000 ft OF LAND SURFACE.

SALT DEPOSITS IN THE UNITED STATES

V. ENVIRONMENTAL FACTORS AFFECTING LONG TERM SAFETY

In assessing the long term safety of storing radioactive wastes at the Lyons site there are several interrelated factors which require definition or resolution. These relate to (1) establishing the present and future adequacy of the geologic and hydrologic regime at the site for the long term containment of these wastes and (2) establishing that the introduction of waste into the salt bed will not adversely affect the existing natural environment with respect to the continued long term stability of the salt bed.

The following sections summarize the available data concerning the present adequacy of the site, the potential impact of the facility on the environment and the general scope of the on-going studies directed towards resolving the uncertainties associated with the safety of the proposed action.

General Location and Site Description - The proposed site is located in Rice County, Kansas, adjoining the City of Lyons on the northeast. According to preliminary results of the 1970 census, Lyons and Rice County have population of 4306 and 12,129, respectively. The nearest population centers are Hutchinson (about 36,000 persons), about 25 miles to the southeast; Salina (about 37,000 persons), and about 45 miles to the northeast; and Wichita (about 274,000 persons), about 65 miles to the southeast. Physiographically, the site is at the eastern edge of the Plains Border section of the Great Plains province, lying between the High Plains to the west and the Central Lowland to the east.

Oil and natural gas are the only natural resources within the general area of the site. Nearby pools and fields include the largely depleted Lyons oil and gas field to the south, the Lyons Townsite pool (consisting of one well, which is located on the proposed site), and the important Chase field lying about 6 miles to the west. Production is mainly from rocks of Pennsylvanian and Cambro-Odovician age. The area lies on the southwest flank of the central Kansas uplift which is the major structural feature controlling the occurrence of gas and oil in this part of Kansas. Recently, exploratory work was undertaken within the proposed site boundaries and confirmed that oil reserves below the site are quite small.

Salt has been produced commercially in this area since 1887. The American Salt Corporation has an operating mine about 3 miles south of the proposed site with underground workings that extend no closer than 1500 ft. from the nonproducing Carey Mine.

A. Suitability of Present Environment

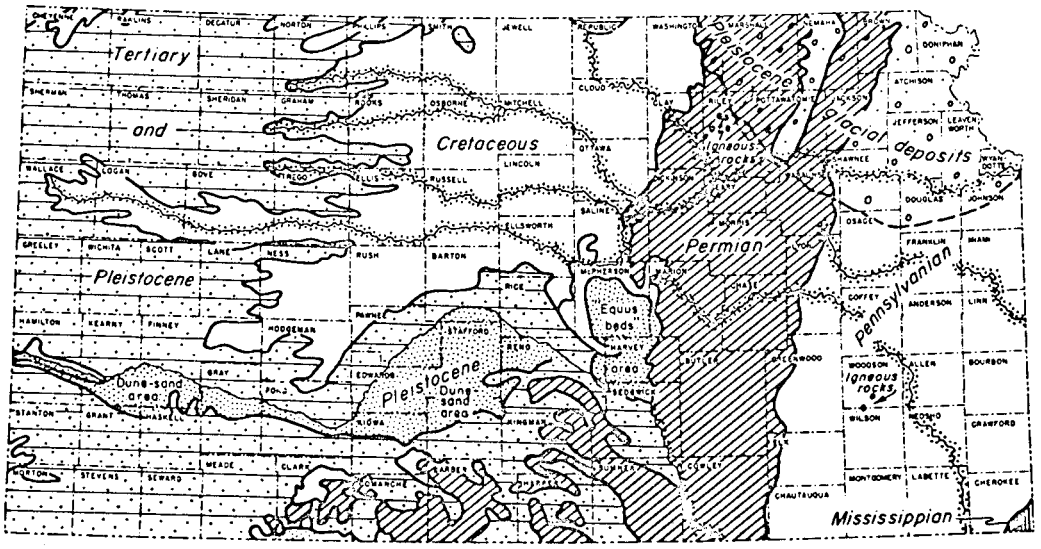
1. Geologic Description of the Site

Physiographically, the proposed repository site at Lyons, as well as a large part of Kansas, lies within the Great Plains Province of the United States. This broad belt of highlands, which extends from Canada to Mexico, slopes gradually eastward from the Rocky Mountains to the Central Lowland. Within the state a relatively thin and single succession of sedimentary rocks cover the greater than 600 million-year-old (Precambrian) basement complex. In

general, the sedimentary rocks, which range in age from about 600 million years (Cambrian) to about 1 million years (Quaternary), all dip gently toward the west (Fig. 3). This slight westward dip of the rocks, coupled with the gradual change in elevation from east to west, has resulted in the general succession of the surface outcropping of the oldest rock in the east to progressively younger ones in the western part of the state. Even though Kansas and the stable interior of the continent have not been subjected to diastrophic movements for the last 600 million years (since Precambrian time), some areas have been structurally positive (rising) in the geologic past, while others have been structurally negative (subsiding). The Lyons site is situated on the eastern flank of one of these ancient structural features, known as the Central Kansas Uplift. This major subsurface feature is presently inactive, and there is good evidence to indicate that it has remained inactive for the past 200 million years.

a. Stratigraphy

The rocks at the site are all of sedimentary origin and, for the most part, are flat lying. In general the stratigraphic sequence begins at the surface with about 50 ft of unconsolidated silty terrace deposits that are principally about 10,000 to 1,000,000 years old (Pleistocene) (Fig. 3). Cretaceous age shales that contain interbedded sandstones about 60 to 135 million years old comprise the section from about 50 to 120 ft below the surface, while Permian age rocks (230 to 280 million



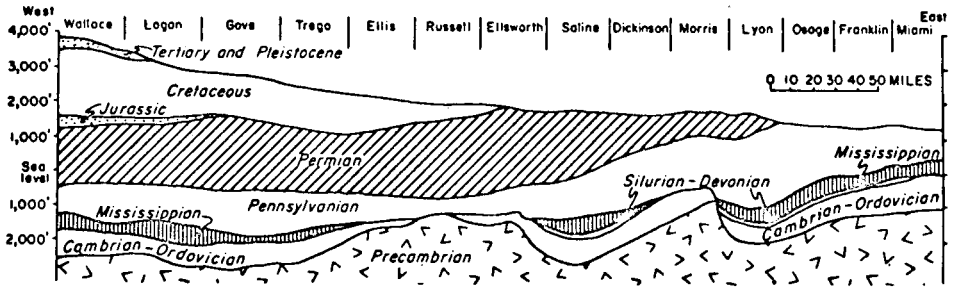


Fig. 3 Generalized Geologic Map and Cross Section of Kansas Rock (after State Geological Survey of Kansas Special Distribution Publication 5, Lawrence, Kansas, December 1963).

years old) lie unconformably beneath the Cretaceous sediments. For our purposes the most important aspect of these rocks is the presence of a thick accumulation of rock salt. The salt beds are nearly 300 ft in thickness, extending from a depth of about 800 to 1100 ft in the Lyons-Hutchinson area, and are capped with several hundred feet of red-colored shale and siltstones. Thick beds of anhydrite (i.e., gypsum - the basic ingredient of plaster of paris) lie below the salt, while the remainder of the Permian rocks consists mostly of alternating layers of shale and limestone. Pennsylvanian rocks (280 to 310 million years old) lie unconfirmably beneath the Permian formations and extend to a depth of about 3200 ft. This thick sequence of mostly alternating beds of shale and limestone with a few sandy members contains many oil and gas horizons, especially below about 2700 ft. Mississippian and Devonian rocks (greater than 310 million years old) are represented in the columnar section only by a relatively thin section of shale. Silurian and Devonian rocks are absent in the columnar section beneath the repository. Ordovician age rocks (425 to 500 million years old) at the site are predominantly shale and limestone. The "Arbuckle" group of rocks lies unconformably between the overlying Ordovician rocks and the Precambrian basement. This thick sequence of predominantly dolomitic rocks contains important oil and gas reservoirs in the general vicinity of Lyons as well as throughout central Kansas (Fig. 4).

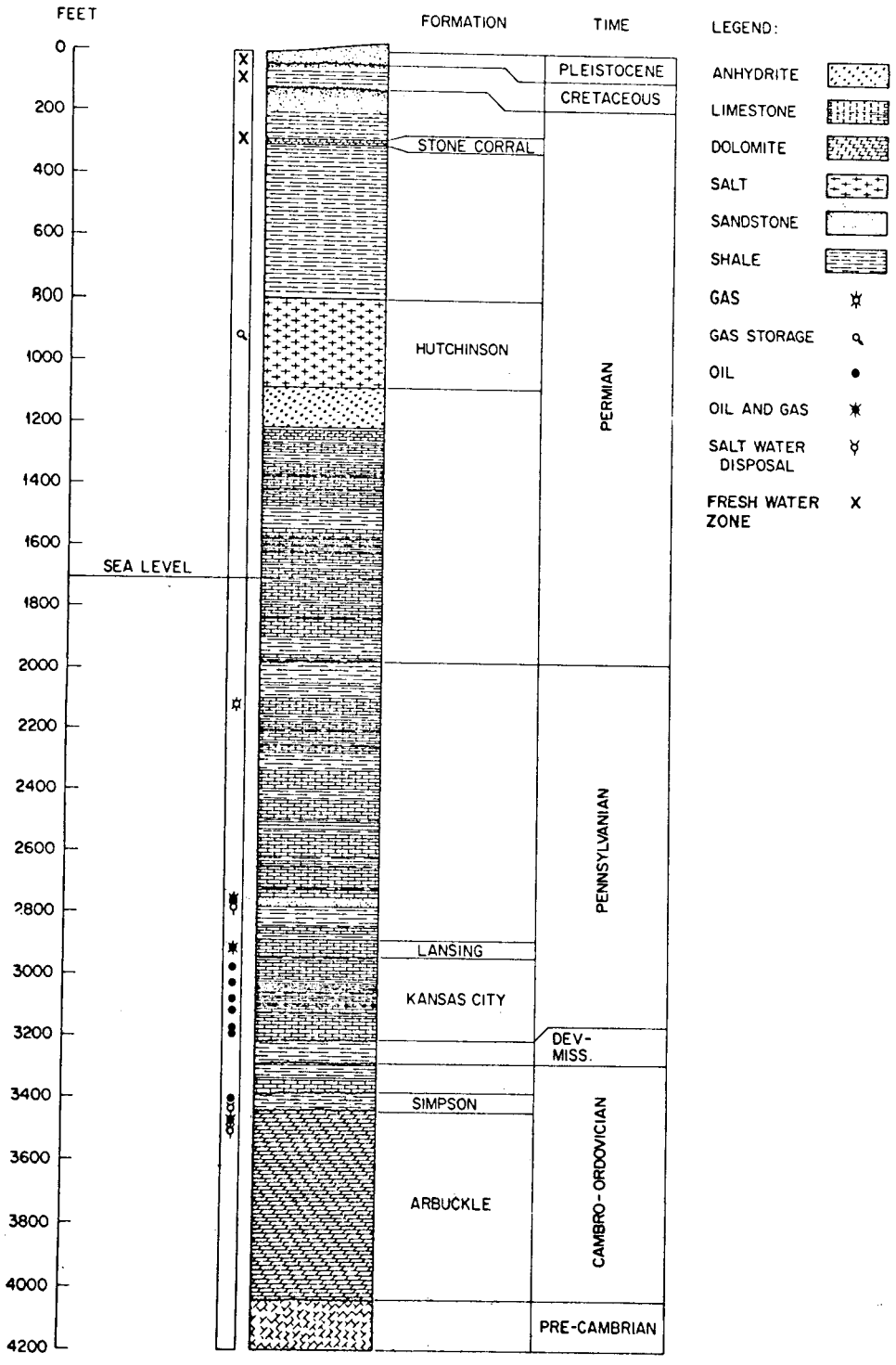


Fig. 4 Generalized Geologic Section, Rice County, Kansas (after Type Log for Rice County, Catalog No. 20-19-8w, Published by Kansas Geological Society).

b. Structure and Tectonics

The rocks beneath the proposed repository site have been subjected to a long and complex history of deformation with the older formations showing, as would be expected, a more complicated regime than successively younger beds. Locally, movements along the Central Kansas Uplift have been instrumental in fabricating the existing structure, while the inclinations of the rocks at the site have also been affected by broad regional warping of the earth's crust. The repository site lies on the eastern flank of the Central Kansas Uplift which extends beneath a large part of that part of the state.

Figure 5 is a map of Kansas that shows the location of historic earthquakes and their relationship to the major structural features in Kansas. The almost complete absence of recorded earthquakes along the Central Kansas Uplift would suggest that this structure had its major development at the end of Mississippian time some 300 million years ago and is now inactive. The earthquakes that have occurred in the central Kansas area range up to a Modified-Mercalli Intensity Scale rating of VI (damage small). These shocks, as well as others in Kansas, have occurred at rather shallow depth (16 to 38 miles) and probably represent minor adjustments in the underlying granitic crustal rocks. Epicentral locations of many of the earthquakes, including the two most damaging, were centered along the Nemaha anticline in eastern Kansas about 100 miles from the Lyons site. Based on the recent seismic history of all of the other structures in

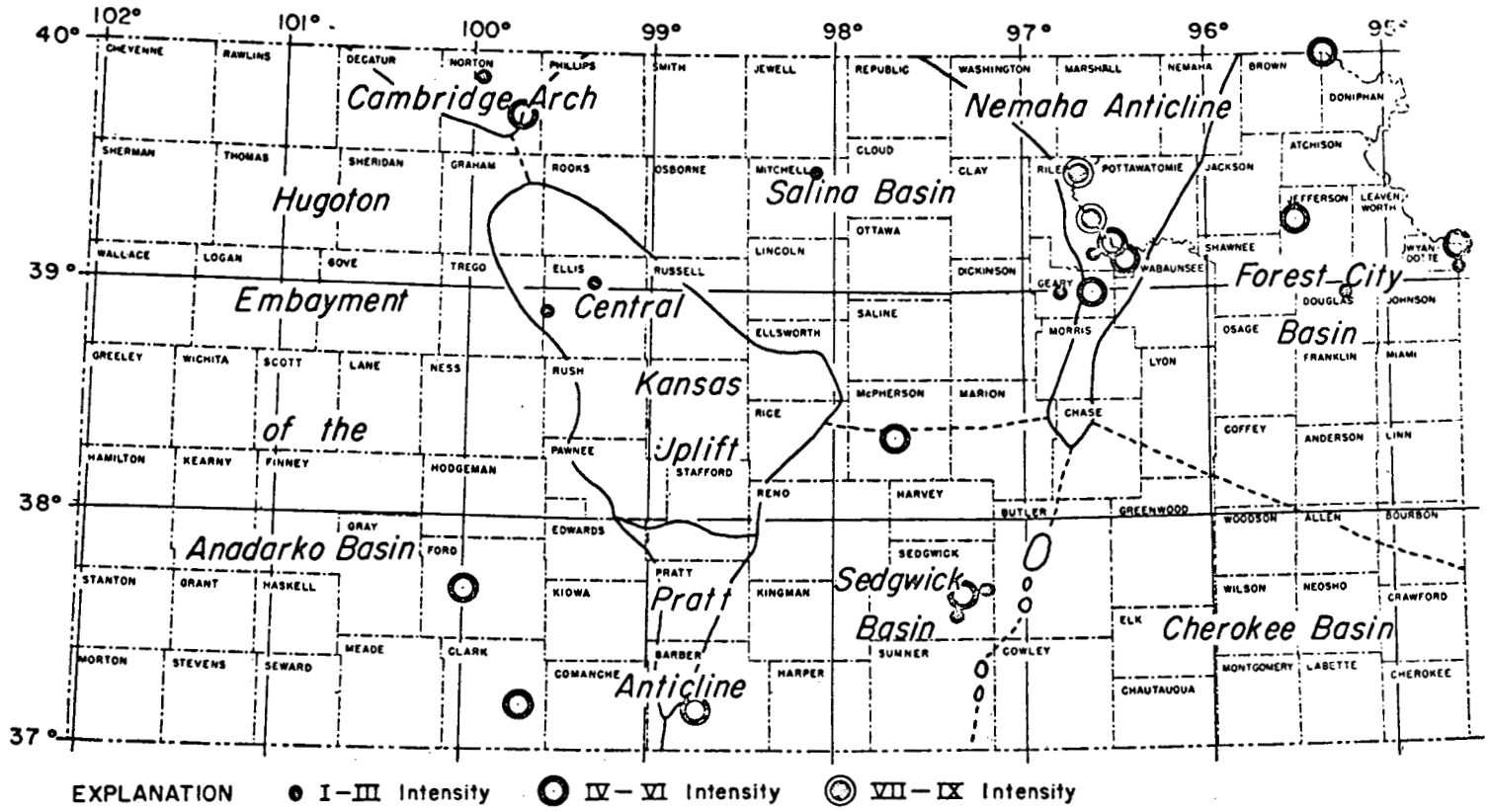


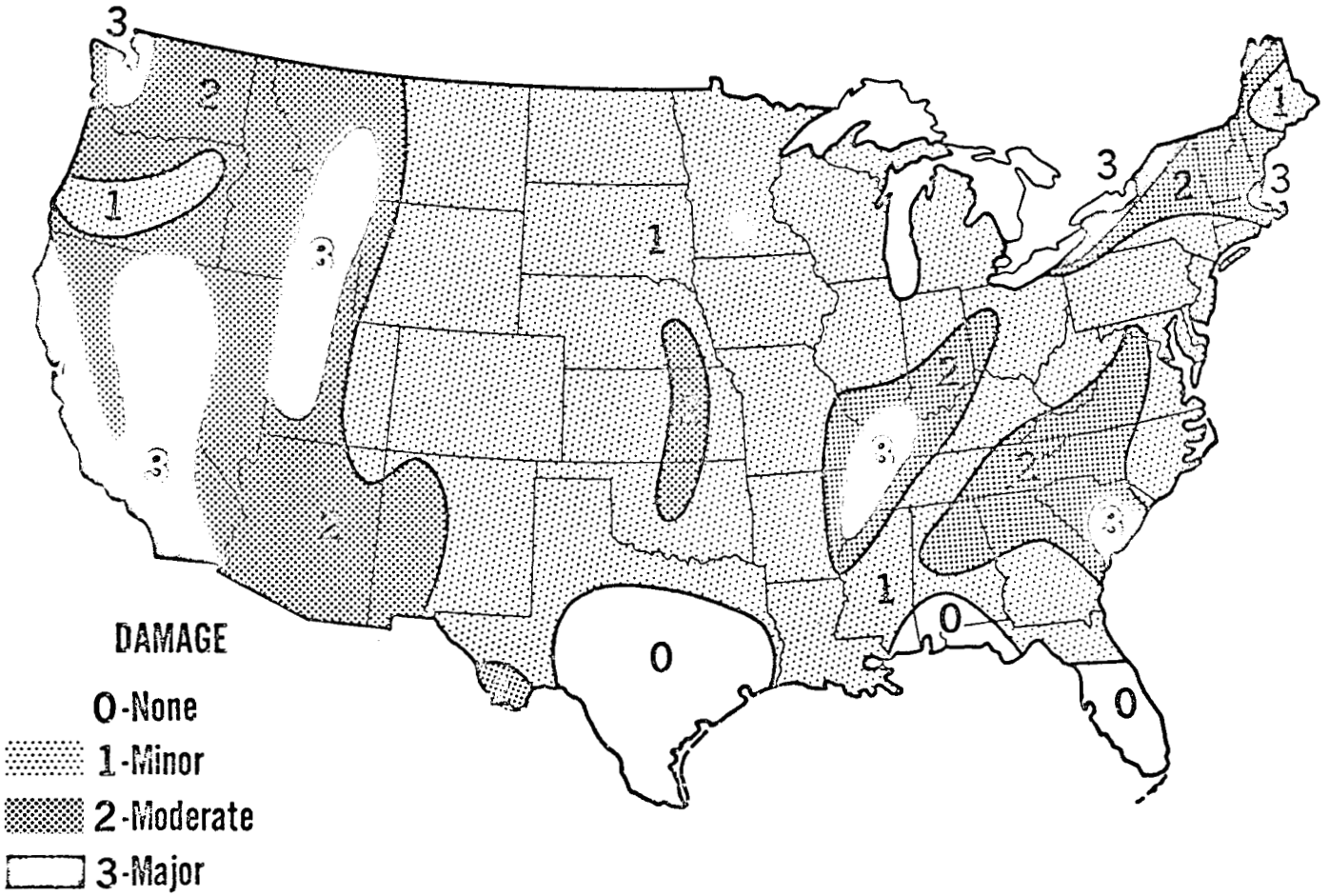
Fig. 5 Map of Kansas Showing Major Structural Features and Location of Earthquake Epicenters (after Merriam, D. F., 1956, History of Earthquakes in Kansas: Seismological Society of America Bulletin, Vol. 46, No. 2, pages 87-96).

Kansas, it is most likely that they are tectonically inactive. The site lies within Seismic Zone I (expected minor damage) according to the most recent seismic risk map published by ESSA and the Coast and Geodetic Survey (Fig. 6).

c. Rock Salt Deposits

The rock salt column beneath the proposed repository consists generally of a succession of layers of rock salt, intercalated with shales and occasionally anhydrite beds. The principal salt zones can be traced laterally from the northeast corner to the southwest corner of the site, although some irregularities in thickness and in lithology occur. In general, lateral consistency in the column is greatest in the lower to middle part of the column and least at the extreme bottom and upper parts of the formations. The thickest and most persistent salt zone lies at a depth of about 1000 ft. below the surface. A 9-ft.-thick bed in the lower part of the zone comprises the mined unit at the Carey Salt Company's workings at the site. The bed of salt is unquestionably the most uniform and the best quality of the entire sequence and is therefore the desired host bed for the waste. The proposed mined area will lie at a level of about 20 ft. above the existing mine floor in the old workings and extend upward a distance of about 15 ft. The floor of the newly mined area will be rock salt, while a thin shale parting will mark the roof. The salt in the proposed excavation area contains

Fig. 6 Seismic Risk Map of the United States



numerous blebs of polyhalite that are commonly concentrated along bedding and give the salt a banded appearance. Due to the structural attitude of the rocks at the site, a constant rise in the mining level will be experienced from the southwest corner of the site to the southeast corner, while there will be essentially no change in the mining level along the western boundary of the site. From the southwest corner to the northeast, the mining level will rise constantly to the apex of a northwestwardly plunging anticlinal fold and then show a gradual decrease.

d. Site Studies

Preliminary site studies of subsurface geology reveal no structural or stratigraphic conditions which would suggest the site is unsatisfactory for this purpose. These studies will be continued as part of the Site Evaluation Program.

2. Hydrologic Description of the Site

Surface water from the area of the site is drained by Owl Creek and an unnamed tributary of Cow Creek (Fig. 7). An 18-year record of the flow in Cow Creek near Lyons indicates an average flow rate of 69 cfs and a maximum of 12,000 cfs; extended periods of no flow were observed in 1938 and 1946. A 6-year record at Hutchinson and a 31-year record at Wichita, indicate that the Arkansas River has experienced average, maximum, and minimum flow rates of about 1,000, 3,000 and 3 cfs, respectively.

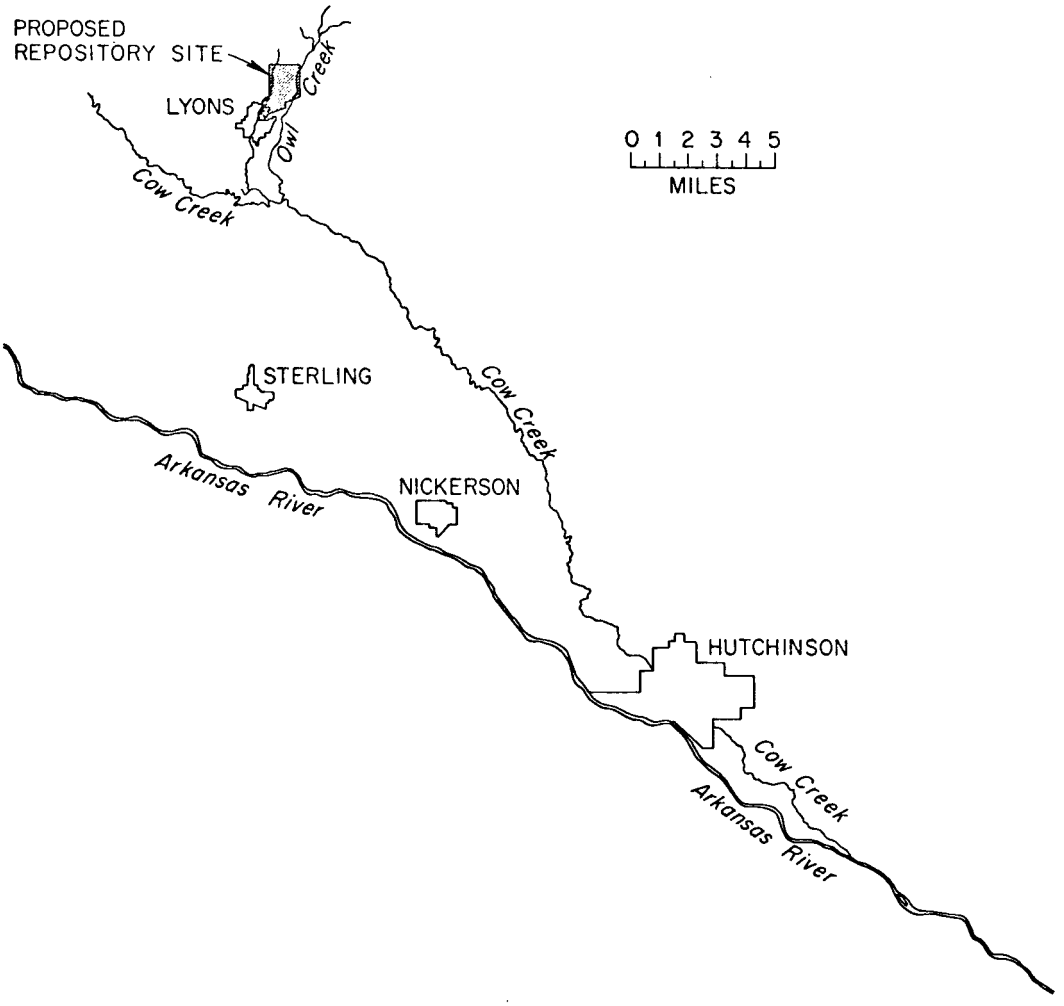
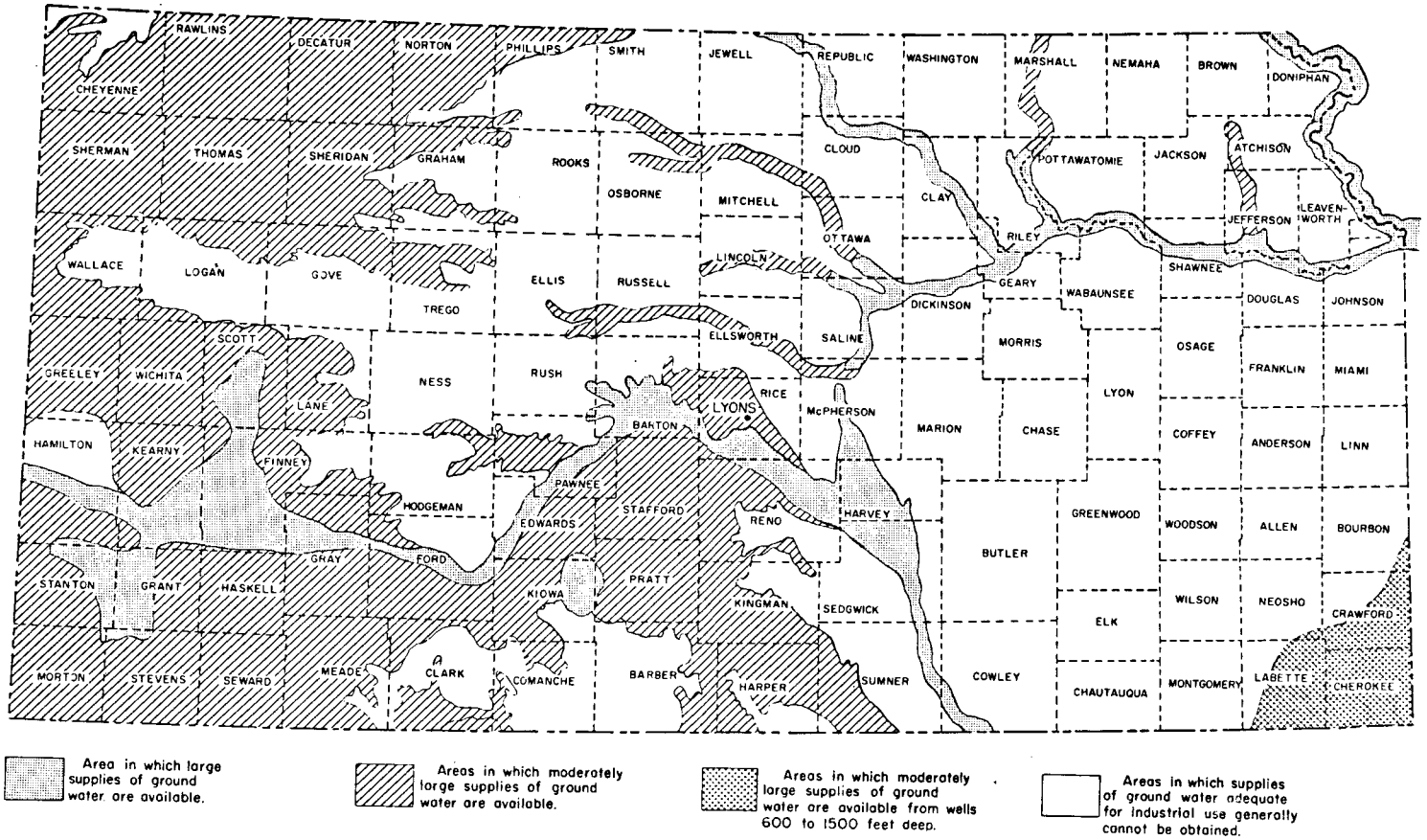


Fig. 7 Surface Drainage at Proposed Waste Repository.

In the general region of the repository, the thick deposits of gravel and coarse sand that fill the large stream valleys are the source beds for the principal supplies of groundwater (Fig. 8). Perhaps the most important source bed is found in the Great Bend region of the Arkansas River Valley which lies a few miles to the south of the site. This region is underlain mostly by sand and gravel deposits of Tertiary and Quaternary age that may be as much as 300 ft. thick. Overlying sand dunes provide an excellent surface for recharge. Depth to groundwater within the area is generally less than 100 ft. Supplies in excess of 1,000,000 gallons per day from these deposits are commonly developed.

At the site, rocks about 1700 feet below the salt bed contain numerous porous beds that contain salt water and perhaps some oil and/or gas. Fresh water is confined essentially to the uppermost 300 ft. of the rock column. The Stone Corral, which lies between about 270 ft. and 285 ft., is the deepest known fresh water aquifer at the site. It may yield water at the rate of about 1 to 3 gal. per min. The Cretaceous age sandstones (45 ft. to 120 ft. below the surface) are capable of yielding water at the rate of about 20 gal. per min. while the overlying unconsolidated silts (0 to 45 ft. below the surface) may yield water at the rate of about 5 gal. per min. The average depth to groundwater in the blanket of terrace deposits at the site is about 25 ft.

Figure 8 Map of Kansas showing by patterns the areas in which may be obtained supplies of ground water adequate for national defense industries (after Lohmen, S. W., et al., Ground-Water Supplies in Kansas Available for National Defense Industries, State Geological Survey of Kansas Bulletin 41).



Within the immediate vicinity of the site there are several wells extending to the Cretaceous age sandstones from which water is drawn for domestic or stock uses. The yields from these wells or from deeper wells would be insufficient for industrial, irrigation, or public water supplies.

The city of Lyons obtains its water supply from several wells in alluvial deposits located about 2 1/2 miles south of the proposed site. The towns of Sterling (about 10 miles south of the site) and Chase (about 10 miles west of the site) also obtain public water supplies from alluvial deposits in the Arkansas River Valley.

Studies of surface hydrology are presently underway to confirm isolation of the salt bed from overlying aquifers.

3. Climatology and Meteorology

Although only incomplete data are available for Rice County, the climate in Lyons can be inferred from nearby station climatological summaries. Analysis of variance of temperature, precipitation and wind from 12 stations in central Kansas showed no significant difference at the 95% confidence level.

A moderately wide range in temperature occurs with the mean annual temperature being about 56°F. The average maximum temperature in July and August is in the 90°-95°F range. The average minimum in January is about 20°F. The maximum high may reach 120°F, however, and the low near -30°F.

The annual average precipitation is about 24 inches, but the lowest may be near 15 inches and the highest near 45 inches per year. Thunderstorms occur on 50-60 days per year. Over half the rainfall events produce 0.75 inches of rain, and from 5 to 10 inches may occur, usually during September. These latter events can cause severe local flooding. Snowfall may be as low as 1 inch per year to a high of nearly 60 inches per year. A one-day snowfall of 20 inches or more with attendant transportation problems is possible.

Lyons lies somewhat west of the area of maximum tornado activity, but tornadoes are not uncommon. Based on 34 years of observation in Kansas and preliminary calculations, the probability of a tornado occurring in a 1-square-mile area was calculated as 1.6 to 3% in a 30-year period.

Winds throughout the area are typical of the Great Plains in general. Seldom calm (less than 5%), over half the recorded wind speeds are greater than 10 knots. The winds blow from the north-northeast through north-northwest about 20% of the time with average speeds of greater than 10 knots. Winds from the south-southeast through south-southwest occur more than 35% of the time with average speeds greater than 12 knots. Sandstorms are not uncommon in the area.

4. Ecology

The proposed site is presently devoted principally to agriculture (pasture and the growing of wheat and sorghum). About 100 head of cattle and 50 head of hogs are bed fed on the area.

The area was originally native prairie and its associated fauna, consisting primarily of bison, antelope, prairie dogs, foxes, coyotes, and quail as obvious elements. The imposition of an agricultural economy on the tract and elsewhere eliminated the large native grazing mammals. Small rodents, reptiles, quail, and rabbits are able to maintain their populations and mourning dove populations have probably increased. Ringnecked pheasants were introduced as a game bird and furnish excellent hunting.

5. Long Term Geological and Hydrological Considerations

a. Erosion

Since a portion of the radioactive wastes to be stored at the proposed repository will remain active for periods of hundreds of thousands of years, estimates are being made of the expected erosion by stream action and glaciation at the site and its effect on the stability of the underlying salt formation for long periods of geologic time. The present rate of erosion for the Arkansas River basin, which includes the Lyons site, has been determined to be about 1.4 in./1000 years. This value, which is a measure only of the uniform lowering of the land surface of the entire basin, suggests that perhaps a hundred feet or so of rock cover would be removed from the formations at the site during the effective lifetime of the waste. Another estimate of the expected erosion can be made from measured stream incisions in the bedrock in

the vicinity of the site during the Pleistocene epoch or the last 1 million years of geologic time. With a recorded channel incision depth of 200 ft. and a projected incision having a similar depth during the next 1 million years of geologic time, it can be concluded that a 200-ft-deep channel could be cut into the present unincised bedrock at the site and/or an additional 200 ft. deepening of the present gravel filled channels in the immediate vicinity of the site could occur. In either case the salt formation would not be breached as it lies some 800 ft. below the present land surface.

To determine more precisely the nature and extent of erosion in the area of central Kansas during the next 1 million years, a study has been initiated whereby estimates of future erosion will be obtained by statistical treatment and extrapolation of modern rates of erosion in several climatic zones that would be representative of the kinds of climate that have existed in the midcontinent during the last million years and would be expected to prevail during the next equivalent period.

In order to further validate these studies, an investigation will be undertaken of the possibility of drastic changes in the drainage pattern of the area, including the Arkansas River, and their consequent effect on the predicted erosion rates at the site.

b. Boundary Solutioning of Salt Formation

Along most of its eastern boundary (about 25 miles east of Lyons), the salt deposit ends abruptly and a series of subsidence ponds and salt water springs overlie the present stratigraphic position of the salt member, which suggests that its original limits extended somewhat farther east. In northwest Saline County, precise dating of subsidence features obtained from river channel migration studies indicates that the salt front has retreated a distance of 5 miles or less in the last 1 million years (or thoughout the Pleistocene), while in McPherson and Harvey Counties, westward migration of the salt has been 13 and 12 miles, respectively, from Delmore (pliocene) to Kansas (a time span of about 5 million years). The natural leaching of the salt body by circulating groundwater depends on the development of secondary permeability in the overlying shales which, in turn, is brought about by erosion when the protective Cretaceous shales and clays are removed. In areas where the overlying shale section is complete, which includes the Lyons site and essentially all of the central Kansas salt area west of the eastern boundary of Rice County, it may be considered to be protected for geologic time periods of at least 1 million years or for about the time span of the Pleistocene.

Additional work using different techniques of dating the westward migration of the salt boundary and an evaluation of the possibility of drastically altered solutioning rates due to man's activities will be undertaken.

c. Penetration Solutioning of Salt Formation

In the central Kansas area, a large number of wells have been drilled through the salt formation in search of oil and gas. Some of these wells date from the last century. In four known cases, a situation has developed where fresh water from near surface aquifers has drained into one of these wells, circulated through a break in the well casing at or near the depth of the salt bed, then discharged down the well into a lower formation, probably the Arbuckle. This circulating water dissolves the salt around the well, eventually causing the collapse of the overlying beds and the development of a "sink" on the surface. These four known cases of penetration solutioning have in common: (1) a shallow aquifer yielding water at the rate of several hundred gallons per minute; (2) an oil well having a history which suggests the possibility of a casing break in the salt zone; and (3) a highly permeable deeper zone having a low hydrostatic head. Three of these four wells had been used as salt-water disposal wells following their productive life.

A number of steps will be taken to preclude the possibility of solutioning by this mechanism at the site: a survey at and around the site will be made. Studies are presently underway to define and determine further the geohydrologic character of

the rocks, and the quantity, direction and rates of groundwater flows in the area, effect of future water usage, thereby assuring the present hydrologic suitability of the site.

B. Potential Impact on Existing Environment

1. Thermal effects

The major perturbation of the environment will result from the introduction of heat into the formation. The total decay heat generation per unit area in the mine will be adjusted such that the bulk temperature of the salt will not exceed 392°F. This temperature has been selected as the maximum desirable based on an assessment of the following considerations: (1) temperature and thermal stress transfer effects on stability of localized areas of the mine and overlying strata; (2) temperature rise in fresh water aquifers; (3) temperatures beyond the boundary of the mine; and (4) observed shattering of unrestrained salt in laboratory experiments above approximately 482°F. This temperature restriction of 392°F is not considered an upper limit. Operating experience may indicate that higher salt temperatures are allowable and, thus, provide a possible avenue for improving the economy of operation.

a. Heat Transfer and Response

Figure 9 presents estimates of the transient temperatures as a function of the distance above and below the disposal plane resulting from planned operation of the high-level facility. Temperature contours above the alpha mine will have shapes similar to those presented in Figure 9, except that the maximum temperatures will be lower and will occur

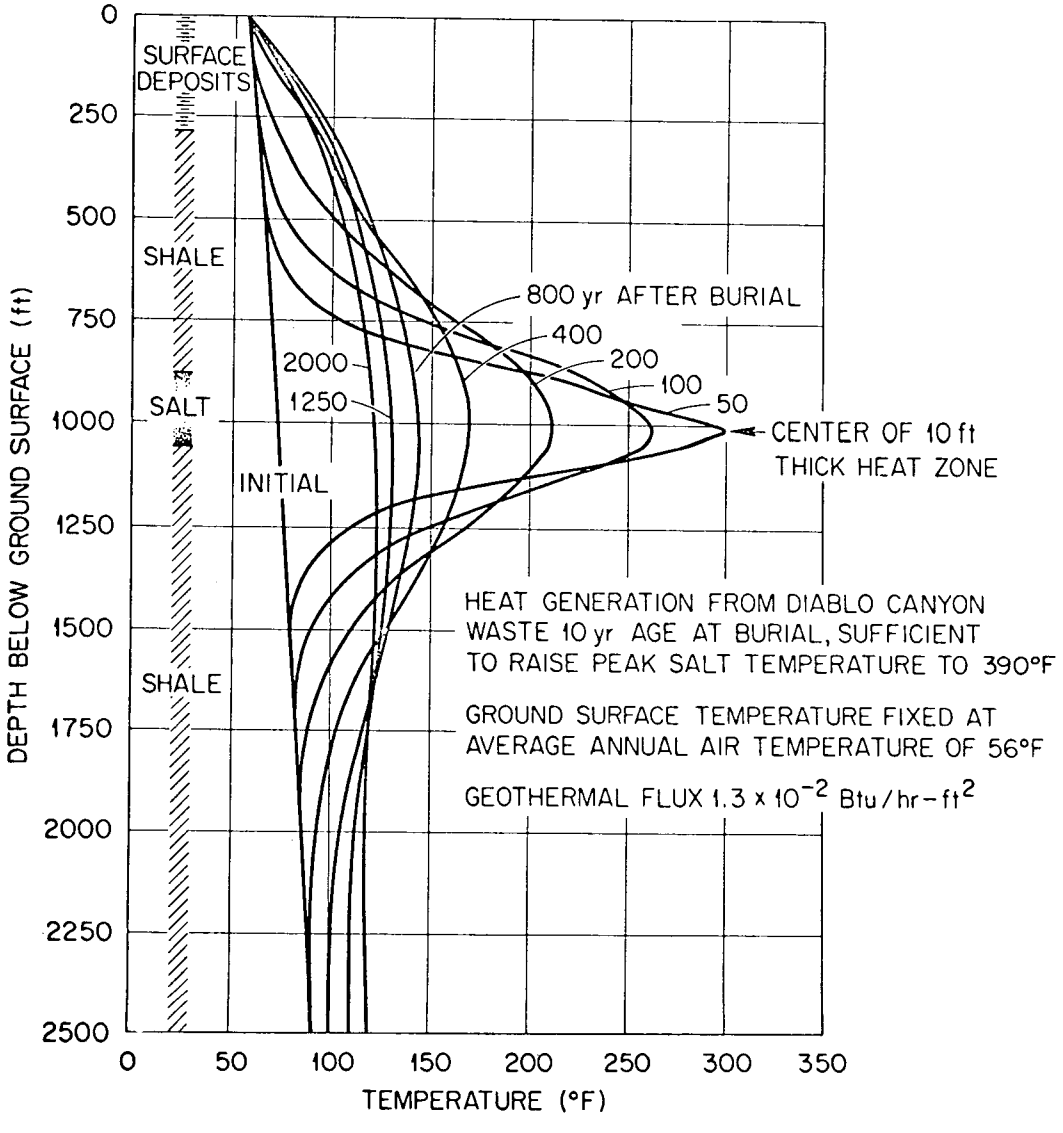


Fig. 9 Estimated Temperature Distributions in the Demonstrational Salt Repository.

after 10,000 years instead of 800 years. These temperature projections have been based on a two dimensional heat flow model using literature values of thermal properties of the major geologic units present at the site due to lack of actual stratigraphic and thermal property data.

A more sophisticated, three dimensional model has been developed and is being employed to refine these estimates using thermal property data obtained from core borings from the site. Preliminary runs using the three dimensional code do not suggest that the referred calculations will be significantly different from previous estimates.

When these data have been obtained and the results of the additional studies are completed, refined estimates will be made on temperature distributions, subsidence, thermal expansion and other related effects. These estimates will be confirmed by actual measurements during the demonstrational phase of facility operations. If the data developed suggests that rock temperatures anywhere in the formation will be such as to pose a threat to the containment of the waste within the salt formation, the maximum allowable heat generation rate at the mine level can be adjusted to an acceptable value. A similar adjustment can be made if calculated temperature rises in overlying aquifers or in strata beyond the site boundaries are deemed excessive.

The following sections will summarize the estimated temperature rise of the surrounding geologic formations, recognizing that these estimates will be refined as additional data are obtained.

b. Aquifer Temperature Rise

The heat front will reach the Stone Corral formation (depth, about 285 ft) after about 100 years, and the temperature rise of water in this formation will reach a maximum of about 32°F after 800 years (pessimistically assuming no flow in the aquifer). Portions of aquifers (also assumed to be stagnant) at depths near 100 ft. would experience temperature rises of about 14°F at about the same time. These temperature rises are not permanent and after reaching these values would begin to fall off.

c. Surface Temperature Rise

The peak heat flux at the ground surface will be no more than six or seven times the natural geothermal flux. This may be compared to the average annual solar flux reaching the ground which is about 10,000 times greater than the geothermal flux. The maximum increase in surface temperature is estimated to be less than 0.1°F. The radioactive decay heat should not, therefore, have any perceptible effect on surface temperature, climate, meteorology, or ecology.

d. Geophysical Impact

In the high-level waste disposal area, the sizes of the disposal rooms and the support pillars between them will be

designed in such a way that, in time, the underground openings are expected to completely close, causing a consolidation and recrystallization of the crushed salt used to backfill the rooms. The pillar deformation necessary to effect this closure results from the overburden load and should occur much more rapidly (65 to 100 years) than is ordinarily the case in other mines because of the elevated temperatures. In the immediate vicinity of the mined rooms, out to a distance of perhaps 10 to 20 feet from the walls and ceiling, fracturing, bed separation, localized crushing, and other extreme effects, will occur. At distances greater than about 20 feet, plastic deformation of the salt is expected to accommodate imposed motions without any of these effects. As the mine closes, resulting in a net decrease in the volume of the geologic system, the rocks will also become heated from the radioactive decay with the resulting thermal expansion representing a net increase in the total volume. Preliminary calculations of the rates of these two processes indicate that they almost exactly cancel each other at all locations in the system, including the surface, except, of course, in and immediately around the openings. This means that the overlying protective rocks (and the surface) should be subjected to only very small deformations and motions for approximately the first 200 years following waste burial.

These deformations and motions should be only slightly greater than those resulting from normal salt mining operations. Beginning about 200 years after waste burial, the heat loss at the surface exceeds the heat input from the waste, and the rocks should begin to contract; that is, begin a recovery of the previous thermal expansion. This process is expected to be very slow, requiring several thousand years to complete, and should eventually result in the development of a very broad, flat, and shallow (about 3-1/2 ft.) subsidence basin over the area. The rate of development of this basin will be so slow and gradual that the shale rocks overlying the salt formation should be able to accommodate this deformation without fracturing or other adverse effect. Likewise, the surface and shallow aquifers should easily adjust to these motions which are only slightly greater than the current rate of surface erosion in the area. It should also be pointed out that the rate of this subsidence over the waste-disposal area will be approximately the same as the rate of subsidence over an equally sized producing salt mine and furthermore, the total amount of subsidence will be approximately half that expected in operating mines because of the backfilled rooms.

Current best estimates of the chronology of the various thermal effects are presented in Figure 10 and Table 5. These estimates will be refined upon obtaining thermal property data from core samples.

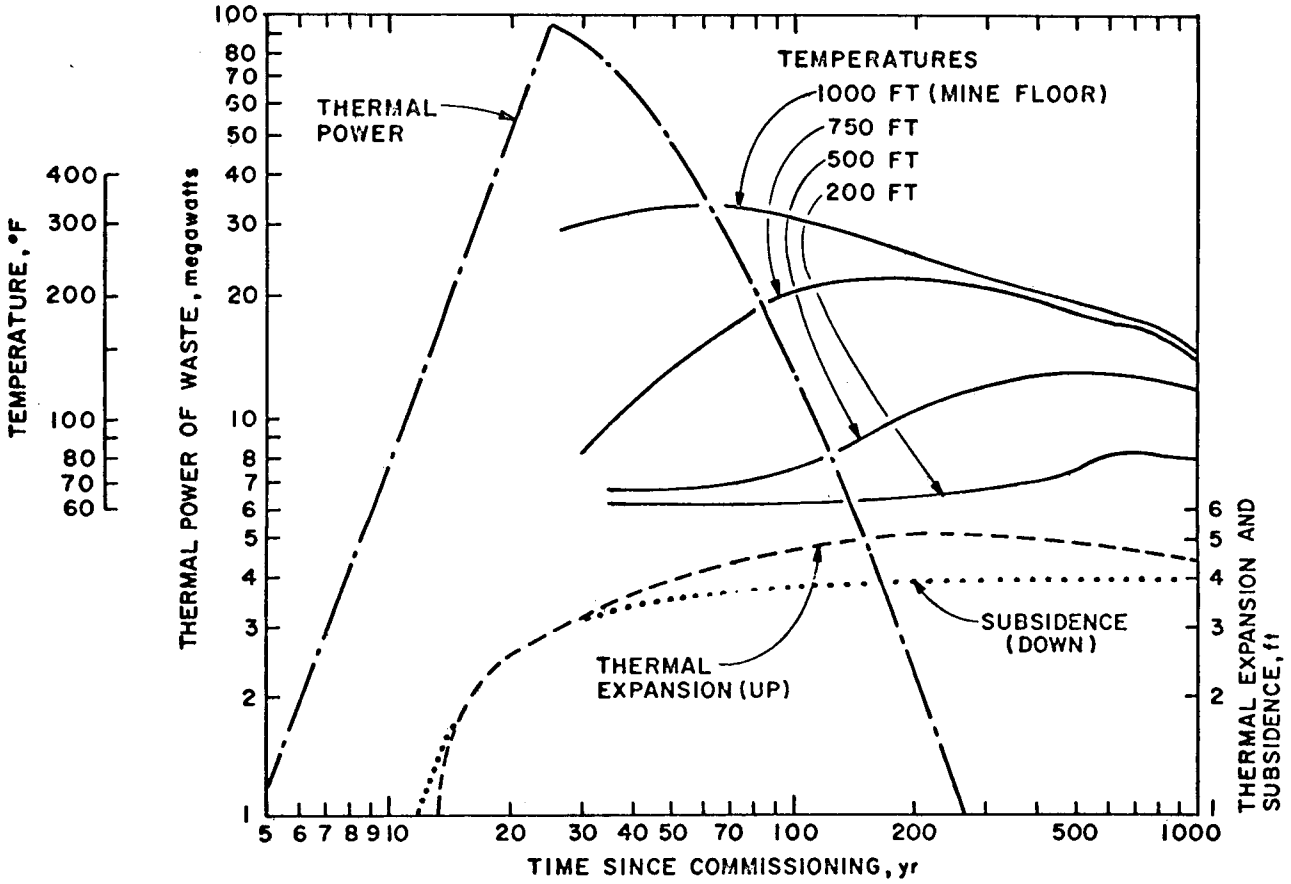


Fig. 10 The Effect of Time Since Commissioning on the Projected Total Thermal Power, Surface Rise Due to Thermal Expansion, Surface Fall Due to Subsidence, and Temperatures Within the Formation.

Table 5 Chronology of Thermal Effects in the Repository

Years	Effect
25	Decommissioning; power peaks at 95 MW.
30	400°F peak temperature rise at 8 in. from cylinders; 10 liters total brine inflow per container.
100	95% closure of voids by subsidence; 0.9-ft increase in typical surface level.
150	110°F peak temperature rise at 750-ft depth.
200	5.2-ft peak in net thermal expansion; 1.3-ft peak in typical surface level.
500	60°F peak temperature rise at 500-ft depth.
700	20°F peak temperature rise at 200-ft depth; 0.1°F peak temperature rise at surface.
3,000	1°F peak temperature rise at 1700 ft from edge of mine at 1000-ft depth.
~15,000	Total ~4-ft subsidence essentially complete; all temperatures within 5°F of initial condition.

e. Temperatures Adjacent to Mine

It is planned that subsurface rights will be purchased for a 1700-foot buffer zone around the periphery of the repository. Estimates of transient temperatures in the horizontal midplane of the high-level mine indicate that the maximum temperature rises at distances of 600 and 1700 feet from the edge of the mine will be 10°F and 1°F, respectively (occurring after about 1,000 years).

f. Brine Migration

Results of laboratory tests indicated that brine in small cavities will be released by fracturing of the salt crystals at temperatures above 250°C, but field tests (Project Salt Vault) indicated the absence of such effects even if small masses of salt around the containers in the floor reach 300°C or greater.

At temperatures below the decrepitation point, these small brine-filled cavities (size range from a few millimeters down to microscopic, and representing about 1/2 percent of the salt volume) migrate toward a heat source. The mechanism for cavity migration is the diffusion of sodium and chlorine ions from the hot to the cold side of the cavity due to the slightly greater solubility of NaCl at the higher temperatures. Migration rates are directly proportional to temperature gradient and increase with increasing temperatures. Calculations indicate that in the high-level facility, the maximum amount of brine that would accumulate in any disposal hole

would be about 2 to 10 liters. Migration of brine would cease approximately 20 to 30 years after burial of the waste. About 60 percent of the total brine inflow would be expected during the first 10 years after burial. In a 50- x 300-foot room, there could be about 200 container holes; so the total integrated inflow of water (brine), if it were all to find its way into the room would be less than 2,000 liters. During the period of operations, the daily ventilating air volume in the waste-disposal area will contain more water than this at its normal relative humidity. Other than its effect on radiolysis and container corrosion, this moisture should not be of any significance.

g. Corrosion of the Containers

Rather early in the Salt Vault program, a number of scouting studies were conducted on the corrosion of various alloys in salt compacts such as were anticipated in salt-mine storage of fission-product wastes. These laboratory capsule studies indicated that type 304L stainless-steel containers would be subject to relatively minor generalized corrosion and pitting attack which diminished with continuing exposure. One capsule exposed in a Co-60 gamma source showed no enhanced corrosive attack because of the radiation exposure.

Subsequent exposure of welded stainless-steel alloy specimens attached to pots of simulated waste buried in the

floor of the Carey mine, and electrically heated to 575°C for 31 days, gave results comparable to those obtained in the laboratory studies.

The tendency of the brine inclusions in the salt beds to migrate up the thermal gradient towards the hot containers and thereby provide a long-term source of corrosive solution was not known when these investigations were carried out. This brine migration produced a number of instances of stress corrosion cracking of stainless steel equipment used in Project Salt Vault. In practically all cases, however, the attack occurred in regions which were sufficiently cool for condensation of moisture, with resultant formation of acidic, concentrated brine solutions known to be aggressive stress corrodants to stainless steels. Such low-temperature, stainless-steel container surfaces would not be expected in the mine. Stress-corrosion cracks penetrating halfway through the wall (0.237 in. nominal) were found in the center of a type 304L stainless steel modified pillar heater which was continuously maintained between 150 and 200°C for ~ 350 days. Conceivably the crack could have been produced during heat-up or cool-down, but this seems unlikely; so mechanisms other than formation of aggressive solutions by condensate are being evaluated. It seems likely that contact with salt in the presence of an HCl steam atmosphere would be sufficient to cause failure.

In general, the experience with carbon steel equipment in Project Salt Vault was more favorable. Moderate generalized attack with no evidence of localized, severe penetration like the stress cracking of the stainless steel was observed.

During the demonstration phase of facility operation, wastes will be buried in retrievable form. Several methods are available by which container life can be prolonged, thus facilitating retrieval. These include: (1) Addition of CaO to the crushed salt backfill to react with the water of the brine accretion with the formation of stable $Ca(OH)_2$; (2) Encapsulation of wastes in containers constructed of stress-corrosion-resistant alloys; (3) The behavior of the carbon steel equipment in the salt environment suggests that a duplex container with type 304L stainless steel on the inside and carbon steel or aluminum on the outside should perform very well; and (4) Burial of waste in a concrete or ceramic sleeve.

h. Movement of Containers After Burial

After the containers of waste have been deposited in the floor of the mine, they will be contained in a material (the salt) which is semi-plastic. For purposes of analysis, the salt can be compared to a very viscous fluid rather than to a rigid solid. Plastic deformation of the floor will contribute to the closure of mined openings brought about by the

effects of the overburden stress and elevated temperatures. The waste containers will be carried along with the deformation of the floor salt and may experience translational motions certainly no greater than two feet vertically and six inches horizontally. The relative motion between the wastes and the salt in this case is zero.

If the waste containers are visualized as being suspended in a viscous fluid, the maximum possible rates of upward or downward movement can be estimated by calculations which neglect many of the resisting drag forces, specifically the frictional drag resistance along the sides of the containers. For extreme values of density difference between the salt and the waste containers, these calculations indicate that the maximum velocity of vertical relative motion between the salt and the waste containers is about 10^{-10} in./year or 1/10,000 of an inch in one million years.

If it is assumed that the waste containers cease to exist entirely and the solidified waste becomes an agglomeration of discrete smaller particles, the velocity of vertical motion becomes much smaller as the size of the particles becomes smaller. The situation here is approximately analogous to the settling velocity of a marble and a grain of sand in water.

i. Future Thermal Effect Studies

(1) Data to be Obtained

In order to establish allowable heat generation rates in the mine, as governed by the factors mentioned previously, additional data must be obtained from samples of the various stratigraphic sections at the site. Some of this information is presently being developed.

Cores (to about 1300-ft depth in one hole, and through the salt member in the other) have been taken at two corners of the proposed facility. Representative samples from more than 80 locations in the full-depth core are being used to obtain thermal property data, including the geothermal flux.

In addition, sufficient data will be obtained from representative core samples to provide estimates of the following thermal and physical properties (as a function of temperature where appropriate): (1) mineral composition; (2) water content; (3) thermal conductivity; (4) specific heat (per unit weight); (5) density or thermal diffusivity; (6) thermal expansion coefficient; (7) Poisson's ratio; (8) elastic modulus; (9) possible phase changes; and (10) effects of stress on physical properties.

(2) Updating of Thermal Calculations

When the previously mentioned stratigraphic, thermal property, and geothermal flux information becomes available, the previous heat transfer calculations will be repeated using the appropriate values. In addition, three-dimensional calculations will be run to ascertain such effects as thickening and thinning or disappearance of salt and/or other rock strata. Since some stratigraphic information is available from various electric logs on five other holes within the proposed site, it should be possible to construct a three-dimensional model which will be a reasonable approximation to the entire high-level disposal facility and to accurately estimate temperatures in the strata surrounding the proposed actual mine layout. These studies and calculations will be verified to the extent practical in the demonstration phase of this facility's operation.

(3) Rheological Studies

With the physical property data outlined above, and the knowledge of the temperature-time relationships from the planned thermal studies, new estimates will be made of work movements due to subsidence, thermal expansion, and any other factors (such as mineral alteration due to changes of phase, hydration, or pore volume) which

are applicable. If it appears that rock temperatures anywhere in the formation are such as to pose a potential threat to the containment of the waste within the salt formation, the maximum allowable heat generation rates at mine level will be adjusted to an acceptable level. This will also be the case if temperatures in aquifers or beyond the property boundaries are found to be excessive.

2. Radiation Effects

Radiation effects will only be of significance in the storage of the high-level wastes. Accordingly, the following statement refers only to the high-level portions of this facility.

a. Radiolysis of Brine

Radiation dosages in excess of 10^{11} rads induce no chemical effects of consequence to the salt; however, it does produce changes in the brine intrusions that constitute about 0.5 vol percent of the salt and in the very small amount of air initially in the voids in crushed salt immediately surrounding the containers. This brine has the following composition: Mg^{++}, 2.3 to 3 M; K^{+}, 0.4 M; Na^{+}, 2 to 1 M; Cl^{-}, 7 to 7.5 M; Br^{-}, 0.05 M. It is slightly alkaline.

The value of G (H_2) in this brine may be as high as 2.1 molecules of H_2 per 100 ev of absorbed radiation energy, and the oxidized species will be O_2 and/or ClO_3^{-} + BrO_3^{-}. Based

on this upper-limit rate, we estimate that the radiolytic hydrogen can be produced at a maximum rate of only about 1 ft^3/min throughout the entire repository when the thermal power from radioactive decay is about 100 MW. The bromates and chlorates around the containers will decompose thermally to halides and oxygen. Ozone and nitrogen oxide formation in the gas-vapor mixture will not be a problem at the low partial pressure of air and at the temperatures which will prevail.

All $MgCl_2$ in solution which gets into the open spaces around the containers will hydrolyze to form HCl, provided that the location of the $MgCl_2$ is such that the HCl can move away from the site of the reaction. The quantity of HCl so produced is so small as to be unimportant except from the standpoint of its possible influence on container life (see below).

Although our evaluations of these effects, based on very pessimistic assumptions, are most favorable, measurements may be made during the demonstration phase of the actual generation rates and resultant concentrations of radiolytic and hydrolytic products that may exist under steady-state conditions around the containers in the mine during the demonstrational phase of the facility operation.

b. Stored Energy

Stored energy refers to energy that may be stored in irradiated solids due to the introduction of defects and

other disorder. When the solid is heated subsequent to its irradiation, energy is released as the solid passes through various stages of reordering. In some cases (particularly in strongly covalent crystals in which large amounts of energy can be stored), all of the energy can be released with a relatively low initiating temperature since the initial energy release can heat the solid sufficiently to trigger energy releases at successively higher transition temperatures. In the case of long-term storage of radioactive wastes, it is important to know how much energy can be stored at saturation in the materials that will be in the radiation field and thermal environment of the repository. (We define saturation as that level of damage at which the radiation removes as much energy by radiation annealing as it supplies by radiation damage.) The materials in question are the glass or ceramic boule containing the radionuclides, the metal container, and the surrounding salt. The temperature of the wastes and their containers will be from 600 to 900°C initially, and will decrease to less than 500°C in about 10 years, while the temperature of the salt will range between 20 and 350°C, depending on its proximity to the waste and the thermal power of the source. The maximum accumulated radiation dose in salt will range from 2×10^{11} rads adjacent to the wastes to about 82 rads at a distance of 5 feet.

Some work with stored energy in NaCl has been reported in the literature. Kobayashi measured an energy release of 2 to 2-1/2 cal/g between room temperature and 400°C in NaCl that was heavily irradiated with protons at room temperature. Bunch and Pearlstein have compared the F-center concentration in X-ray-irradiated NaCl with the stored energy, and report a value of 12.4 eV per F center. For a saturation concentration of 2×10^{19} F centers/cm^3, this would yield a saturation stored energy of 4 cal/g.

Experimental investigations designed to yield upper-limit values of the amount of energy that can be stored in salt under the conditions that will exist in the repository have been carried out. In the course of these investigations, stored energy has been measured by solution calorimetry and by differential scanning calorimetry on samples of salt taken from the Lyons mine and irradiated with an electron accelerator at different temperatures and dose rates (Table 6). These experiments suggest that energy storage in the salt cannot exceed 15 to 20 cal/g at ambient temperatures; and at temperatures above 100°C (such as will exist in the vicinity of the high level wastes), no more than 1 or 2 cal/g can be stored.

Although there have been no measurements to date, of energy storage in solidified wastes, it is quite likely that energy can be stored in some of these materials, and over a wider temperature range than is possible in salt. Studies

Table 6 Stored Energy Measurements in Rock Salt by Solution Calorimetry

Sample	Irradiation Temperature (°C)	Dose (rads)	Stored Energy (cal/g)
		Electron-Irradiated Samples	
V_oA	30	1.7×10^{10}	14.1
V_oB	30	1.7×10^{10}	1.6[a]
V_oC	30	1.7×10^{10}	6.9[b]
V_1	80-100	3×10^{10}	3.0
V_2	80-100	8.3×10^{10}	2.1
V_3	80-100	1.1×10^{11}	4.3
		Project Salt Vault Samples	
Hole 10 (7-1/2-ft depth)	125	8×10^{7}	0
Hole 4A (11-ft depth)	165-200	9×10^{8}	0
Hole 4B (9-1/2 to 11-ft depth)	165-200	9×10^{8}	0

[a]Heated at 250°C for 7 hr.

[b]Stored at 25°C for 78 days.

are being undertaken to characterize the potential for energy storage in the solidified wastes. These calculations will be verified by direct measurement during the demonstrational phase of repository operation.

(1) Thermal Effects

A variety of calculations have been made to evaluate the maximum transient temperatures in the salt that could result from an instantaneous release of stored energy. In this study, we have evaluated primarily the effect of initial age of the waste, initial thermal power, and the length of time that the cylinder has been stored in the salt. The energy storage has been conservatively overestimated as one percent of the total deposited photon-neutron energy (Figure 11) up to a maximum saturation value of 200 cal/g in the calcined waste and 20 cal/g in the salt.

The transient temperature in the vicinity of a waste cylinder before and after a stored energy release was calculated using numerical analysis techniques of the type described previously. Of the cases studied, the maximum thermal effect of a stored energy release occurred under the assumption that a cylinder having initial thermal power of 5000 watts and initial waste age of 10 years resulted in a stored energy release 30 years after burial

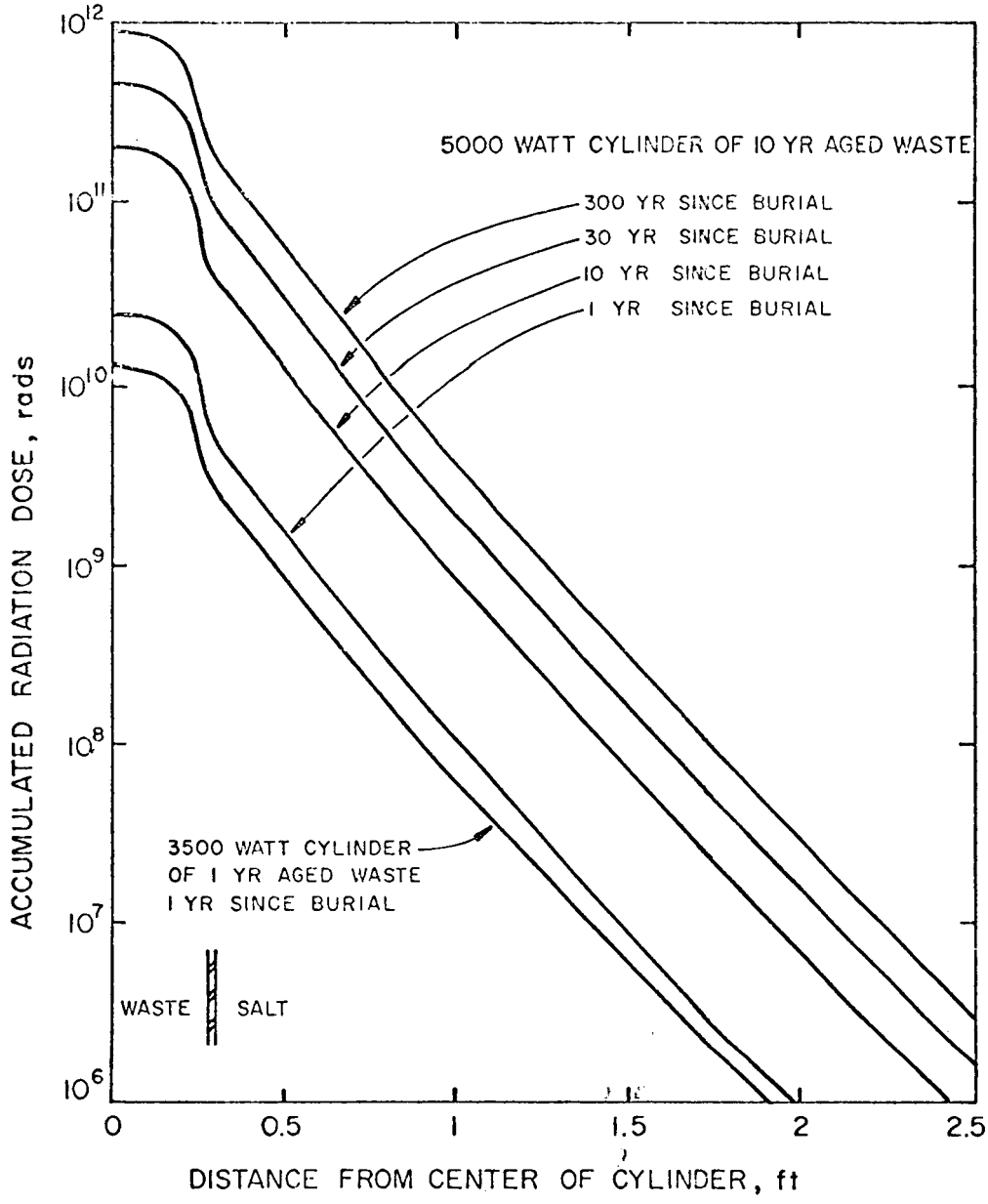


Fig. 11 Accumulated Photon-Neutron Dose in the Horizontal Midplane of Cylinders of Solidified High-level Waste Buried in Salt. Waste cylinders have inside diameter of 6 in., steel wall thickness of 0.25 in., and active height of 8 ft.

Table 7 Estimated Maximum Temperature and Volume Increases That Could Result from Release of Stored Energy Developed by a Waste Cylinder Stored in Salt

Properties of Waste Cylinder[a]				
Initial thermal power, W	5000	5000	520	3500
Initial age of waste, years	10	10	10	1
Time of storage in salt, years	1	30	30	1
Distance between cylinders, ft	27	27	8	12
Volume Change due to Thermal Expansion, ft^3				
Waste and salt	0.12	0.36	0.13	0.08
Brine	1.53	5.62	1.79	0.88
Total	1.65	5.98	1.92	0.96
Maximum Temperature Rise, °F				
1 ft from center of cylinder	56	170	150	49
4 ft from center of cylinder	4	7	4	3
Midpoint between adjacent cylinders	0.9	2	4	2

[a]Cylinders are assumed to have diameter of 6 in. and active length of 8 ft.

in the salt (Table 7). The effect of this release was to cause no melting of the salt and a temperature rise of less than $2^{o}F$ at 13.5 feet from the center of the cylinder.

(2) Mechanical Effects

Rapid thermal expansion of the waste and nearby salt resulting from a release of stored energy can potentially result in the rapid release of mechanical energy. An overestimate of the maximum amount of mechanical energy generated can be made by assuming that the expansion occurs reversibly against the ambient overburden pressure of 1,000 psi.

Table 7 presents results of estimates of maximum stored energy generation for the several assumed conditions of mechanical energy release. Materials properties that were assumed for these calculations are given in Table 8 Thermal expansion of the brine which constitutes 0.5 percent by volume of the salt was overestimated by assuming that the brine is pure water, using thermodynamic data from steam tables.

These estimates show that the maximum amount of mechanical energy generated is conservatively less than the equivalent of one pound of TNT. This amount of energy release would result in practically no deformation of the floor of the room above the pot.

Table 8 Assumed Properties of Calcined Waste and Salt Used for Analysis of Stored Energy Release

Calcined Waste	
Density, lb/ft^3	113
Thermal conductivity, Btu/hr·ft·°F	0.25
Heat capacity, Btu/lb·°F	0.22
Coefficient of cubical expansion, °F^{-1}	0.88×10^{-5}
Rock Salt	
Density, lb/ft^3	135
Brine content, vol %	0.5
Thermal conductivity, Btu/hr·ft·°F	1.81
Heat capacity, Btu/lb·°F	0.218
Coefficient of cubical expansion, °F^{-1}	0.67×10^{-4}
Melting point, °F	1470
Crushed Salt	
Density, lb/ft^3	95
Brine content, vol %	0.5
Thermal conductivity, Btu/hr·ft·°F	0.36
Heat capacity, Btu/lb	0.218

c. Isotope Migration

Analyses have been made of the various mechanisms by which radioisotopes can migrate within the mine. An analysis of solid-state diffusion of plutonium in NaCl indicates that this isotope should not migrate more than about 25 cm in one million years at a temperature of 350°C; however, there is little information available on surface diffusion of isotopes along grain boundaries. Experimental investigations of this mechanism have been initiated.

Recognizing that the waste containers can deteriorate in a relatively brief period of time after burial, the prospects for enhancement of the volatility of isotopes by steam arising from the brine within the salt has been considered. This appears to be a very remote possibility; however, the desirability for performing observations with unpackaged wastes under actual or simulated burial conditions will be evaluated.

Investigations are under way to determine the permeability of crushed salt to gases and to nonvolatile radioisotopes, and on the formation and fate of PuO_2 aerosols. This information is needed in the design of the mine ventilation system and for the analysis of the possible consequences of accidents.

VI. FACILITY DESCRIPTION

A. Description of the Repository

The Repository will utilize the existing 180-acre Carey mine and approximately 800 acres of the adjoining salt formation. In addition, a buffer zone approximately 1700 ft. wide will be established around the periphery of the site through the acquisition of subsurface mineral rights. While being designed to accept all of the alpha and high-level wastes to be generated in this country through the year 2000, this facility will be operated initially as a demonstrational facility. During this demonstration phase it is planned to obtain verification of pertinent calculational techniques by in-situ measurements, effluent and environmental monitoring, and other activities to confirm that all aspects of the operation of this facility can be carried out safely and reliably without endangering the health and safety of the public. This demonstration period is to be carried out during the early years of facility operation when the volume of wastes to be buried will be quite small. During this period, all wastes buried will be in a fully retrievable form.

The mine will be designed so that within 60 to 100 years the salt, by the processes of deformation and recrystallization, will have caused reconsolidation of the entire area, and the wastes will be completely isolated from the biological environment. The conceptual design is currently being developed; accordingly, the following generalized descriptions must be considered preliminary.

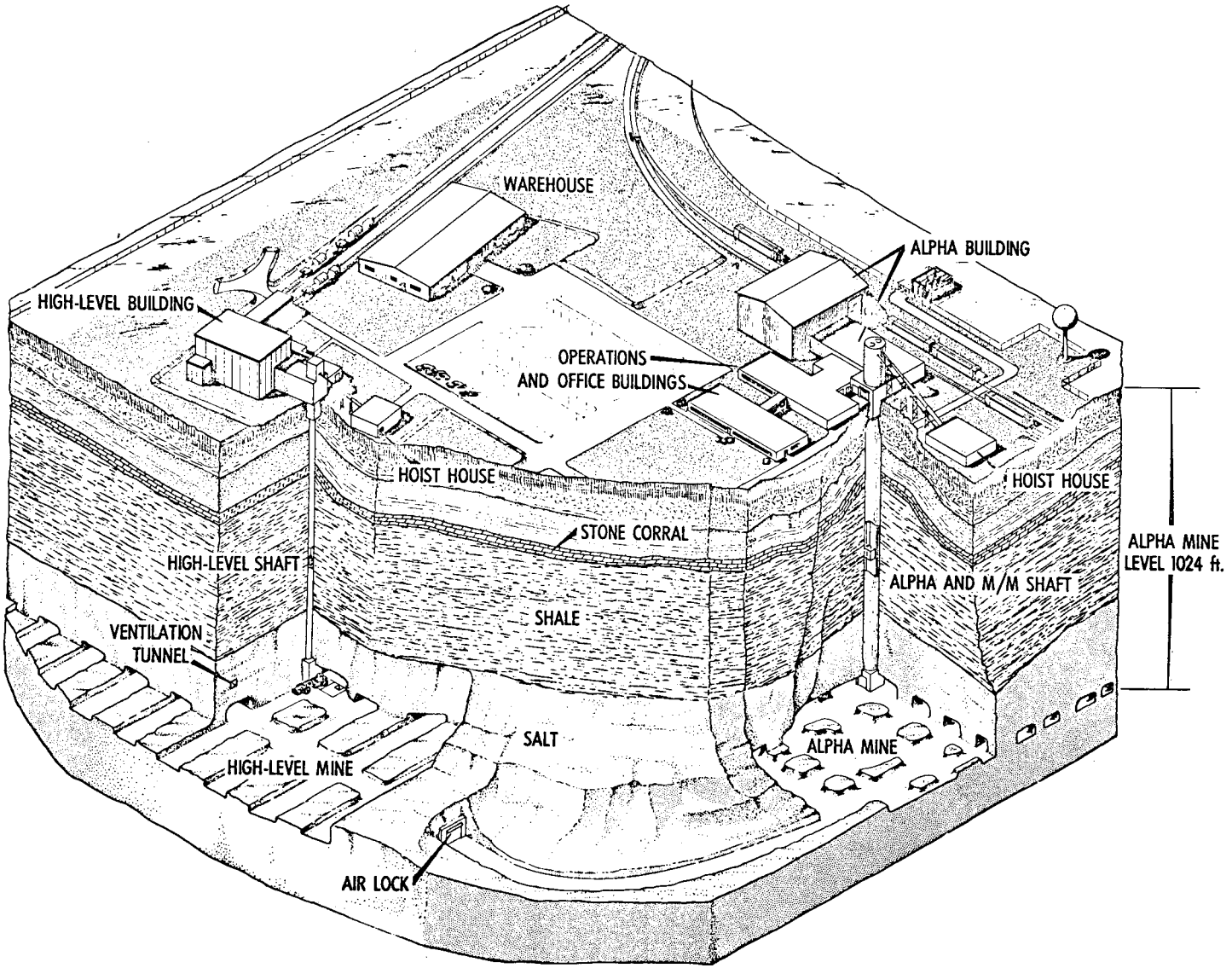
The principal components of the Repository are (Fig. 12): (1) the existing Carey salt mine situated about 1000 ft. below the surface which will be used for storage of the alpha wastes; (2) a building in which the alpha waste packages are received, monitored, and transferred to the existing mined area by direct handling techniques; (3) a building equipped to receive containers of high-level wastes and transfer them remotely from their shipping casks to the mine level; (4) a newly mined area for burial of the high-level wastes; and (5) various support facilities such as operations and office buildings, a warehouse, and those other services and utilities that are required for mining and underground storage operations. All facilities will be designed to ensure that the confinement capability and radiation safety are maintained following exposure to credible internal and external forces (including flood, tornadoes and earthquakes).

B. High-Level Waste Facility

The High-Level Waste Facility consists of a waste receiving building, a newly mined area underground, and miscellaneous surface support facilities. The high-level mine will adjoin the Alpha Mine (Fig. 12).

1. High-Level Waste Receiving Building - Solidified high-level wastes, sealed within containers of high integrity will be shipped to the repository in massive, heavily shielded casks. The high-level waste receiving building will provide necessary facilities for unloading the containers of waste from the cask and for their inspection, decontamination (if necessary), and transfer to the mine level.

Figure 12.



FEDERAL REPOSITORY

Portions of this building that may potentially contain radioactive material will operate under a negative pressure with respect to the atmosphere and will be, wherever appropriate, resistant to natural phenomena such as earthquakes and tornadoes. Contained portions of the building will be ventilated with conditioned air supplied by a recirculating system. HEPA filters will be installed in the return ducts of the system to collect any airborne particulates and prevent their redistribution into the uncontaminated areas. The ventilation flow pattern will always be from areas of low-contamination potential to areas of successively higher contamination potential.

2. High-Level Mine - The high-level mine will be developed over the life of the repository using conventional salt mining techniques. The required rate of mining will increase during the life of the facility from about 200,000 tons/year initially, to about 1.3 million tons/year during the last several years of operation. Most of the salt will be used for backfilling; eventually, the remainder will, after monitoring for contamination, be raised to the surface and may either be offered for sale to commercial outlets or deposited in other nearby salt mines.

The containers of high-level waste received at the mine level will be transported in shielded equipment to rooms mined in the salt formation and buried in holes in the salt. The spacing

between containers will be adjusted such that the radioactive decay heat will be dissipated without exceeding a bulk salt temperature of 392°F. After the burial area of a room has been utilized, the room will be backfilled with crushed salt and sealed from the remainder of the mine.

C. Alpha Waste Facility

The alpha waste facility will be comprised of a surface level receiving and handling building, a shaft and hoist for lowering the waste into the mine, and all of the underground workings of the existing Carey Salt Mine. The presently mined-out area underlies about 200 acres of land, and the mine should provide approximately 20 million cubic feet of storage space for alpha waste (Fig. 12).

The alpha waste receiving building will provide confined and monitored earthquake- and tornado-resistant facilities in which waste packages can be unloaded, monitored for external contamination, decontaminated if necessary, and lowered into the mine. Initially, shipments of alpha waste will be made only by rail in specially designed railcars, (ATMX 600 series) but it is probable that provisions will be made to receive motor freight at a later date.

The presently mined-out area will provide space for storing about 20 million cubic feet of alpha wastes, and the alpha facility will have the capability to handle 1 million cubic feet of waste per year. The alpha waste transfer shaft will terminate in an alpha-confinement room

at mine level. Here, the packages of waste will be unloaded from the jointing cage and transported to the disposal rooms where they will be unloaded and stacked. When an area or room has been completely filled, it will be backfilled with salt and sealed. The mine will be ventilated with air supplied through the multipurpose shaft, and maintained at pressure below that of the atmosphere. All air exhausted from the facility will be filtered and monitored prior to release through a stack.

D. Safety Systems

Safety and effluent control systems will be incorporated into the facility to mitigate the consequences of credible accidents and to reduce effluents from the facility to the lowest practical level. As noted previously, critical areas of the facility will be designed to maintain confinement and safe shutdown capability in the event of severe natural events which could be anticipated at the site such as floods, tornadoes, and earthquakes. The details of these systems will be described in the facility Conceptual Design and Safety Report currently in preparation. This document will provide the basis of the initial safety review of this project by the Advisory Committee on Reactor Safeguards.

1. Radiation and Environmental Monitoring Programs - Several types of monitoring programs will be carried out at the facility. These can be characterized generally as "on-site" and "off-site" monitoring. The "on-site" program will be carried out by the operating contractor.

It will be the contractor's responsibility to assure that all operations within the facility are performed in accordance with accepted radiation protection standards. Additionally, the operating contractor will also be responsible for monitoring any and all effluents from the facility at the point of release to assure that such releases are as low as practicable and below applicable regulations. Details of the monitoring program will be further developed as the design of the facility progresses and will be described in the Design and Safety Report.

The second type of monitoring deals with the surrounding environment both during the active life of the facility and after its decommissioning to assure the absence of any detrimental effects. The details of this program will be developed in consultation with appropriate Federal and state agencies and will necessarily involve obtaining base-line data on the existing radiological and ecological environment.

E. Packaging and Shipment of Wastes

Both the alpha and high-level wastes will be shipped to the repository in a manner approved by the Atomic Energy Commission and in accordance with a certification of compliance that is granted by the Department of Transportation (DOT). These shipments shall conform with all applicable regulations of the DOT (49 CFR 173.389 through 173.399) and the Atomic Energy Commission (AEC Manual Chapter 0529 and 10 CFR 71).

The alpha wastes will initially be shipped to the repository sealed within 8x8x20 ft. returnable cargo containers. These containers will be placed within railcars of special design (ATMX 600 series) which serve as a rugged container that is resistant to possible collisions and fires. The returnable cargo containers, in addition to facilitating unloading of the railcar, will provide an additional secondary confinement barrier against the accidental dispersion of the waste. Comparable shipping systems for truck transport may be developed at a later date. Sealed containers of solidified high-level waste will be transported in massive, heavily shielded casks, designed to withstand severe transportation accidents without releasing their contents.

As required by these regulations, packages and transport containment systems are designed and constructed to withstand the effects of severe transportation accidents without the release of radioactive materials. These same standards have been accepted for world-wide use in the regulations of the International Atomic Energy Agency. Shipment of waste to the repository will be made under the same rules as are currently applied to shipments of other radioactive materials.

No specific protection will be required by carrier personnel handling either high or low-level waste shipments. Both types of waste will be loaded by the shipper and unloaded at the repository with no intermediate handling of packages. DOT regulations concerning the external radiation levels on radioactive shipments are such as to

eliminate any requirements for additional protection of the transport workers other than that provided by the packages themselves. These radiation limits specified in 10 CFR 71, will assure that the transport workers will not be exposed to radiation in excess of the values recommended by the Federal Radiation Council, the International Commission on Radiological Protection, and the AEC.

Shipment of radioactive waste to the repository does not present any new or unique problems, nor require the development of a markedly different system technology. Shipments of both high-level and low-level radioactive materials have been made routinely and safely for 25 years without a single case of radiation exposure to the general public.

The Commission has recently been assured by the Federal Railroad Administration that the roadbeds over which the wastes will travel to the repository will be inspected prior to the first shipments.

F. Waste Retrieval Systems

Once radioactive wastes are emplaced in the salt repository, they will be regarded as in permanent storage. It is not planned that they will be relocated elsewhere. Retrieval would only be considered in light of an objective safety problem under circumstances which to date have not been postulated. The facility will, however, be designed so as not to preclude retrieval.

With respect to the high-level wastes, the burial locations for each container will be accurately surveyed and recorded so that the precise location of the wastes will be known. Retrieval through use of remotely controlled automatic mining equipment would thus be possible. Because of their radiation characteristics, alpha wastes would not offer retrieval problems equivalent to the high-level wastes. The present state of development of mining techniques and equipment are considered adequate to enable development of waste retrieval systems. During the course of the facility design, retrieval system concepts will be developed. Specific features of such concepts will be tested during the demonstration phase which will take place during the initial years of facility operations to confirm, if necessary, that retrieval can be accomplished effectively.

VII. IMPACT ON HUMAN ENVIRONMENT

A. Radiologic and Physiologic Effects

Repository systems for protection of the general public and operating personnel against exposure to radioactive and physiologically hazardous materials are being designed to comply with all Federal regulations governing radiation safety, mine safety, and industrial safety. The principal regulations that dictate safety provisions of the Repository are AEC Manual Chapter (AECM) 0524 and 10 CFR 20 for radiation safety; 30 CFR 57 for mine safety; AECM 0550 and 41 CFR 50-204 for industrial safety; and AECM 0529 and 10 CFR 71 for transportation safety. A description of these systems and their performance specifications will be contained in the Conceptual Design and Safety Report.

The only significant source of off-site exposure to radioactive or other materials originating from the Repository will be from very small quantities of airborne particulate materials that escape through high efficiency particulate air (HEPA) filters. It is planned that there will be no discharge of liquid waste from the Repository. Wastes generated as a result of Repository operations (such as decontamination solutions) will be solidified, packaged and buried in the mine. Aqueous residues will be recycled with any excess water being evaporated to the atmosphere after appropriate decontamination.

Instrument systems will be provided for continuous monitoring of radiation levels and concentrations of airborne materials in the work areas, in stack effluents, at the boundary of the site, and at selected off-site locations.

The materials that will escape to the atmosphere in small concentrations include: (1) particulate matter resulting from resuspension of surface contamination; (2) gases (^{85}Kr, ^{3}H, He) that result from decay of the waste; (3) radon gas that occurs naturally in the mine; (4) nonradioactive gases (H_2, HCl) that result from decomposition of the salt, corrosion, electrolysis, and radiolysis; (5) exhaust fumes from diesel equipment; and (6) salt particles. Concentrations of these materials in work areas of the Repository will be maintained well below the applicable standards for occupational exposure.

1. Off-Site Consequences of Normal Releases - Present estimates of the rate of release of these materials to the atmosphere and the maximum off-site concentrations that will result at the southern boundary of the site, are presented in Table 9. These maximum concentrations are less than 0.1% of the applicable standards for exposure of the public (10 CFR 20), and in general, are well below the concentrations of the same materials that exist at present due to natural and man-made sources.

   It is estimated that over the life of the Repository, the buildup of off-site surface contamination of various radioactive species will ultimately result in a level that is less than 1% of the level that presently exists for the same species (including

such radioisotopes as ^{90}Sr, ^{137}Cs, and ^{239}Pu) which have been deposited by fallout. At these levels of surface contamination, the experience has been that the materials cannot be reconcentrated to hazardous levels in food chains. The off-site monitoring program will verify these assumptions.

2. Off-Site Consequences of Non-Routine Events - The facility will be designed to maintain its confinement capability in the event it is subjected to extreme natural occurrences such as earthquakes, tornadoes and floods which can be credibly anticipated at the site.

Similarly, the facility will be designed to mitigate the consequences of credible accidents occurring within the site boundary so as to comply with all applicable standards and regulations (e.g., 10 CFR 100) governing the operation of nuclear facilities.

B. Geophysical Impact

See discussion under Section V.B.1.d.

C. Ecological Impact

The principal long-term ecological effects are expected to be physical in character resulting from the man-made improvements such as roads, parking areas, and other structures, e.g., the alpha waste and high-level receiving buildings. While there will be certain changes

to the surface ecology resulting from construction activities, these can be minimized and should only be of a temporary nature. The thermal effect on the surface ecology should not result in any detectable change in the dominant character of the grassland community or the fauna since the increase in the surface soil temperatures will be negligible. Thus, following construction, revegetation with indigenous species could be achieved if desired with no adverse ecological effects. In general, no significant effect on wildlife populations is anticipated either in regard to numbers or in species composition.

Because effluents from the repository will not result in an increase in either the levels of surface contamination or in the concentration of airborne activity, no impact on the ecology is anticipated. This assessment will be confirmed as part of the planned environmental monitoring program.

Table 9 Estimated Release Rates and Average Annual Off-site Concentrations of Radioactive and Other Materials Resulting from Full-Scale Operation of the Repository

Material	Average Annual Rate of Release to Atmosphere	Average Annual Off-site Concentrations Resulting from Repository Effluents[a]	Percent of Applicable Standards for Exposure of the Public[b]	Percent of Estimated Present Concentration in the Atmosphere
High-level waste particles	0.007 Ci/year	2×10^{-15} Ci/m^3	0.02	5.0
Alpha waste particles	0.04 μCi/year	1×10^{-20} Ci/m^3	0.0001	0.02
^{85}Kr (spontaneous fission)	0.014 Ci/year	4×10^{-15} Ci/m^3	0.000004	0.04
^{3}H (spontaneous fission)	0.0009 Ci/year	3×10^{-16} Ci/m^3	0.0000004	0.002
^{222}Rn (natural sources)	0.9 Ci/year	2×10^{-13} Ci/m^3	0.02	0.2
^{220}Rn (natural sources)	0.04 Ci/year	1×10^{-14} Ci/m^3	0.0003	0.2
H_2 (corrosion, radiolysis, electrolysis)	37 scfm	0.2 ppm	0.002	40.
He (alpha decay)	0.001 scfm	0.000004 ppm	4×10^{-8}	0.00008
HCl (brine decomposition)	0.07 scfm	0.0003 ppm	0.006	100.
CO_2 (diesel exhaust)	50 scfm	0.2 ppm	0.004	0.07
CO (diesel exhaust)	0.05 scfm	0.0002 ppm	0.0004	0.2
NO_2 (diesel exhaust)	0.05 scfm	0.0002 ppm	0.004	7
SO_2 (diesel exhaust)	0.03 scfm	0.0001 ppm	0.002	1
CH_2O (diesel exhaust)	0.0007 scfm	0.000003 ppm	0.00003	0.05
Soot (diesel exhaust)	2 lb/year	0.1 μg/m^3	0.0007	0.2
Salt particles	5 lb/year	0.2 μg/m^3	0.001	0.8

[a] These are the maximum concentrations which result at the southern boundary of the site.

[b] Based on one-third of limits in 10CFR20, Table II, Column 1 for radionuclides and threshold limit values (American Conference of Governmental Industrial Hygienists) for other materials.

VIII. IMPACT ON LOCALITY

A. Impact on Utilities and Municipal Services

Electric power for the repository will be supplied by the Kansas Power and Light Company. Reliable electric standby power will be provided for all critical systems. Potable water for sanitary needs and fire fighting will be supplied from an existing main. An emergency water supply for the fire control system will be provided. Sanitary sewage from all areas will be pumped into the municipal system. Any radioactive wastes generated from decontamination operations in the repository will be appropriately processed and disposed of in the mine.

The municipal gas, water, and sanitary sewage systems serving Lyons, Kansas, have adequate existing excess capacity to serve the repository. Ample electric capacity is also available. Extensions to existing distribution systems will be required for some of the services.

B. Impact on Resources

1. Water - Construction and operation of the repository should have no impact on either the quantity or quality of the water resources in the area. No radioactive liquid effluents will be released from the facility and municipal water and sewage systems have adequate existing excess capacity to serve the Repository. The

provisions which will be incorporated into the facility to prevent contamination of ground-water supplies in the event of abnormal operation of the facility will be detailed in the Conceptual Design and Safety Report.

2. Occurrences of Oil and Gas - At the present time, there is one producing oil well located within the boundaries of the proposed site. This well has always been a very minor producer and there is evidence that production will be terminated in the near future. Adjacent wells have all been dry holes. There are no other producing oil or gas wells in the immediate vicinity although several wells have been drilled. Based on this information, it is believed that there are no significant mineral resources presently underlying the repository site which would be interdicted.

3. Occurrence and Distribution of Rock Salt - Rock salt reserves are essentially inexhaustible. Indeed, it is estimated that the rock salt reserves in the State of Kansas alone exceed five billion tons or enough to meet the present needs of the United States for the next 500,000 years. Salt deposits are known to exist in most sections of the country, having been found in 24 of the 50 states. With the vast amount of rock salt deposits existing within the U.S., it is evident that the few million tons of salt that would be used to retain the radioactive wastes at the Kansas repository are too small to have any measurable effect on the reserves of this abundant natural resource.

C. Sociological Impact

1. Population - Projected full-scale operation of the repository will result in the addition of perhaps 200 jobs to the Lyons community.

   As noted previously, the establishment of this facility may attract other commercial or nuclear-related activities to this area.

2. Esthetics - The repository will not be offensive with respect to sprawl, noise, waste effluents, large utility usage, or conspicuous engineered features.

3. Relocation - There are three houses on the area occupied by approximately 14 people. Included in these are a tenant, his wife and 7 children, a man and wife and boy who just graduated from high school, and the third house is occupied by a man and wife.

4. Transportation - Construction and operation of the facility will result in increased rail and truck shipment to the repository. These will be equivalent to what would be expected to be necessary to service a moderate production facility and will not impose an undue burden on the transportation facilities. Carload shipments of alpha waste are estimated at 420 in 1980, growing to 1200 in the year 2000. Carload shipments of high-level waste are estimated to be 23 in 1980 and grow to 585 in the year 2000 on an annual basis.

5. Archeology - There are significant archeological sites in northeastern Rice County but there are no known prehistoric Indian relics or other antiquities on the intended repository site. Acquisition of the site will, however, comply with the requirements of the Federal Antiquities Act, if applicable.

Principal Alternatives to Salt - Several other possibilities have been studied or seriously considered for the long-term storage of high level and alpha wastes. Among the more notable are the following:

"Perpetual" tank storage - Storage of wastes as liquids in near-surface tanks has been a successful means for containing radioactive wastes to date; however, this practice can be considered only as an interim measure because the waste is contained in a mobile form within the biosphere. The tanks must also be periodically replaced due to corrosion.

Disposal as solids in surface or near-surface vaults - This alternative, while representing an improvement over the storage of liquids in tanks, does not provide the high degree of assurance of long-term isolation as is available in the case of storage in mined caverns in deep geologic formations. Surface or near surface vaults would promote the proliferation of waste disposal sites and would require a high degree of physical control and periodic replacement of these structures to maintain this isolation. Furthermore, analyses indicate that the costs for storage in concrete vaults would be significantly more expensive than storage in mined repositories.

Storage in mined cavities in geologic formations other than bedded salt - The Commission has under active study the use of mined cavities in bedrock underlying its Savannah River, S. C., site, and in basalt

underlying its Hanford, Washington, site, for the storage of large quantities of existing production wastes from those facilities. Such wastes would be stored as liquids or slurries. The production wastes at these sites are much less hot thermally than unfractionated wastes from commercial fuel reprocessing plants. Current AEC programs at those sites are intended to determine the suitability of bedrock storage for production waste storage. Considerable in-site exploration work remains to be done at Savannah River before approval could be given to use of this method of storing on-site wastes, and the Hanford program is still further into the future. Thus, the bedrock storage concept technology is not currently available for consideration for the proposed initial repository.

Salt "Domes" as Possible Future Sites - Salt domes have always been considered as feasible in principle as bedded salt deposits for the disposal of radioactive wastes. The 1955 National Academy of Sciences Committee on Waste Disposal made no distinction between domes and bedded formations in their recommendation that salt deposits offered the best prospect for waste disposal. Since that time, all of our considerations on the general advantages of natural salt formations for this purpose have failed to reveal any fundamental reason for excluding the possibility of a repository in domal structures. However, there are several problems in selecting a specific dome and, more importantly, in demonstrating its suitability as a site for waste disposal operations. These problems are related to:

The geometry of the structure - Since domes can be very irregularly shaped, it would be necessary to accurately determine the outline of the site being considered, primarily to ensure that the excavations will not too closely approach the edge, thereby producing an inflow of water. Also, the necessary width of the barrier between the edge of the dome and the limit of the underground workings has not been established.

The tectonics of the structure - The salt domes of the Gulf Coast region apparently have resulted from the upward intrusion of massive volumes of salt from source beds buried at great depths. The velocity of emplacement is apparently no more than a few millimeters per year, and there is evidence suggesting that at least some of the domes are still moving at that rate. Therefore, before a particular dome could be considered suitable for waste disposal, it would be necessary to demonstrate that it was not currently active, that rejuvenated movement, either natural or induced by repository excavation or the resulting heating due to radioactive decay, would be impossible, and that past movements had not resulted in residual stress concentrations which would interfere with the excavation operations and the programmed closure of the openings at the completion of waste disposal operations.

The hydrological regime around the structure - Because they are intruded through overlying sediments, domes are not protected from dissolution by circulating groundwaters by thick sequences of impermeable shales.

In fact, the anhydrite "cap rock" immediately overlying most Gulf Coast domes is believed to be the insoluble residue left by the dissolution of as much as several thousand feet of the dome height. Site investigations would have to define in considerable detail the characteristics of the groundwater flow around the dome and demonstrate the future extensive dissolution of the salt would be impossible.

Alpha Waste Storage - Solidified alpha wastes are currently stored in a few controlled and monitored near-surface burial grounds primarily at AEC installations. Present practices do not constitute a present threat to the health and safety of the public. However, the Commission has concluded that storage in the repository would be preferable to the continuation and proliferation of the near-surface storage of alpha contaminated wastes from its installations.

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A P P E N D I X

Comments Received on Draft Environmental Statement and AEC Responses

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

June 4, 1971

Honorable Robert J. Docking
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State Capitol Building
Topeka, Kansas 66612

Dear Governor Docking:

Thank you for your letter of February 22, 1971, commenting on the Draft Environmental Statement for the proposed radioactive waste repository near Lyons, Kansas. The Final Statement has been revised to reflect your comments to the maximum extent practicable. In addition, we have also made numerous other additions and revisions in response to comments received from Federal agencies and others. We believe the enclosed Statement conforms with the letter and spirit of the National Environmental Policy Act of 1969. Also enclosed is a report indicating the disposition of the comments contained in your letter. In this report we have not attempted to respond to specific comments but we have referenced the sections of the Environmental Statement which have been revised or amplified in response to your concerns. You will note that many of the comments call for information and answers which cannot be included in an environmental statement which must be prepared well in advance of doing the work which will provide the answers. However, in the Environmental Statement we have indicated AEC's intention with respect to addressing these matters during the course of the design and development of the operational procedures. In addition we have also included an extensive bibliography of published works on the salt mine concept including related research and development.

We share your concern that the future of Kansas be protected and we assure you that the necessary studies and investigations will be conducted and a final determination of the site suitability made prior to the permanent emplacement of any wastes in the Lyons facility. In the December 2 Preliminary Report of the State Geologic Survey, several comments were made regarding

AEC's intentions with respect to heat transfer and energy storage studies. We have enclosed a copy of a press release from the Kansas University News Bureau which indicates that a better understanding of these issues has been reached between members of the AEC, ORNL, and the State Geologic Survey staff. I wish to reassure you that AEC does intend to provide a truly safe national repository.

Sincerely,

John A. Erlewine

John A. Erlewine
Assistant General Manager
for Operations

Enclosures:
1. Final Environmental Statement
2. Comments on Draft Statement
3. AEC Response to Comments
4. Press Release

AEC STAFF REPORT ON COMMENTS OF HONORABLE ROBERT DOCKING, GOVERNOR OF KANSAS, ON THE DRAFT ENVIRONMENTAL STATEMENT FOR THE PROPOSED RADIOACTIVE WASTE REPOSITORY NEAR LYONS, KANSAS

Transportation

Comment - Roadbeds and tracks in Lyons are in questionable condition. . .

Response - This comment goes beyond what we conceive to be the scope of an environmental statement. However, we have expanded the discussion on Transportation and noted that the Commission has received assurances from the Federal Railroad Administration that tracks and roadbeds on the routes over which radioactive waste will be shipped to the Repository will be inspected prior to the first shipment of waste.

Comment - Adequate designs for transportation systems have not been presented despite assurances that they will conform to the specifications of the D.O.T. and AEC.

Response - As noted above, this goes beyond the scope of the statement. However, transportation systems and interfaces will be addressed in the course of the design of the facility and development of its operational procedures.

Comment - The handling procedures to prevent sabotage or loss of fissionable materials are not described. In addition, container problems need to be treated for a variety of reasons.

Response - Handling and other operational procedures will be generally described in the Conceptual Design and Safety Report. Until the completion of the detailed design, these descriptions must be

considered preliminary. Similarly, procedures for the accountability of special nuclear materials are operating procedures and is contingent upon completion of the detailed facility design.

The statement has been revised to consider the questions raised concerning the containers of high-level wastes from the standpoint of (a) corrosion (Sec. V.B.1.g.), (b) movement after burial (Sec. V.B.1.b.), and retrievability (Sec. VI.E.).

Surveillance and Monitoring

Comment - Monitoring and surveillance is not adequately considered in the Environmental Statement.

Response - The final impact statement has been amplified in the discussion of the radiological and environmental monitoring programs (Sec. VI.D.). The details of these programs will be developed in consultation with appropriate Federal and state agencies during the design phases of this project.

Retrievability

Comment - The planning and implementing necessary to assure retrievability of high-level wastes are not provided . . . when the containers disintegrate, the particles of waste will be free to migrate.

Response - The position of the Commission on the question of retrieval of the high-level waste has been amplified in Sec. VI.E. As noted in testimony before the Joint Committee on Atomic Energy, this repository is a demonstration facility. During this period of demonstration pertinent calculational techniques and operational procedures will be verified by in situ measurements (Sec. VI.A.). All wastes buried during this period will be retrievable. The systems by which retrieval could be effected will be developed during the design of the facility.

The migration of isotopes has also been discussed in Sec. V.B.1.h. and Sec. V.B.2.c.

Geological and Site Integrity

Comment - The Kansas scientists are concerned with the effects of heat and radiation damage and subsidence as it relates to the integrity of the site.

Response - The Environmental Statement has been significantly revised to reflect our present knowledge about the proposed site and the additional studies required to confirm the present and future stability of the site. Specifically, these topics are covered in the following sections: (a) Thermal effects (Sec. V.B.1.), (b) Radiation damage (Sec. V.B.2.), and (c) Subsidence (Sec. V.B.1.d.).

from the K.U. NEWS BUREAU

THE UNIVERSITY OF KANSAS, LAWRENCE 66044
TOM YOE, Director - Phone: (913) 864-4630

LAWRENCE -- Officials of the State Geological Survey at the University of Kansas and the Atomic Energy Commission and other specialists have agreed to the need for a systematic plan of investigation on the proposed atomic waste repository in abandoned salt mines near Lyons and are mapping detailed study proposals for future research on the site.

The new understanding on research directions is a result of a high-level scientific meeting held Monday and Tuesday (April 5-6) at K.U.

During the talks, scientists from the AEC's Oak Ridge National Laboratory presented technical reports on heat flow and rock mechanics contingencies for close analysis by outside experts.

About 35 physicists, geologists and engineers from several universities and technological schools and from private firms attended the talks organized by the State Geological Survey. During the final afternoon session, the group split up to discuss rock mechanics and radiation damage.

Dr. William W. Hambleton, director of the Survey, said Oak Ridge scientists Dick Cheverton and Bill McClain demonstrated that the AEC staff is quite capable of performing the technical mathematical modeling of probable behavior of salt and shales under temperature and stress. Such modeling is necessary if researchers are to lay a firm groundwork for specific studies on the Lyons site.

The State Geological Survey has consistantly demanded more thorough investigations on the Lyons mines before action is taken to obtain Congressional funding for the repository.

Hambleton said both Oak Ridge scientists and local experts agree to the need for a systematic research plan. "The AEC will define a systematic program of investigations with checkpoints along the way for evaluation of research and analysis of the results."

By checkpoints, the director said he means technical meetings similar to the one held at K.U. this week. He envisions reports at such meetings from all concerned research agencies, possibly including the AEC and Kansas Survey staffs and other federal organizations, universities and private companies.

At each meeting, outside scientists would review findings and possibly determine new directions for study.

Dr. Hambleton and Dr. John Halepaska, Survey hydrologist who chaired the recent meeting, emphasized that accurate speculations on actual geological behavior at the mines and on the safety factors involved cannot be made on the basis of completed studies.

"To approach this complex problem rationally," Hambleton said, "we must first work out an accurate model and then apply facts obtained from research on the particular site."

The recent meeting was devoted almost entirely to the first phase of this approach--arriving at accurate mathematical models.

To forecast the safety of storing canisters containing solidified atomic wastes in the Lyons mines at this point is also an impossibility. In fact, Halepaska said, this might be the third phase of the study, coming after development of models and application of specific facts.

"We can hardly consider or even talk about safety until we have developed the necessary mathematical tools," he said,

Dr. Hambleton said he foresees a great deal of cooperation among various private, state and national agencies in carrying out the proposed research plan. The Kansas Survey, the AEC administrators in Washington, D.C., and the staff at Oak Ridge have been in close contact.

Dr. Hambleton expects to have a fairly solid research program with a detailed timetable for projects and scientific review sessions laid out by the end of April.

"The AEC is willing to engage in the studies we believe should be done," he said. Under the timetable they hope will be adopted, he and Halepaska projected that scientists would be able to make a valid appraisal of the project's feasibility in about two years.

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STATE OF KANSAS

Office of the Governor

STATE CAPITOL BUILDING
TOPEKA, KANSAS 66612

ROBERT B. DOCKING
GOVERNOR

February 22, 1971

Mr. John A. Erlewine
Assistant General Manager for Operations
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Erlewine:

I am pleased to submit the recommendations and concerns of the appropriate state agencies and citizens of Kansas with respect to the November 1970 draft of the Environmental Statement, Radioactive Waste Repository, Lyons, Kansas. We advise the recommendations in the attached Report be included in the final draft of the Environmental Statement.

The concept of isolating radioactive wastes from the natural environment to protect the health and welfare of our citizens is a positive step toward the goals of the National Environmental Policy Act. The efforts of the Atomic Energy Commission to develop methods of reducing the waste volume and permanently disposing of them in impermeable rocks are necessary and commendable.

Because bedded salt deposits presently offer one of the more satisfactory methods for disposal of radioactive waste and a site near Lyons, Kansas, has been chosen as the repository location by the Atomic Energy Commission, the State of Kansas is responsible to its citizens for assuring the safety of the project over thousands of years. Despite the fact that we cannot conceive of all problems which may arise, investigation must be undertaken with respect to those problems which are foreseeable and which are herewith recommended.

The major problems not covered adequately by the Environmental Statement fall into the categories of transportation, geological and site integrity, surveillance and monitoring, and retrievability. These problems are reviewed in considerable detail in the enclosed Report.

The Atomic Energy Commission has limited itself initially to a discussion of only rail transportation. Some of the railroad beds and tracks in Kansas over which these loads would necessarily traverse to reach Lyons are in questionable condition and further investigation is necessary to assure the

safety of delivering shipments to the site. In addition, adequate designs of the transportation system have not been presented despite reassurances from the Atomic Energy Commission that they will conform to the specifications set by the Department of Transportation and the Atomic Energy Commission. The handling procedures to prevent sabotage or loss of fissionable material are not described. In addition, the container problems need to be treated in greater depth for a variety of reasons.

Monitoring and surveillance is not adequately considered in the Environmental Statement. The Atomic Energy Commission contracted with Kansas scientists to make a preliminary site evaluation and their recommendations that the site be monitored before, during, and after its use as a repository have not been acknowledged. The surveillance of the ecological, meteorological, hydrological, geological, radiological, and thermal factors must also be instituted as soon as possible to allow the detection of any serious alteration in the environment of this site.

According to our Kansas scientists, the planning and implementing necessary to assure retrievability of the high level wastes are not provided. The only provision cited which allows recovery is the documentation of the location of casks. This is inadequate because the wastes are presently scheduled to be encapsulated in casks which will lose their integrity within a few years after burial. When the casks disintegrate, the solid particles of radioactive waste will then be free to migrate according to their heat and radioactive material content.

The Kansas scientists are concerned with the effects of heat, radiation damage and subsidence as it relates to the integrity of the site. They suggest that the evaluation in the Environmental Statement is based on a homogeneous bed of salt rather than the layered salt and shale which actually exists, and that therefore this evaluation may not be realistic.

I am concerned that the future of Kansas be protected and feel that the investigations recommended in the attached report must be undertaken promptly. The final draft of the Environmental Statement should indicate this intent.

On behalf of the people of Kansas, I would like to thank you for the opportunity of reviewing and commenting on the Environmental Statement. Our objectives are similar--to assure the safety and welfare of the people while disposing of a hazardous waste in a permanent and safe location. I feel sure that the Atomic Energy Commission wishes to provide a truly safe national repository.

With every good wish.

Very truly yours,

Robert Docking
Governor of Kansas

Enclosure

Report on

THE ATOMIC ENERGY COMMISSION'S ENVIRONMENTAL STATEMENT

To

Governor Robert B. Docking

by the

Advisory Council on Ecology

on

February 22, 1971

In December of 1970, the Atomic Energy Commission forwarded a Draft of the Environmental Statement, Radioactive Waste Repository, Lyons, Kansas, to the Governor of Kansas for review and comment. Governor Docking transmitted the Draft to the Advisory Council on Ecology for preparation of a statement to the Atomic Energy Commission.

The Advisory Council on Ecology distributed the Environmental Statement to its members and members of the Kansas Nuclear Energy Council, Kansas Academy of Science, Kansas Department of Health, Kansas Geological Survey, and knowledgeable citizens for comment. This report has been compiled by the Advisory Council on Ecology from the responses received.

General Comments

The Environmental Statement does not include a documentation that permits evaluation of all aspects of the facility, a description and degree of implementation of continuing studies and development programs prescribed in the qualified endorsement of NAS-NAC Committee, and it is recommended that this be included in the revised draft.

A better organization of the Statement, use of standard language, and the inclusion of a bibliography would allow scientists and those with a legitimate interest to have a better knowledge of the proposal.

Adequate designs for the transportation system and receiving facilities are not yet available. The proposed National Academy of Science Committee on Transportation, which is to aid in the development of these designs, should be appointed as soon as possible and charged with examining the possibilities for a safe transport system, which would include alternate modes of transportation.

Report on AEC's Environmental Statement
To Governor Robert Docking
February 22, 1971

The report of the National Academy of Science's Committee on Radioactive Waste Management is cited as concluding that the bedded salt use for disposal of radioactive waste is "satisfactory pending additional conformatory data and evaluation."

It is recommended that the A.E.C. document the additional data and evaluations which the Committee indicated are required to assure the safety of the project. Without this information, and the plans which the A.E.C. has to obtain the information, the Environmental Statement is little more than a review of existing incomplete knowledge.

Environmental Impact

The impact of the disposal of waste on the geological environment needs additional consideration because of several factors.

Heat - The thermal impact of the project cannot be adequately estimated because the project has been designed without a clear understanding of heat diffusion problems. Models used for solution of the complex heat-flow problem have been based upon a rock section consisting of units of pure salt and pure shale. The actual rock section consists of laminated salt and shale, and analytical results may be very erroneous. The analytical solutions for heat flow and temperature distribution assume homogeneous and isotropic media in two dimensions only for steady and unsteady conditions, and are based on constant rock properties. Furthermore, heat flow per cannister is an assumed value, and actual values have not yet been determined. The Kansas Geological Survey calculations, based on introduction of 10 and 20 foot shale layers, 15 and 55 feet above the mine, indicate a 34 percent rise in the peak temperature of the mine as compared with a peak temperature in pure salt. Physical properties of rocks do change with temperature, and the physical properties of salt especially are susceptible to temperature change. Some of these property changes range from the fourth to the tenth power of the temperature. In addition, we have no measure of pore pressures that may develop in fluid-bearing shales.

Radiation Damage - As long as the waste containers maintain their integrity, only small quantities of salt would be subject to high-energy, heavy-particle radiation. However, release might occur once or twice a year for about three years by rapid melting or explosion. This could cause the containers to migrate to lower depths, possible to shale layers, and faults could develop in overlying rocks because of explosions. However, the metal containers as designed are expected to begin to deteriorate within six months, and the ceramic material containing the radioactive wastes is

expected to deteriorate within several years. As a result, radioactive particles could migrate through the salt. If the particles are heavy, downward migration might occur due to localized melting; if they are light they might migrate upward. Water is available in the salt, and the waste particles could be suspended by turbulent boiling. Furthermore, the solid particles would expose the salt to significantly higher radiation doses. The ceramic material in the containers also can store energy. Gamma radiation can cause chemical breakdown of salt and radiolysis could result in formation of new chlorine compounds that are capable of leaching plutonium. Thus, statements that burial locations for each container will be accurately surveyed and recorded so that precise location of the wastes will be known are incorrect. The recovery of dispersed wastes in a hostile environment at high temperature and radiation levels is also difficult. Although the staff of Oak Ridge National Laboratory and the A.E.C. have stated that the technology for such recovery is available, no design concept has been submitted for review.

The effects of radiation damage to salt have not been adequately examined. Samples of salt obtained from the Salt Vault site at Hutchinson show energy storage of approximately 10 to 50 calories per gram from gamma radiation. Samples of salt irradiated with protons from the Van de Graaff Accelerator show energy storage as high as 80 calories per gram. A problem arises from the potential capacity of the salt to undergo rapid thermal excursion through sudden release of the stored energy. The release of 80 calories per gram would cause temperatures in the affected region to rise from 300°C. to 620°C. These high temperatures could result in greater flowage of salt around the containers and could cause an explosive effect due to sudden thermal expansion.

Geologic Integrity - The geophysical impact of the project is based on the assumption that the impermeability of the salt bed will protect against release of radioactive material to underground water resources, and that the salt deposits are free of circulating groundwaters and are isolated from underground aquifers by essentially impermeable shale. Temperatures at the surface, in water bearing rocks, and in the salt are considered to be of relatively little significance. The report concludes that closure of the mine, caused by consolidation and recrystallization of crushed salt back-filled into rooms, will eventually find expression in very shallow subsidence at the surface. These movements are judged to be so slow and gradual that the surface and all intervening rocks will adjust to this deformation without deleterius effects, and any fractures which might develop will be readily healed by plastic deformation of the salt.

In general, it is true that the salt deposits are free of circulating groundwaters and are isolated from underground aquifers by essentially impermeable shale. However, these rocks never have been subjected to the thermal or radiological stresses that are assumed. Futhermore, there is reason to judge that the assumed stresses may be in error. Even so, some structural deformation is evident from our geological studies. The salt thins over structural highs, the Harper Sandstone exhibits numerous high-angle fractures which appear to be open, and the overlying Kiowa Formation exhibits high-angle fractures which do not appear to be open. Thermal and radiological stresses interacting with the stresses caused by consolidation and recrystallization of the salt could produce shear in overlying rocks, and subsidence of some magnitude.

Accordingly, the seal of overlying rocks could be broken, creating vertical permeability and permitting entry of surface or sub-surface waters. Our investigations of the sandstones of the Kiowa Formation reveal that water in them may be under artesian pressure. It is imperative that studies be continued to determine whether this underflow exists and whether it could feed a system of fractures. One can state with some certainty that access of water to the salt, at calculated or higher than calculated temperatures, would create a thermal convection and circulation system. Most certainly, solution of the salt would take place and the integrity of the storage site could no longer be maintained. The solution of these problems are crucial to the safety of the repository site.

The precise number of oil and gas wells on the site and the plan for sealing them should be included in the Environmental Statement. This is a vital consideration to the integrity of the bedded rock and must be completed before the operation of the repository is authorized.

The enclosed letter from Dr. Hambleton of the Kansas Geological Survey contains an orderly discussion of the thermal, geophysical, and radiological problems.

Ecological Impact

The ecology section of the Environmental Statement is inadequate. Despite the tremendous potential for ecological problems which the project presents, less than one page is devoted to this subject.

Radiological and Physiological Effects - Page 37 in the Statement concludes, "In general, no significant effect on wildlife populations is anticipated either in regards to numbers or in species composition."

The descriptions of the site ecology should include more than the bare mention of the vertebrate components. A statement of the functional relationships between all known components of the ecosystem is essential, along with a description of the required research.

Ecologists at Kansas State University conducted surveys and reported on various aspects of the site ecology. In the fall of 1970, they submitted extensive reports with recommendations. These scientists state that the determination of what is "significant effect" on the ecology is important and cannot be detected unless continual monitoring of the environment is instituted immediately.

Meteorological Effects - The climatological and meteorological section presented a very light overview of the wind patterns and velocities. An assessment of the potential problems related to the spread of escaped radioactive particulates or gases, and an adequate monitoring system to detect accidental releases to the atmosphere must be included. In view of some of the recent accidental releases of radioactive material, it is imperative that this problem receive further consideration, especially with respect to potential for carrying radioactive material downward over populated areas.

Surveillance and Monitoring - The need for monitoring to detect changes if they occur is essential. The continuous studies proposed by the Kansas State ecologists would monitor the effects of the repository site on the plant-animal ecosystem. These studies require acquisition of at least two (four would be more ideal) 160-acre tracts of land for purposes of establishing controls. Studies must be initiated prior to the development of the repository site if they are to be of any value in monitoring the effects of the operations on the site.

A surveillance and monitoring system for all aspects of the project should include the following:

a) Studies must be conducted before, during, and after the active storage of radioactive wastes, on the composition of the vegetation, populations of invertebrate and vertebrate animals, decomposers, and the radionuclide concentrations in important members of each trophic level in the area. Such studies must be made both on the repository site and on control sites with as similar soils and vegetation as it is possible to find. The control areas should be about five miles away, preferably to the east and west.

It is likely that the heat in the soil will alter the moisture relations and the biota to some extent. Even though change in the biota may well be acceptable, the extent of change must be determined, and we must know the source

and rate of increase if they occur. The control areas must be far enough away from the repository site so as to preclude radionuclide contamination, yet the areas should be close enough to determine normal radionuclide concentrations and to make comparative studies possible and to keep weather variations low.

b) Monitoring of radionuclide concentrations and thermal levels must be carried on in the atmosphere, stream, groundwater, and soil of the repository area, the control areas, and of selected other sites in Rice or adjoining counties. Such a plan should be included in the Environmental Statement.

c) Meteorological records must be collected before, during, and after storage of radioactive wastes, both on the repository site and on the control areas.

The enclosed letters from Dr. Robel and Dr. Hulbert contain more specific information on the proposed monitoring and surveillance programs which need to be initiated.

Transportation

The transportation problems are a major concern. The Atomic Energy Commission has apparently planned to utilize only railroad shipping for waste transport. The design plans for the unloading points include railhead transfer stations without provision for truck or air shipments. This decision has been made although the suitability of railroad beds to take the loadings associated with the large shipments and heavy shielded railroad cars is not mentioned.

If statements that the surface temperature of the high-level shipping casks will be approximately 350°C is correct, then the containers will not be in conformance with the A.E.C. or Department of Transportation regulations. If the casks are to approach this temperature, and no cooling system is included, then the railroad cars will constitute a hazard to railroad employees.

Utilities

Provision of adequate utilities is also important. Although the Environmental Statement suggests that ample electric capacity is available, recent communications indicate that the provision of service to the high level mine is dependent upon construction of a new substation by Kansas Power and Light Company. It is recommended that an emergency power supply be available in addition to the planned surface utility supply.

Report on AEC's Environmental Statement
To Governor Robert Docking
February 22, 1971

Retrieval

A primary concern with regard to the high level mine is related to the retrieval of the stored wastes. The Statement on P. 18-19 implies that because the storage site will be permanent, and because the circumstances requiring recovery are not obvious at the present time, no effort will be expended to plan or demonstrate a system which would allow recovery. This type of negative attitude could endanger the health and welfare of the citizens of the state of Kansas.

The facility must be designed to facilitate retrieval. The portion of the paragraph beginning on line 23 of page 18 of the Environmental Statement is misleading. Not only is there insufficient data available to demonstrate that the capsules can be relocated with precision after they have been buried for ten or more years, but the remote mining equipment which is necessary to accomplish this is not available.

Waste Containers

The report implies that the high level waste residues are to be encapsulated in high integrity containers. This concept is misleading if the capsules used by Oak Ridge National Laboratory during the Salt Vault tests are selected. The tested containers were light walled (0.125 inch) stainless steel containers which are well-suited to the operations involved in encapsulating the waste, but not suited for long-term integrity if the container is subjected to mechanical shock, internal pressure or the corrosive environment of the salt bed. In order to protect the safety of the working area and the surrounding environment, it is important that these containers be properly engineered for high integrity.

Waste packages of alpha wastes should be required to be sealed containers in standard sizes for handling and storage operations. The waste should be non-toxic, non-flammable solids with the same stipulation for the containers. In addition, the containers should be of sufficient structural integrity to sustain handling, stacking, and crushed salt backfilling operations. The returnable containers should not be restricted to rail car transport as discussed under transportation.

Waste-storage canister design should include consideration of canister structural integrity in bedded salt environments for reasonably long periods of time, concurrent with the design to facilitate retrieval of stored waste material. (Concrete compression members between concrete liners are a possibility.) This is important because the spacing of containers to preclude radioactive decay from heat creating excessive temperatures in the salt cannot be assured if the waste containers lose their integrity and are free to migrate in the salt.

To Governor Robert Docking
February 22, 1971

Site and Facilities

The Site Selection section of the report should include water as a valuable resource for the State of Kansas. The description of the site and requirements should include a stipulation for permanent bomb-resistant markers located at the corners of the site to serve as warning monuments to future generations. The peripheral surface area of the storage vaults should be dimensionally defined and marked. The sub-surface salt and mineral rights should also be acquired prior to authorization for the project with contingencies for expansion planned in order to provide a thermal cushion area. All planning for future repositories or expansion of the present site should be completed before the project is undertaken.

The alpha waste facility should mention the surveillance and control procedures to prevent fissionable material from being introduced into the waste storage area. A receiving inventory checking system, either in the surface facilities or in the mine, should be provided to assure control of strategic fissionable material or sabotage attempts. The A.E.C. should have plans, procedures, facilities and personnel for this surveillance system included in the Environmental Statement.

The description of the high level waste facility is vague. The facility will supposedly consist of a waste receiving building, a newly mined area underground, and miscellaneous surface support facilities. The miscellaneous surface support facilities should be described in detail as should the monitoring system for exhaust gases. Emergency plans for mine shutdown in the event of a power failure, accident, or other unforeseen problems must be discussed also.

There is no discussion regarding a surface holding area (swimming pool). Such a holding area is required and must be capable of accommodating a receival backlog created by one or more of the following conditions: (a) mining disruptions, (b) storage cavity drilling flow times associated with matching spacing requirements and radiation levels of waste containers, (c) uncoordinated surges in receival of waste material, and (d) high rejection rates from repository inspection of waste containers. These eventualities must be planned for and accommodated by the surface facilities.

Excess Salt Disposal

The discussion of the mine operation indicates that most of the salt will remain below the surface. This will be very difficult to accomplish as the rates of storage increase during the later years of operation. The mining operation will generate ever increasing quanitites of salt and will become a sizeable aspect of the repository operation. Space requirements for the mined salt indicate that disposal will become a critical problem. When this problem arises, it is recommended that the salt be sold to commercial outlets or deposited in other nearby salt mines as stated. The possibility of solution and injection into geological formations should not be considered.

December 2, 1970

PRELIMINARY REPORT ON STUDIES OF THE RADIOACTIVE WASTE DISPOSAL SITE AT LYONS, KANSAS

by

THE STATE GEOLOGICAL SURVEY OF KANSAS

Introduction

During August of 1970, the State Geological Survey of Kansas in cooperation with the U. S. Geological Survey, the U. S. Corps of Engineers, the State Department of Health, and Robert Walters of Walters Drilling Company initiated a detailed study of the surface geology, ground water hydrology, and subsurface geology of a nine-square-mile area centered on Lyons, Kansas. Included in the study are an evaluation of the possible effects of high-intensity radiation on salt in proximity to the radioactive waste containers, and heat transfer problems related to those containers. The State Geological Survey of Kansas, under Kansas statute 48-1601, is charged with responsibility for continuing studies on the geologic effects of storing radioactive materials in subterranean areas. The studies at Lyons have been supported by Oak Ridge National Laboratory and Union Carbide Company with funds, now approaching $100,000, provided by the Atomic Energy Commission.

Although a number of oil and gas exploratory test holes have been drilled near the site, little geological information was recorded for the rocks from the surface through the salt. Accordingly, Oak Ridge National Laboratory contracted with the U. S. Corps of Engineers to drill a hole at the northwest

corner of the 1,000-acre site. The Corps of Engineers was required to obtain a six-inch core from the surface through the salt to a depth of approximately 1,300 feet, to obtain a complete suite of geophysical logs, and to test water-bearing formations under direction from geologists of the State Geological Survey and the U. S. Geological Survey. This work has been completed and the core and logs have been brought to the offices of the State Geological Survey. The core has been slabbed and photographed in color. Additionally, one might note, the Geological Survey has been provided with an outstandingly complete record of these rocks; this record from the A.E.C. No. 1 core hole will be the object of continuing investigations for many years.

A second hole has been completed at the southeast corner of the proposed 1,000-acre repository site by the Corps of Engineers. The rocks were not cored, except through the salt section, but a complete suite of samples was obtained, along with a complete suite of geophysical logs and water samples.

Preliminary studies of the surface and near-surface geology and hydrology in the area have been completed by staff of the State Geological Survey. Approximately 40 shallow holes have been drilled, and extensive studies have been made (and are continuing) of outcropping rocks.

Preliminary Results of Surface and Subsurface Investigations

Ground water is the principal source of water supply for municipal, industrial, irrigation, stock and domestic use in

the Lyons area. All of the large wells, yielding 300 to 1,000 gallons per minute, are located in alluvial deposits in the Arkansas River Valley, Cow Creek Valley, and Little Cow Creek Valley south and west of the city of Lyons and the proposed repository. Thicknesses of these deposits range from a few feet to as much as 180 feet.

Sandstones of the Cretaceous Dakota Formation and Kiowa Formation also contain water of good quality for stock and domestic use. Sandstone beds, ranging in thickness from only a few inches to several tens of feet, occur throughout the Kiowa Formation, and are a potential source of water supply. The Stone Corral Formation of Permian age is the lowermost rock unit that may contain fresh water. It is approximately 18 feet thick and thins toward the outcrop area to the east.

Water samples were obtained from 29 test holes and 13 domestic supply wells. Standard chemical and radioactive analyses were performed by the State Department of Health; the Geological Survey analyzed all water samples for trace elements. All of the water analyzed is a hard, calcium bicarbonate type. Samples ranged from 250 to 650 parts per million of dissolved solids. The water is generally of good quality except in local areas where it is contaminated by sodium chloride from oil field brines or surface operations of salt mines.

The preliminary report of subsurface geologic conditions is derived from study of information from the two wells drilled by the Corps of Engineers, from study of the rocks in the salt mine shaft, and from records obtained from the files of the

Geological Survey and other sources. The lowest density of control points is in the central part of the proposed storage site.

The salt section is of nearly uniform thickness, and there is no evidence of any post-depositional solution at the top of the salt section. Salt ranges in thickness from 250 to 300 feet in the area. Some structural deformation is evident. The salt thins over structural highs, especially in the eastern part of the area in the vicinity of the abandoned Lyons gas field. Non-salt beds generally exhibit lateral continuity in the middle part of the section, with less lateral continuity in beds at the top and bottom of the section. No evidence of faulting was found, although the Harper Sandstone exhibits numerous high-angle fractures which appear to be open. It is possible that some fluid movement could occur along these fractures. High-angle fractures occur in the overlying Kiowa Formation also, but they do not appear to be open.

Preliminary Conclusions from Surface and Subsurface Studies

Preliminary studies of the surface geology and hydrology and subsurface geology reveal no structural or stratigraphic conditions that should cause concern with respect to the geologic conditions at the repository site. No unexpected conditions were revealed, and the rocks generally exhibit lateral continuity except for local structural highs and some thinning of salt and other rock units. The studies, however, will provide invaluable information for detailed analysis relating to heat flow.

Heat Transfer

Problems relating to heat flow and surface subsidence remain largely unsolved. To date, models used for solution of the complex heat-flow problem have been based upon a rock section consisting of a unit of pure salt and a unit of pure shale. Accordingly, the analytical solution for heat flow distribution assumes homogeneous and isotropic media in two dimensions only for steady and unsteady conditions. Furthermore, the heat flow per canister is an assumed value, and actual values have not yet been determined.

The actual rock section consists of laminated salt and shale. Trial calculations, based on introduction of ten and 20 foot shale layers, 15 and 55 feet above the mine, indicate a 34 percent rise in the peak temperature of the mine as compared to a peak temperature rise in pure salt.

Conclusions Regarding Heat Transfer

Oak Ridge National Laboratory and A.E.C. staff have exhibited remarkably little interest in the heat flow problem, and have not demonstrated capability for solving three-dimensional problems involving a complex laminated section. The interaction of subsidence, thermal expansion, and heat flow could be responsible for breaking the seal of overlying rocks, and permitting entry of surface or subsurface waters. The State Geological Survey regards solution of this problem as crucial to the safety of the repository site.

Energy Storage from Radiation Damage

Investigations have been undertaken by staff of the Geological Survey and Oak Ridge National Laboratory of energy storage in radiation-damaged salt. Samples of salt obtained from the project Salt Vault site at Hutchinson show energy storage of approximately 10 to 50 calories per gram from gamma radiation. Samples of salt irradiated with protons from a Van de Graaff Accelerator show energy storage as high as 80 calories per gram. A problem arises from the potential capacity of the salt to undergo rapid thermal excursion through sudden release of the stored energy. The release of 80 calories per gram would cause temperatures in the affected region to rise from 300° C. to 620° C. These high temperatures could result in greater flowage of salt around the containers, and could cause an explosive affect due to this sudden thermal expansion. As long as the waste containers maintain their integrity, only very small quantities of salt would be subject to high energy, heavy particle radiation. However, release might occur once or twice a year for about three years and melting or explosion might cause containers to migrate to lower depths, possibly to shale layers, and faults could develop in overlying rocks because of explosions.

In addition, the metal containers are expected to deteriorate within six months, and the ceramic material containing the radioactive waste is expected to deteriorate within several years. Accordingly, radioactive particles could migrate through the salt. If the particles are heavy, downward

migration might occur due to localized melting; if they are light they might migrate upward. Water is available in the salt, and the waste particles could be suspended by turbulent boiling. Furthermore, the solid particles would expose the salt to significantly higher radiation doses. Although the total expected dose per container is 2×10^{10} rads, we have indication that the dose may be significantly larger.

The ceramic silica glass also can store energy, and gamma radiation can cause chemical breakdown of salt. Radiolysis could result in formation of new chlorine compounds that are capable of leaching plutonium.

Conclusions Regarding Radiation Damage

Staff of Oak Ridge National Laboratory and the Atomic Energy Commission have exhibited remarkably little interest in studies of radiation damage. The State Geological Survey regards this problem as extremely critical to safe storage of radioactive waste at the Lyons site.

Transportation and Retrieval of Waste

Although the State Geological Survey has no direct responsibility for transportation problems and retrieval of radioactive wastes, we would be remiss if we did not call attention to these critical factors and reinforce the conclusions and concern of other state agencies involved in these problems. We judge that plans for safe transportation of these radioactive materials are completely inadequate and

that no contingency plans for retrieval of waste exists at all. We conclude that these two elements are critical and crucial to the safe storage of radioactive materials at the Lyons site.

The University of Kansas
STATE GEOLOGICAL SURVEY
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66044
Phone (913) 864-3101
WILLIAM W. HAMBLETON
State Geologist and Director
ERNEST E. ANGINO
Assoc. State Geologist and Assoc. Dire

January 15, 1971

Mr. Dale E. Saffels
Chairman
Advisory Council on Ecology
State Corporation Commission
State Office Building
Topeka, Kansas 66612

Dear Mr. Saffels:

I am responding to a letter from Governor Robert Docking, dated December 29, 1970, asking me to forward comments to you regarding a draft copy of Environmental Statement, Radioactive Waste Repository, Lyons, Kansas from the Atomic Energy Commission under covering letter from John A. Erlewine, and a report entitled Disposal of Solid Radioactive Wastes in Bedded Salt Deposits by the Committee on Radioactive Waste Management of the National Academy of Sciences. I am pleased to have opportunity to comment on these reports because I have been widely quoted in the newspapers as stating that I wrote the National Academy report, that the report endorses the Lyons site for radioactive disposal, and that I thereby express my approval and endorsement of the project. These statements are not correct. Actually, I served on the Panel on Disposal in Salt Mines of the Committee on Radioactive Waste Management, and I did make major contributions to the Panel report, which subsequently was reviewed and changed by the parent Committee. For the most part, I agree with the National Academy report, which does not give unqualified endorsement of the Lyons site, and contains many constraining statements. For example, under Summary and Conclusions, the Committee states that disposal in bedded salt is the safest choice now available, provided the wastes are in an appropriate form and the salt beds meet the necessary design and geological criteria. The Committee states that the site near Lyons, Kansas is satisfactory, subject to the development of certain additional confirmatory data and evaluation. The recommendations of the Committee for additional studies and investigations are the same recommendations of the Kansas Geological Survey, and I acknowledge

responsibility for making sure that they were a part of the report. Included in the recommendations are geological and hydrological studies, including cored and logged drill holes; study of subsidence of the mine, studies of radiation damage affects, further information on the thermal and mechanical properties of the salt beds and other key stratigraphic units, theoretical and experimental work using cored material to determine the possibility of thermally initiated flow patterns, additional information on thermal conductivity, thermal diffusion, thermal expansion and phase changes, and a waste retrieval plan.

I am disturbed to note an Appendix to the Committee report which was not a part of the original report. Seemingly, the statements in the Appendix were added gratuitously in an attempt to refute some of the concerns of the Committee.

As to the Environmental Statement, I find many parts of it to be general, meaningless, and a public relations effort design to relieve the fears of critics. Throughout the report, conclusions are based upon results derived from studies using simplified models or naive assumptions. The assumption is made that the impermeability of the salt bed will protect against release of radioactive material to underground water resources, and that the salt deposits are free of circulating groundwaters and are isolated from underground aquifers by essentially impermeable shale. Temperatures at the surface, in water bearing rocks, and in the salt are considered to be of relatively little significance. The report concludes that closure of the mine, caused by consolidation and recrystallization of crushed salt backfilled into rooms, will eventually find expression in very shallow subsidence at the surface. These movements are judged to be so slow and gradual that the surface and all intervening rocks will adjust to this deformation without deleterious affects, and any fractures which might develop will be readily healed by plastic deformation of the salt.

The report states that once radioactive wastes are emplaced in the salt repository they will be regarded as in permanent storage. Retrieval would only be considered in light of an objective safety problem under circumstances which to date have not been postulated. However, the facility will be designed so as not to preclude retrieval. The burial locations for each container will be accurately surveyed

and recorded so that retrieval by use of remotely controlled automatic mining equipment would thus be possible. With regard to transportation, solid wastes will be shipped in a special container by rail during initial years of operation, and wastes will be packaged and shipped in conformance with A.E.C. and Department of Transportation regulations. All of these statements should be scrutinized carefully.

Geological Integrity Of The Site

In general, it is true that the salt deposits are free of circulating groundwaters and are isolated from underground aquifers by essentially impermeable shale. However, these rocks never have been subjected to the thermal or radiological stresses that are assumed. Furthermore, we have reason to judge that the assumed stresses may be an error. Even so, some structural deformation is evident from our geological studies. The salt thins over structural highs, the Harper Sandstone exhibits numerous high-angle fractures which appear to be open, and high-angle fractures, which do not appear to be open, occur in the overlying Kiowa Formation.

Thermal and Radiological Stresses

The project has been designed without a clear understanding of heat diffusion problems. Models used for solution of the complex heat-flow problem have been based upon a rock section consisting of units of pure salt and pure shale. The actual rock section consists of laminated salt and shale, and analytical results may be very erroneous. The analytical solutions for heat flow and temperature distribution assume homogeneous and isotropic media in two dimensions only for steady and unsteady conditions, and are based on constant rock properties. Furthermore, heat flow per cannister is an assumed value, and actual values have not yet been determined. Our own trial calculations, based on introduction of 10 and 20 foot shale layers, 15 and 55 feet above the mine, indicate a 34 percent rise in the peak temperature of the mine as compared with a peak temperature in pure salt. Physical properties of rocks do change with temperature, and the physical properties of salt especially are susceptible to temperature change. Some of these property changes range from the fourth to the tenth power of the temperature. In addition, we have no measure of pore pressures that may develop in fluid-bearing shales.

The Oak Ridge National Laboratory and A.E.C. staff have exhibited remarkably little interest in a proper study of the heat flow problem, and have not demonstrated capability for solving three-dimensional problems involving a complex laminated section.

The affects of radiation damage to salt have not been adequately examined. Samples of salt obtained from the Salt Vault site at Hutchinson show energy storage of approximately 10 to 50 calories per gram from gamma radiation. Samples of salt irradiated with protons from the Van de Graaff Accelerator show energy storage as high as 80 calories per gram. Thus, an additional thermal problem arises from the potential capacity of the salt to undergo rapid thermal excursion through sudden release of the stored energy. The release of 80 calories per gram would cause temperatures in the affected region to rise from 300° C. to 620° C. These high temperatures could result in greater flowage of salt around the containers and could cause an explosive affect due to the sudden thermal expansion. Thus, thermal and radiological stresses interacting with the stresses caused by consolidation and recrystallization of the salt could produce shear in overlying rocks, and subsidence of some magnitude.

Accordingly, the seal of overlying rocks could be broken, creating vertical permeability and permitting entry of surface or subsurface waters. Our investigations of the sandstones of the Kiowa Formation reveal that water in them may be under artesian pressure. It is imperative that studies be continued to determine whether this underflow exists and whether it could feed a system of fractures. One can state with some certainty that access of water to the salt, at calculated or higher than calculated temperatures, would create a thermal convection and circulation system. Most certainly, solution of the salt would take place and the integrity of the storage site could no longer be maintained. The State Geological Survey regards solution of these problems as crucial to the safety of the repository site, and urges most strongly that studies be undertaken immediately.

Retrieval Problems

As long as the waste containers maintain their integrity, only small quantities of salt would be subject to high-energy, heavy-particle radiation. However release might occur once or

twice a year for about three years and melting or explosion could cause containers to migrate to lower depths, possibly to shale layers, and faults could develop in overlying rocks because of explosions. In addition, the metal containers are expected to begin to deteriorate within six months, and the ceramic material containing the radioactive wastes is expected to deteriorate within several years. Accordingly, radioactive particles could migrate through the salt. If the particles are heavy, downward migration might occur due to localized melting; if they are light they might migrate upward. Water is available in the salt, and the waste particles could be suspended by turbulent boiling. Furthermore, the solid particles would expose the salt to significantly higher radiation doses. The ceramic material also can store energy, and gamma radiation can cause chemical breakdown of salt. Radiolysis could result in formation of new chlorine compounds that are capable of leaching plutonium. Thus, statements that burial locations for each container will be accurately surveyed and recorded so that precise location of the wastes will be known are relatively meaningless. Furthermore, the recovery of these dispersed wastes in a hostile environment at high temperature and radiation levels is scarcely a trivial problem. Although the staff of Oak Ridge National Laboratory and the A.E.C. have stated that the technology for such recovery is available, no design concept has been revealed.

Transportation

Although not really within the competence of the staff of the Geological Survey, our views concerning transportation are stated here in order to reinforce the expressed concerns of competent staff in other state agencies. If statements that the surface temperatures of transportation casks will be approximately 350° C. are correct, most certainly these containers will not be in conformance with A.E.C. and Department of Transportation regulations. Furthermore, railroad roadbeds in Kansas are judged by authorities to be in exceedingly poor condition. Adequate designs for a transportation system have not been revealed, and to the best of our knowledge the proposed National Academy of Sciences Committee on Transportation has not yet been appointed.

I hope that these comments will be useful to you in assembling comments for the development of a statement by Governor Docking, and I enclose an additional copy of our preliminary report dated December 2, 1970 for your possible use.

Sincerely yours,

William W. Hambleton
Director

WWH:ds

Enclosure

KANSAS STATE UNIVERSITY *Manhattan, Kansas 66502*

DIVISION OF BIOLOGY

February 2, 1971

Mr. Dale E. Saffels, Chairman
Advisory Council on Ecology
State Corporation Commission
Fourth Floor, State Office Building
Topeka, Kansas 66612

Dear Mr. Saffels:

In response to the letter from Governor Docking of December 29, I am sending the following comments concerning the detailed environmental statement on the proposed Radioactive Waste Repository at Lyons, Kansas. My first comment is in the subject area in which I have the most competence. The others are more general comments.

1. The statement assumes, on the basis of planning, that there will be no change sufficient to affect the biota, including man, either from the heat produced or from radioactive wastes in the environment. I am willing to accept that this is probably so, but this is an experimental undertaking and we cannot guarantee that it is so. The escape of radioactivity from the recent underground nuclear test in Nevada, which planners said would not occur, and the problems encountered in the lunar space craft, where extreme care is used to assure success, both attest to the fact that perfection is not assured. Perhaps equally important, even if no adverse effects do arise, it will be important that we be able to establish that no effects did occur. It will be likely that someone in the area around the repository who gets sick, or who has livestock or plants that get sick, will accuse the repository for causing the malady. Without constant surveillance and study, we will not be able to know whether such accusations are true or false. In addition, in any experimental facility we need to check on all possibilities in order to learn as much as possible from the experiment and to detect unintended effects. For these reasons I consider it essential that we in Kansas require that the policy statement include the following:

   a. Studies must be conducted before, during, and after the active storage of radioactive wastes, on the composition of the vegetation, populations of invertebrate and vertebrate animals, decomposers, and of the radionuclide concentrations in important members of each trophic level in the area. Such studies must be made both on the repository site and on control sites with as similar soils and vegetation as it is possible to find. The control areas should be about five miles away, preferably to the east or west.

   It is likely that the heat in the soil will alter the moisture relations and the biota to some extent. Even though the change in the biota may well be acceptable to us, it is of great importance to know what the change is. Less likely is the possibility of radionuclide concentrations in the biota becoming hazardous, but we must know whether these levels are high or low, and we must know the source and rate of

increase if they occur. For all these changes it is essential that control areas a few miles away be established for comparison studies, preferably one east and one west. The control areas need to be far enough away to have radionuclide concentrations that might come from the repository at a level low in comparison to the repository site, yet the areas should be close enough to make comparative studies easy and to keep weather variations low.

b. Monitoring of radionuclide concentrations must be carried on in the atmosphere, stream, groundwater, and soil of the repository area, the control areas, and of selected other sites in Rice or adjoining counties.

c. Meterological records must be collected before, during, and after storage of radioactive wastes, both on the repository site and on the control areas.

2. The statement on p 36 says that there is only one low-producing oil well on the repository site and that other information from the area indicates that no significant mineral resources underly the repository site. A petroleum geologist at Saline, O. S. Fent, recently told me that he understands that one new producing well was drilled on the area, and that more drilling is in progress. It would appear that the statement needs to be modified in light of this. It also seems pertinent to have competent personnel see if this affects the plans for the site. Finally, it emphasizes the fact that judgements given in the statement can be incorrect.

3. On the basis of what I know, I urge that we in Kansas require that the excess salt be disposed of preferably by sale or storage in another mine, or if these are not possible, by shipment to the ocean, although this latter possibility is not desirably ecologically. I believe it would be unwise to convert the excess salt to a brine and inject it into the Arbuckle Formation, because we lack sufficient knowledge of possible effects of such injection. For example, the argument that such disposal by petroleum industry has worked well does not seem valid, as they remove more than they inject. The injections of material near Denver are suspected of having some detrimental effects in that area. If the brine were to later move into a fresh-water acuifer, the economic effect would be considerable.

4. It seems to me wise to have the State of Kansas receive some financial remuneration for the storage of radioactive wastes in the state. The method is not my concern, but might be a certain amount per cask of waste shipped to Lyons. The reason I suggest this is that we are the ones to most suffer if something does not work out as planned at the facility, and one way to reduce the chance of this is to have the State, or a reliable independent laboratory selected by the state, conduct surveillance, in addition to

surveillance conducted by the AEC. I am aware that the AEC is trying to plan well, and is concerned with safety. However, there can be honest mistakes, and also it is possible for the AEC to become a promoter of nuclear power with a zeal or method that causes carelessness or oversight. If the state also is keeping watch, the chance of wrong procedures continuing long unnoticed are diminished. Surveillance by the state will cost money, and it certainly seems right that the cost be a part of the cost of power production, and not come from the general tax sources of Kansas.

It is not clear to me what the steps are in developing the Lyons Project, so I am not sure if all of the above comments are meant to be covered by the environmental statement of AEC. However, the lack of understanding of steps can be one of the ways that mistakes are made, so it seems wise for us to ask about these points and to follow up on them until we are sure they are satisfactorily resolved. I will be glad to amplify on any of my statements expressed herein.

Sincerely,

Lloyd C. Hulbert

Lloyd C. Hulbert
Associate Professor

LCH:kd

KANSAS STATE UNIVERSITY *Manhattan, Kansas 66502*

DIVISION OF BIOLOGY

February 9, 1971

Mr. Dale E. Saffels, Chairman
Advisory Council on Ecology
Kansas Corporation Commission
Fourth Floor, State Office Building
Topeka, Kansas 66612

Dear Dale:

This letter is being drafted in response to the November 1970 Environmental Statement on the proposed Radioactive Waste Repository compiled by the United States Atomic Energy Commission. My comments will be slanted toward the potential effects of this project on the plant-animal community since you and Dr. Hambleton will treat the transportation and geological portions respectively.

The statement by AEC that "No significant impact on the environment resulting from either the construction or operation of the proposed repository is anticipated" is well and good. However, there are no plans to monitor the environment to detect changes if they do occur. Without continual monitoring of this "experimental project", no scientist can say in 25 years that there were no adverse effects..... similarly in 25 years, AEC could not defend itself against charges of adverse effects if no monitoring takes place. I have great confidence in AEC's engineering capabilities, however if their interpretation of environmental relationships is actually as naive as their report seems to indicate, then I feel even more strongly that we must have independent (state) controls on this project. The AEC report devotes less than one page to the effects of the proposed project on the ecosystem. What is stressed is that (page 37) "In general, no significant effect on wildlife populations is anticipated either in regards to numbers or in species composition." One might question what is "significant" to AEC, likewise, what do they mean by "anticipated." Few plans are ever foolproof as exemplified by the accident at the Idaho Falls plant in 1961, the accident at the Windscale Works in England (400 square miles contaminated), the nerve gas accident in Skull Canyon, the escape of radioactive materials from recent underground nuclear blasts in Nevada, the high level releases of strontium 90 from the Nuclear Fuel Services plant in New York, etc. None of these were anticipated, but they did happen as have many many more such unanticipated events which we term accidents.

In an attempt to obtain some ecological information on the proposed repository site, AEC contracted seven ecologists at Kansas State University (via the Oak Ridge National Laboratory) to conduct surveys of the area and to then recommend precautionary measures to insure the protection of the environment at the Lyons site. These seven reports were submitted to AEC in September and October of 1970 and constituted over 130 pages of material. None of these data is mentioned in AEC's environmental statement nor are any of the recommendations mentioned in AEC's statement. All seven of the ecologists

in Kansas recommended independently that continuous studies must be conducted on the site to detect changes if they occur. No such plans are mentioned in the November 1970 environmental statement prepared by AEC. If AEC does not plan to do this, then the State of Kansas must conduct them for its own protection. The continuous studies proposed by the Kansas State ecologists would essentially monitor the effects of the repository site on the plant-animal ecosystem. These studies would require acquisition of at least two (four would be more ideal) 160-acre tracts of land on which to conduct research. The data collected on these control sites would then be compared to similar data collected from the repository site. These studies must be initiated prior to the development of the repository site if they are to be of any value in monitoring the effects of the operations on the site.

Recommended studies included, but were not limited to, the following areas.

1. An evaluation of the potential effects of chronic and accidental releases of radioactive wastes into the environment.

   a. Pathways and flow rates of ^{90}Sr, ^{137}Cs, ^{244}Cm, ^{241}Am, and Pu through the terristrial ecosystem.

   b. Pathways and flow rates of ^{90}Sr, ^{137}Cs, ^{244}Cm, ^{241}Am, and Pu through the aquatic ecosystem.

   c. Potential dispersal of radioactive contamination to humans in the 40 to 60-mile area surrounding the Lyons site via terrestrial animals.

   d. Potential dispersal of radioactive contamination to humans in the Arkansas River Drainage via aquatic organisms (this includes Hutchinson, Wichita, and Arkansas City in Kansas)

   e. Changes in species composition of the flora and fauna on the Lyons site; most critical in this area are the natural balances in the ecosystem, i.e., populations of ectoparasites are known to increase rapidly in response to very small changes in radioactive contamination and ectoparasites are known to transmit many diseases to humans, livestock, and plants.

2. Potential effects of temperature changes on the ecology of the site.

   a. Effects of a 10-14^{o}F temperature increase on the deep (60-70 ft) root systems of trees on the area.... including those in Lyons itself.

   b. Effects of a 3 to 5^{o} temperature increase on the deep (3 to 15 ft) root systems of perennial grasses and herbs.

   c. Effects of a 1^{o}F or more temperature increase on the biota of soil, especially the incubation time of eggs of economically important insects and the reproductive potential of pathogenic bacteria.

d. Changes in soil-water interactions due to changes in soil temperatures, primarily those affecting soil fertility and decomposition action of bacteria.

e. Potential effects on Cow Creek of temperature increases in the subsurface and surface runoff water from the site.

The above are but a few of the types of unanswered questions posed by ecologists. Funds and manpower are needed to answer them. Many issues have not even been mentioned in AEC's environmental statement, including the increased cost of road and residence maintenance due to subsidence on the area, increased costs for the Lyons citizenry to cool drinking water taken from warm aquifers, etc. Until we have answers to many of the above questions or at least are assured that these questions will be given serious consideration, I strongly recommend that the Advisory Council of Ecology advise Governor Docking not to accept, as adequate, the November 1970 environmental statement prepared by the United States Atomic Energy Commission. I would recommend further that the Advisory Council on Ecology make its reactions known, via the Governor of the State of Kansas, to the Environmental Protection Agency and the President's Council on Environmental Quality.

Sincerely,

R. J. Robel, Vice Chairman
Advisory Council on Ecology

RJR/fg
cc: Governor Docking
Dr. William Hambleton

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 4 1971

Honorable Robert J. Dole
United States Senate

Dear Senator Dole:

Thank you for your letter of March 29, 1971, enclosing a copy of the statement you filed with the Joint Committee on Atomic Energy which we understand represents your comments on the draft Environmental Statement for the proposed radioactive waste repository near Lyons, Kansas. The final statement has been revised to reflect your comments to the maximum extent possible. Also, we have made numerous additions and revisions in response to comments received from Federal agencies and Governor Docking of Kansas. We believe the enclosed statement conforms with the letter and spirit of the National Environmental Policy Act of 1969. Also enclosed is a report indicating the disposition of the comments contained in your letter, including the comments made a part of your statement from the Senate Committee on Public Works. In this report we have not attempted to respond to specific comments but we have referenced the sections of the Environmental Statement which have been revised or amplified in response to your concerns.

We note that many of the comments call for information and answers which cannot be included in an environmental statement which must be prepared in advance of doing the work which will provide the answers. However, we do intend to address these matters during the course of the design of the facility and development of the operational procedures. As we have previously stated, this project will be reviewed by the statutory Advisory Committee on Reactor Safeguards where these issues will be fully explored. In addition, we have included in the final statement an extensive bibliography of published works on the salt mine concept including related research and development.

We will keep you informed of significant developments on this project and assure you of our intention to work closely with officials of the State of Kansas in developing the necessary assurance that this facility can be constructed and operated without endangering the health and safety of the citizens of Kansas.

Sincerely,

John A. Erlewine

John A. Erlewine
Assistant General Manager
for Operations

Enclosures:
1. Final Environmental Statement
2. Comments on Draft Statement
3. AEC Response to Comments

AEC STAFF REPORT ON COMMENTS OF SENATOR ROBERT J. DOLE ON THE DRAFT ENVIRONMENTAL STATEMENT FOR THE PROPOSED RADIOACTIVE WASTE REPOSITORY NEAR LYONS, KANSAS

Unanswered Questions

Comment - A complete discussion of the effects of the proposed project on the environment should be available in the technical scientific literature and should be incorporated into the Environmental Statement.

Response - The Environmental Statement has been revised to include a bibliography of pertinent reports (Sec. X) relating to the development of the salt disposal concept as well as related waste management research and development.

Radioactive Emissions - Continuous Monitoring

Comment - Radioactive emissions from any proposed repository should not be allowed to exceed those required throughout the nuclear industry.

Response - The Environmental Statement has been amended to include a discussion of radiological and environmental monitoring which will be carried out in connection with the operation of the repository (Sec. VI.B.1.). The facility will be designed to maintain the releases of radioactive materials from the facility to the lowest practical levels and below applicable regulations.

Retrieval

Comment - There is no indication of the steps that would be taken should retrieval be required at a later time. These possibilities must be evaluated and an objective safety program provided for -- before actual construction begins.

Response - The position of the Commission on the question of retrieval of the high-level wastes has been amplified in Section VI.E. As noted in the revised Statement, this repository is a demonstration facility. During this period of demonstration, pertinent calculational techniques and operational procedures will be verified by in situ measurements, (Sec. VI.A.). All wastes buried during this demonstration period will be readily retrievable. The systems by which retrieval could be effectuated will be developed during the design of the facility.

Effect on Groundwaters

Comment - There is no data presented in the Environmental Statement on the relationship of the groundwaters used as water sources for the communities of Lyons, Sterling, and Chase to the groundwaters in the vicinity of the proposed site. Should these groundwaters be from the same geologic aquifers, there would be a risk of not only contaminating these water supplies but also the disruption of water supplies. This question requires resolution prior to the initiation of construction.

Response - The portion of the Environmental Statement describing the details of the near surface aquifer systems existing at the repository site has been expanded to show the general relationship of the aquifers at the site and local groundwater supplies. Additionally, the Statement reflects the fact that there are on-going hydrologic studies being carried out at the site to assure that there is adequate isolation of the salt from the overlying water-bearing formations. The effluent control systems (Sec. VI.D. and Sec. VIII.B.) state that there will be no liquids released from the facility and the effluent control systems which will be incorporated into the facility will prevent any significant contamination of local groundwater supplies.

Comment - There is also need for further information on the potential effects of the future development of groundwaters on the salt beds to be employed.

Response - As part of the site evaluation studies, the effect of future changes in groundwater use patterns or control rates will be evaluated in terms of their effect on the future stability of the salt beds.

Comment - Public health and environmental policy should dictate resolutions of these points preferably before site development is initiated, but definitely before the site is used for the disposal of solidified radioactive wastes.

Response - The Commission has publicly stated in testimony before the Joint Committee on Atomic Energy and before members of the Kansas State Legislature that wastes will not irrevocably be buried at the facility until all significant safety questions have been adequately resolved. It should be noted that certain confirmatory tests and measurements will require the emplacement of radioactive wastes within the salt. However, as noted in Sec. VI.E. of the Statement, these wastes will be buried in a fully retrievable form.

AEC STAFF REPORT ON COMMENTS RECEIVED FROM STAFF OF THE SENATE COMMITTEE ON PUBLIC WORKS ON THE DRAFT ENVIRONMENTAL STATEMENT FOR THE PROPOSED RADIOACTIVE WASTE REPOSITORY NEAR LYONS, KANSAS

General Comments

Comment - There is inadequate documentation of the soundness of the salt disposal concept by non-nuclear professionals.

Response - The statement has been revised to include a bibliography (Sec. X.) and an expanded section (Sec. II) on the background of the project.

Comment - Salt domes represent a significant alternative - further explanation for the rejection of salt domes is warranted.

Response - The revised statement includes an expanded section (Sec. IV.) outlining the rationale for excluding domes as a site for the initial repository.

Comment - The statement does not include any discussion of the environmental monitoring programs.

Response - Statement revised to indicate that monitoring programs will be developed and implemented.

Comment - Where alternatives are discussed, plans of other countries should be discussed.

Response - We do not believe such a discussion is appropriate for inclusion in this statement. The IAEA recently held a symposium on the ultimate disposal of radioactive waste dealing with the waste management plans of other nations. This report should be available in the near future.

Specific Comments

Comment - The risks of the transport system as a whole should be analyzed.

Response - We do not believe that such an analysis is appropriate for inclusion in the impact statement on the repository. We believe that existing regulations and regulatory processes are adequate to assure the safety of existing and proposed transport systems. The section on transportation and packaging of radioactive wastes (Sec. VI.F.) has been expanded to reference the applicable regulations of the DOT and AEC.

Comment - Although risks attendant to repository operations are small, detailed analyses appear desirable.

Response - As noted in Sec. VI.D. of the revised Statement, questions related to the safety of facility operations will be adequately addressed in the Conceptual Design and Safety Report, currently in preparation.

Comment - Details on how perpetual care will be carried out is unclear.

Response - Regulation (10 CFR 50) requires the Government to own the property on which repositories are located. The nature and extent of perpetual care will be developed in the course of determining charges to the repository users of which perpetual care will be a part.

Comment - Data is needed on the radioactive elements of biological significance, their chemical form and solubility.

Response - The statement has been modified (Sec. III.) to include this information.

Comment - No evaluation is included of the possibility of accidents during transport. Conformation with DOT/AEC rules is not the only issue.

Response - It does not appear appropriate to include in the impact statement a discussion of the adequacy of existing and internationally accepted standards regarding the shipment of radioactive wastes. As previously noted, the statement covering transportation (Sec. VI.F.) has been expanded.

Comment - There is no discussion of the risk of spills, methods used to deal with spills or effect of spills on operations.

Response - Discussions of potential accidents which could occur within the facility, including spills and safety systems (Sec. VI.D.) which will be employed to mitigate the consequences of potential accidents are operational considerations and will be described in the Conceptual Design and Safety Report.

Comment - No statements are made concerning the steps that would be taken should retrieval be required . . . an objective safety program for retrieval is needed at this point.

Response - An expanded statement covering the Commission's position on retrieval has been included in the revised document (Sec. VI.E.). However, the concepts for such plans are matters which can only be developed in the course of the design of the facility and during the demonstration phase.

Comment - No evidence presented that radioactive materials will not intrude into the adjacent mine.

Response - The operating American Salt Company mine workings are located approximately 1800 ft from the active repository workings. The revised Environmental Statement presents (Sec. V.B.2.c.) estimates concerning the migration of radioactive materials through solid salt. These estimates indicate that particles of solidified wastes will move at a rate less than 1/10,000 of an inch in one million years.

Comment - Once a vault or mine area is opened up at depth, fractures in salt will not recrystallize under lithostatic pressure.

Response - If the comment has been interpreted correctly, it would suggest that closure, collapse and subsequent recrystallization does not occur in mined out areas. This statement does not appear to be supported by available evidence. The Lyons mine is presently undergoing closure. See Section V.B.1.d. for discussion on Geophysical Impact.

Comment - Once a hole is opened up, it will fill from the sides and top and may cause the formation of cracks along which infiltrating downward percolating waters may flow to dissolve larger cavities.

Response - The potential for the initiation of solutional processes by various means is being evaluated as part of the ongoing site studies and has been addressed in the revised Statement (Sec. V.5.b.c.).

Comment - The implication that estimates of the westward migration of the salt front (i.e., 5 miles in 1 million years) may not be valid for the future, considering future man-made alterations in the geohydrologic regime.

Response - The potential for adverse alterations in the regional hydrology will be assessed as part of the ongoing site evaluation studies.

Comment - The two most significant factors are seismic activity and the potential for groundwater contamination (after earthquake).

Response - As noted in Sec. VI.D., the facility will be designed to maintain confinement and safe-shutdown capability in the event of an earthquake of intensity appropriate to the site. Details of the facility earthquake design criteria will be outlined in the facility Conceptual Design and Safety Report. The potential for seismic events which would compromise the integrity of the salt will be evaluated after completion of ongoing site studies. Studies carried out thus far reveal that there are no structural or stratigraphic conditions which would suggest that the site is unsuitable for the proposed use.

Comment - No evidence is presented to support the contention that the heat effect will counteract subsidence. Since the temperature effect (i.e., thermal expansion) does not take place immediately consideration should be given to this problem, particularly as it applies to contamination of the groundwater.

Response - The general topic of expansion, subsidence and thermal effects has been expanded in the revised statement (Sec. VI.B.1.d. and Sec. V.B.1.c.) reflecting the additional measurements which will be made to confirm these estimates.

Comment - The possibility of groundwater contamination is of importance as is the possibility of subsidence and fracturing of the rock above the salt bed allowing waters to penetrate the salt bed.

Response - The potential impact of subsidence and expansion has been addressed in the revised statement (Sec. V.B.1.d. and Sec. V.B.1.e.).

Comment - There is no data presented in the Environmental Statement on the relationship of the groundwaters used as water sources for the communities of Lyons, Sterling and Chase to the groundwaters in the vicinity of the proposed site. Should these groundwaters be from the same geologic aquifers there would be a risk of not only contaminating these water supplies, but also the disruption of water supplies. This question requires resolution prior to the initiation of construction.

Response - The portion of the Environmental Statement describing the details of the near surface aquifer systems existing at the repository site has been expanded to show the general relationship of the aquifers at the site and local groundwater supplies. Additionally, the Statement reflects the fact that there are ongoing hydrologic studies being carried out at the site to assure that there is

adequate isolation of the salt from the overlying water-bearing formations. The effluent control systems (Sec. VI.D. and Sec. VIII.B.) states that there will be no liquids released from the facility and the effluent control systems which will be incorporated into the facility will prevent any significant contamination of local groundwater supplies.

Comment - There is also need for further information on the potential effects of the future development of groundwaters on the salt beds to be employed.

Response - As part of the site evaluation studies, the effect of future changes in groundwater use patterns or control rates will be evaluated in terms of their effect on the future stability of the salt beds.

BOB DOLE
KANSAS

STANDING COMMITTEES:
AGRICULTURE AND FORESTRY
PUBLIC WORKS

SELECT AND SPECIAL COMMITTEES:
SMALL BUSINESS
NUTRITION AND HUMAN NEEDS

United States Senate
WASHINGTON, D.C. 20510

March 29, 1971

Dr. Glenn T. Seaborg, Chairman
Atomic Energy Commission
Washington, D. C. 20545

Dear Dr. Seaborg:

Since the tentative selection of Lyons, Kansas as the site of a nuclear repository, I have been concerned that all precautions be taken to protect the health and welfare of Kansas citizens. I recently filed a statement on this subject with the Joint Atomic Energy Committee, and have enclosed a copy for your perusal.

It is my hope that the Committee and the Atomic Energy Commission will seriously consider my comments as well as those of others who testified on the project. I feel that underground storage of radioactive wastes in salt formations is basically a sound concept, but certain basic questions must be answered about this particular project in the Environmental Impact Statement.

Sincerely yours,

BOB DOLE
U. S. Senate

BD:cc
Enclosure

FROM: THE OFFICE OF U.S. SEN. BOB DOLE
NEW SENATE OFFICE BUILDING
WASHINGTON, D. C. 20510
(202) 226-8949

FOR RELEASE: MARCH 16, 1971

JOINT COMMITTEE ON ATOMIC ENERGY

STATEMENT BY SENATOR BOB DOLE
MARCH 16, 1971

(FULL TEXT)

NUCLEAR REPOSITORY

MR. DOLE: MR. CHAIRMAN, I appreciate this opportunity to appear before your Committee to comment on the proposed nuclear repository for the long-term storage of solidified radioactive waste, to be located at a site near Lyons, Kansas.

Although a final decision has not been made on the use of this site, considerable attention has focused on the proposal in Kansas. Many Kansans are questioning the desirability of allowing solidified high-level nuclear waste to be stored in Kansas for an extended period of time, possibly hundreds of years, others support the project and look to the economic benefits that will accrue to Lyons and Rice County.

PRIOR EVALUATION

This project is representative of the need for assessment of the implications of 20th century technology -- in this instance the disposal of nuclear wastes that are by-products of nuclear power generation before committing ourselves to the fullscale development of such technology. Secondly, we must consider carefully the

procedures by which a site is selected for application of the necessary technology.

Scientific information furnished me supports the concept of the underground storage of radioactive wastes in salt formations as intrinsically the safest of the alternatives under consideration by this country. My concern is whether Lyons, Kansas, is an appropriate site. This will be the first national repository for radioactive wastes. Following these hearings, funds may well be authorized for development of the Lyons, Kansas site. Before a decision is made to fund such development, I would urge that regardless of how very, very small the risks attendant to the proposed repository, a detailed analysis of these risks be performed, adequate to satisfy not only the Federal Government, but the citizens of Kansas. Furthermore, should the facility be prepared prior to resolution of appropriate public health and environmental concerns, actual deposit of radioactive wastes should be deferred until these issues are resolved.

INDEPENDENT REVIEW

On June 17, 1970, the Atomic Energy Commission announced its tentative selection of Lyons, Kansas as a storage site. Since then I have endeavored to keep myself informed of the full implications of this decision to public health and welfare of the citizens of Kansas and the economic development of Kansas.

Recently, when Mr. Russell Train, Chairman of the Council on Environmental Quality appeared before the Senate Public Works Committee, I questioned him on whether the Council had authority to police this proposal. Chairman Train indicated that a full study of the proposed project would be conducted consistent with Section 102

of the National Environmental Policy Act of 1969. This study would include comments on a draft Environmental Impact Statement by all concerned Federal Agencies as well as State and Local Governments.

Subsequently, during the confirmation hearings for William D. Ruckelshaus as Administrator of the Environmental Protection Agency, I raised similar questions. After the hearings, I received a letter from Mr. Ruckelshaus advising me that the Environmental Protection Agency, through the Radiation Office, would insure that the repository will not pose any dangers to the citizens or the environment in Kansas.

Because the Atomic Energy Commission is both promoting this proposal and evaluating its potential implications, I felt a need for an independent review of the project, and undertook steps to obtain a non-governmental evaluation from scientific and technical experts. At my request, Senator Jennings Randolph, Chairman of the Senate Public Works Committee, circulated the Atomic Energy Commission's Draft Environmental Impact Statement on the proposed nuclear repository to the Committee's Scientific Advisory Panel for review and comment. I ask that Senator Randolph's letter to me transmitting the comments of the Advisory Panel members and a summary prepared by Mr. Richard D. Grundy of the Public Works Staff be included in this hearing record at this point.

UNANSWERED QUESTIONS

My review of the comments of the Scientific Advisory Panel indicate several basic questions have not been answered by the Draft Environmental Impact Statement. This statement is required by the

National Environmental Policy Act, and as such should include a complete discussion of the effects of the proposed project on the quality of our environment in Kansas. Although adequate answers to these questions may be available in technical and scientific literature, they should be incorporated in the Environmental Impact Statement.

RADIOACTIVE RELEASES

While there is controversy over the adequacy of current radiation standards, the history of minimizing radioactive releases from nuclear power plants shows a steady decrease in the amounts of radiation that are permitted to enter the environment. The Atomic Energy Commission has played a significant role in assuring that radioactive releases from power plants are minimized consistent with the best available technology. The proposed nuclear repository is a part of this system.

RADIOACTIVE EMISSIONS

As a Senator from Kansas, I would insist that radioactive emissions from any proposal repository not be allowed to exceed those required throughout the nuclear energy industry. After controlling releases elsewhere, to allow higher levels of emission at or in transportation to the proposed repository would in effect be asking Kansans to not only store the wastes of our nation's energy system but also to accept a higher risk of possible adverse effects. I mention this possibility because the potential problem is not discussed in the Draft Environmental Statement.

CONTINUOUS MONITORING

There is also an obvious need for long-term environmental monitoring for possible atmospheric releases of radiation and groundwater contamination. Yet, there is no indication in the statement of intended or anticipated environmental monitoring programs or their costs. Such programs would be expensive and must be provided for in the authorization of this project. At an absolute minimum, there must be continuous monitoring to protect the citizens of Kansas.

RETRIEVAL

In addition, I am particularly concerned with three apparent omissions in the Draft Environmental Impact Statement. Although an extensive review is provided of the waste handling facilities for the highly radioactive wastes, there is no indication of the steps that would be taken should retrieval be required at a later time, either due to intrusion of water into the salt formation or a spill of the solidified radioactive materials within the repository. These possibilities must be evaluated and an objective safety program provided for -- before actual construction begins.

EFFECT ON GROUNDWATERS

My second concern is the current and possible future uses of groundwaters in the vicinity of the proposed repository. The communities of Lyons, Sterling, and Chase are now obtaining their water supplies from groundwaters. Yet, there is no data presented in the Environmental Statement on the relationship of these groundwaters to the groundwaters in the vicinity of the proposed site. These may, in fact, be from the same geologic aquifers. Should this prove true,

there would be a risk of not only contaminating these water supplies, but also the disruption of water supplies. Therefore, this question requires resolution prior to the initiation of construction.

There is also a need for further information on the potential effects of the future development of groundwaters on the salt beds to be employed. The Advisory Panel's comments suggest that alternation of current groundwater use patterns or withdrawal rates could affect the stability of the salt beds. The possibility therefore exists that land use might be restricted in order to provide the necessary protection for the nuclear waste repository. The consequent effect might be the restriction of the future economic development of Kansas.

Thirdly, I am concerned that the hazard during transit and transfer of the material both in Kansas and from wherever that material is generated, have not been sufficiently discussed.

QUESTIONS MUST BE RESOLVED

While I am not qualified to pass judgment on the scientific merit of the questions raised by the Advisory Panel, I do feel that a prudent public health and environmental policy should dictate resolution of the points raised, preferably before site development is initiated, but definitely before the site is used for its intended purpose -- the disposal of solidified radioactive wastes.

This is the first site to be constructed for the disposal of solidified radioactive wastes in the nation. The costs of disposal should not, however, be the determinitive factor in considering

alternatives. The first such facility should employ all the safeguards that are considered desirable and provisions should be made for retrieving the wastes should this become necessary in the future.

Ultimately, the costs of operating such a repository will be charged to the nuclear power industry and in turn the general public. Initially, however, public health concerns dictate that the Federal Government insure that safety, not economics, be the overriding concern, and that at every step of the process adequate margins of safety be provided.

United States Senate

COMMITTEE ON PUBLIC WORKS
WASHINGTON, D.C. 20510

March 11, 1971

Honorable Robert Dole
United States Senate
Washington, D.C.

Dear Bob:

Pursuant to your request of December 29, 1970, the draft environmental statement concerning the proposed Radioactive Waste Repository in Lyons, Kansas, was circulated to the Advisory Panel to the Committee on Public Works for review and comment.

Replies were received from Professor James R. Arnold, Professor Robert R. Curry, Professor Jean H. Futrell, Dr. Ralph E. Lapp, Professor Gene E. Likens (including comments by Dr. Franklin Long and Dr. Robert Morison), and Dr. George Woodwell. A summary of their comments was prepared by Mr. Richard D. Grundy of the Committee Staff. A copy of this material is enclosed.

Should you desire to pursue this further, Mr. Grundy is available to work with your staff. His background is particularly appropriate to this issue. Mr. Grundy has a Master of Public Health Degree in Radiological Health, and prior to joining the Committee Staff, he spent 8 years with the Bureau of Radiological Health, Public Health Service. This program is now a part of the Environmental Protection Agency.

It has been my pleasure to have been of assistance to you in this regard.

With warm personal regards,

Truly,

JENNINGS RANDOLPH
Chairman

Enclosures

United States Senate
COMMITTEE ON PUBLIC WORKS
WASHINGTON, D.C. 20510

March 11, 1971

MEMORANDUM

TO: Richard B. Royce
Chief Clerk and Staff Director

FROM: Richard D. Grundy
Professional Staff

SUBJECT: Radioactive Waste Repository, Lyons, Kansas

At the request of Senator Dole on December 29, 1970, the draft environmental statement for the proposed Radioactive Waste Repository in Lyons, Kansas, was submitted to the Advisory Panel for review and comment. The subject statement was prepared by the Atomic Energy Commission pursuant to the National Environmental Policy Act (Public Law 90-190). Comments were received from the following individuals:

Professor James R. Arnold
Professor Robert R. Curry
Professor Jean H. Futrell
Dr. Ralph E. Lapp
Professor Gene E. Likens
(Including comments by
Dr. Franklin Long and Dr.
Robert Morison)
Dr. George Woodwell

Copies of their comments and my memorandum of January 12, 1971, are attached.

Several deficiencies are apparent regarding the subject environmental impact statement and knowledge concerning the use of the proposed site in Lyons, Kansas. These are enunciated herein. A prudent public health and environmental policy should dictate resolution of the points raised before the site is used for its intended purpose--the disposal of solidified radioactive wastes.

MEMORANDUM

SUBJECT: Radioactive Waste Repository, Lyons, Kansas

The concept of underground storage of radioactive wastes in bedded salt formations is scientifically sound. Although there is a concensus that the salt burial concept is intrinsically the safest of all known methods of radioactive waste disposal, the environmental statement (section 2) does not document this. It would be useful to obtain the opinion of scientific and technical personnel outside the nuclear energy community on this point (see Futrell).

When discussing the alternative methods for radioactive waste disposal, salt domes, as contrasted to bedded salt, are considered and rejected on the basis of insufficient information. This is a significant alternative, therefore, a further explanation as to the reasons for rejection is warranted.

There will obviously be a need for long-term environmental monitoring for possible atmospheric releases and ground water contamination. Yet, there is no indication in the Statement of intended or anticipated environmental monitoring programs (see Lapp).

While alternative waste disposal methods are discussed from a technical standpoint, it would be useful to discuss the plans of other countries for dealing with radioactive wastes of these types. The plans of Great Britain, France, Japan, Italy, Spain, Russia, and Belgium should be included. Since Japan does not have suitable geology for underground disposal, a discussion of their plans would be particularly desirable (see Lapp).

The following specific observations were made regarding the technology for radioactive waste disposal and use of the proposed repository in Lyons, Kansas:

(1) There are risks associated with the transportation and handling of radioactive wastes which are not included in environmental statements. These risks should be developed for the system as a whole (see Lapp). Although the risks attendant to the proposed repository can be assumed very, very small, a detailed analysis of these risks appears desirable, adequate to satisfy the inhabitants of Lyons, Kansas, and State and local officials (see Long).

(2) Considering the Lyons, Kansas proposed repository, it is envisioned that it will be maintained in the perpetual care of the Federal Government. The details on how this will be carried out over the suggested 800 years required is unclear.

(3) When presenting the projected inventories of radioactive wastes (section 2) only gross quantities are provided. Data is needed on the radioactive elements of biological significance (e.g., cesium, plutonium, strontium) and their chemical form (see Futrell and Lapp). Information appears warranted on the solubility of these materials, also. This would provide an indication for potential leaching into surrounding strata (see Futrell).

(4) The discussion of the packaging and shipment of wastes (section 2.3) does not include an evaluation of the possibility of accidents during transport of the material to the repository site (see Arnold, Lapp, and Long). Considering the potential quantities of radioactive materials involved, conformance with AEC and DOT regulations for packaging and shipment is not the only issue.

(5) A review is provided of the "high level", very radioactive, waste handling disposal facilities (section 3.2). There is no discussion, however, of the risk of spills, the effects of spills on this operation, or the methods that would be employed to deal with spills (see Arnold and Long). Also, there is no indication of the steps that would be taken should retrieval be required at a later time because of intrusion of water into the salt formation. An objective safety program for retrieval is needed at this point.

(6) A description is provided of the proposed site (section 4.1). Mention is made of an operating salt mine that extends to within 1500 feet of the proposed site. Yet, there is no evidence presented on the possibility of intrusion of radioactive material into the mine (see Arnold).

(7) A significant factor in selecting a repository site is the geological history and stability of the salt deposits selected. Let us assume that salt deposits are the most suitable alternative, the existence of bedded salt being an indication of long periods without the presence of groundwaters. Normally, fractures occurring in salt beds quickly seal through flow of the salt and its recrystallization under pressure of overlying rock materials (called lithostatic pressure). However, this ceases to be the case once a vault or mine is opened up at depth, (see Curry).

Not all kinds of fractures above such a vault would seal as quickly as before such a vault were constructed, since the separate blocks of overlying salt and other materials can then yield by flow toward the vault - both by gravity and by slow flowage from zones of higher lithostatic pressures alongside of the vault itself. Thus, by the very nature of salt as a slowly flowing substance beneath the earth's surface, once a hole is opened up, it fills from the top and sides of the cavity, and may cause the formation of cracks along which infilterating downward percolating waters may flow to dissolve larger cavities.

Such underground leaching of the salt beds has occurred about 25 miles from the depository site and we are told that this occurred at a slow rate of five miles of retreat of the leaching front in the last 1 million years (section 5.5). This occurred at a time when no one lived in Kansas, no vaults were mined in the salt, and no human alteration of the surface and subsurface water flows occurred.

(8) Possibly the two most significant environmental factors to be considered are seismic activity and the potential for groundwater contamination. The Lyons, Kansas, site lies in a low seismic risk area. However, the development of seismic risk data is a relatively recent capability since instrumentation has been available for only about fifty years or less.

On the basis of available data (see Curry), the seismic risks in Kansas may well be higher than stated, although not so high as to render the site impractical. Consideration should be given to the construction of a bern to avoid a concavity should subsidence occur as a result of seismic activity (see Curry).

MEMORANDUM

SUBJECT: Radioactive Waste Repository, Lyons, Kansas

Page

(9) Under normal circumstances, the possibility for subsidence would be expected to occur immediately. The statements (section 5.3) suggests the heat effect of the radioactive material will counteract the subsidence. No supporting evidence is presented. Since the temperature counteracting effect does not occur immediately, subsidence may result and further consideration should be given to this possibility (see Curry).

(10) The possibility of groundwater contamination is of importance. Also, a serious hydrologic consideration is the possibility of subsidence and fracturing of rock above the salt bed allowing waters from aquifers above the salt bed to penetrate the salt bed (see Curry). This possibility requires evaluation.

(11) The communities of Lyons, Sterling, and Chase are cited as obtaining their water supplies from groundwaters (section 4.3). Yet, there is no data presented on the depths of the wells involved or their relationship to the groundwaters and the geologic formations in the vicinity of the repository site (see Arnold and Curry). There is the risk of not only contamination of water supplies,but also disruption of water supplies.

(12) An omission from the report is consideration of future developmental use of groundwaters. Alteration of current use patterns or withdrawal rate could affect the stability of the salt beds themselves (see Curry). In both Kansas and Nebraska in some locations, groundwater is being used or withdrawn at faster rates than natural rates of recharge. Therefore, consideration should be given to anticipated land use patterns of Kansas as a whole and their impact on groundwater usage.(see Curry).

Richard D. Grundy

ATTACHMENTS:

Ltr, Prof. James R. Arnold, Jan. 25, 1971
Ltr, Prof. Robert R. Curry, Feb. 16, 1971
Ltr, Prof. Jean H. Futrell, Feb. 16, 1971
Ltr, Dr. Ralph E. Lapp, Feb. 14, 1971
Ltr, Prof. Gene E. Likens, Feb. 18, 1971
Ltr, Dr. George Woodwell, Jan. 25, 1971
Memo, Richard D. Grundy, Jan. 12, 1971
Ltr, Dr. Ralph E. Lapp, Feb. 8, 1971

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, L. I., N. Y. 11973
TEL. AREA CODE 516 YAPHANK 4-6262

DEPARTMENT OF
BIOLOGY

REFER:

January 25, 1971

Mr. Richard B. Royce
Chief Clerk and Staff Director
Committee on Public Works
U. S. Senate
Washington, D. C. 20510

Dear Dick:

I have read with much interest the draft of the environmental impact statement proposed by the AEC for the Radioactive Waste Repository in Lyons, Kansas. I have not been involved in the studies that led to selection of Lyons or in the design of the storage system. I am however considerably more than casually aware of the problems that this type of storage is designed to solve. I find the statement convincing.

Much of the argument against nuclear power has hinged on the difficulty of containing the waste. The Lyons plant is designed to solve the waste storage problem, efficiently and with safety. The decision to use a salt mine is obviously based on a large amount of careful research, considerable experience with various types of storage, as well as on such questions as cost and efficiency of transport. I see no reason to question the validity of the statements of the amounts of radioactivity that would be released or to question the flat statements (pages 33 and 37) that there would be no hazard to life through release of these quantities. If the development of nuclear power is to be challenged on the grounds of public safety, it should not be challenged for a facility such as the one covered by this statement.

If all Environmental Impact Statements were as comprehensive, the National Environmental Policy Act would be a brilliant success.

Yours sincerely,

G. M. Woodwell

CORNELL UNIVERSITY
DIVISION OF BIOLOGICAL SCIENCES
ITHACA, N.Y. 14850

SECTION OF ECOLOGY & SYSTEMATICS
Bldg. 6, Langmuir Lab.

February 18, 1971

Mr. Richard Royce
Chief Clerk and Staff Director
United States Senate
Committee on Public Works
Washington, D.C. 20510

Dear Dick:

I've enclosed some comments by Dr. Franklin Long and Dr. Robert Morison of Cornell University on the AEC Federal Repository. I'm sorry that I was unable to devote any time myself to this project, but I did circulate the proposal and the attached comments are of interest.

Sincerely,

Gene E. Likens
Associate Professor

GEL:ps
Enc.

contained enough strontium-90 to kill everyone on the planet.) I make this nuclear vignette not to scare the pants off people but to point up the magnitude of the problem. I would suggest that Sec. 5.6 under "Sociological Impact" the AEC statement ought to acknowledge psychological impact.

It is my impression in studying AEC documents that cost of waste disposal is an important factor in considering alternatives. It is true that privately-operated processing plants will be charged for the cost of disposal. However, I would think that it should not be a determinative factor. If, for example, it is thought worthwhile to store the radwastes in retrievable containers, then siting factors mentioned for the Lyons site may not be critical. For example, storage of radwastes in air-cooled casks in caverns, say, in eastern New Mexico could be considered even though the area is more seismic than Kansas.

The AEC statement does not detail surveillance techniques to be used around the Lyons site to monitor the aquifers.

I understand that the AEC still has research and development programs on solification and fixation of high-level radwastes in process and these are estimated to require 2 to 3 more years for completion. It might be worthwhile to treat the Lyons Repository as an initial trial for radwaste disposal and defer commitment of it on a long term basis until the AEC can assess the virtues of vitrification and other techniques that might lend themselves to air-cooled cavern storage.

Preliminary Comments on AEC Draft Environmental Statement
Radioactive Waste Repository, Lyons, Kansas

General Observation: The AEC draft statement is a competent assessment of many aspects of the radwaste disposal problem as it applies to high-level solidified fuel elements. The statement is, however, lacking in many details that are available in other AEC documents such as ORNL-4451 UC-70-Waste Disposal and Reprocessing (July 1970). Anyone who assesses the AEC draft statement should take into account the back-up material available in ORNL-4451.

It is noted that the AEC statement is submitted to the Council on Environmental Quality. The Council has only a very small professional staff and a heavy load of environmental statements to review. As a physicist I would judge that a competent review of the radwaste disposal problem, specific to salt bed repositories, would require 3 or 4 professionals working at least 3 months to provide a suitable overview of the matter. I believe that the Council does provide a mechanism for such critical review but only if professional manpower is available to match wits with the AEC experts.

As I see it, disposal at the Lyons site is essentially "forever" i.e. a one-way commitment of high-level wastes that will be stored for many centuries. It would be highly useful for any review to inquire into the repository plans of other nations, including Japan, which are going nuclear.

The AEC statement is not one that a non-technical person will comprehend with ease. In view of the magnitude of the high-level waste disposal problem I would suggest that an AEC statement should be prepared, summarizing the detailed "flow" of radwastes from the time they leave the nuclear power sites through their reprocessing to the time of their interment. This statement should make explicit the quantities of radwastes to be committed to the Kansas repository each year, the number of cask shipments entering Kansas each year, and the total inventory of radwastes at the repository by year through the year 2020. This inventory should detail the specific composition by radionuclide of the radwastes.

I would think that it would be highly useful if environmental statements submitted to CEQ would define some class of environmental risk not only for the specific proposal (i.e. repository) but for the whole system, which in this case involves reprocessing and shipping.

For example, in the high-level radwastes the single nuclear species strontium-90 (Sr-90) appears to be the principal villain. However, krypton-85 is also in the cast of characters. Question: will it be AEC policy to trap Kr-85 and store it? If so, at what site?

The Environmental Statement (pg.8) projects 19,000 tons (MT) per year of fuel reprocessing for the year 2,000. Assuming an average of 60,000 curies of strontium-90 per metric ton, this yields 1.2 billion curies of Sr-90 as the annual through-put in the year 2000. Since there will be at least 500 cask-shipments to Kansas per year this would mean a total of 24 million curies of strontium-90 per shipment. (A body burden of 1 millionth of a curie of Sr-90 would produce a bone-dose of 3 rem per year. I can just see some conservationist standing in the rail tracks opposing such traffic at the Kansas state border, claiming it

7215 Park Terrace Drive
Alexandria, Va.
22307

14 Feb 71

Dear Dick:

Here are some thoughts on "salting it away".

I am enclosing a copy of my Chapter 6 from my new book since it might be about the easiest way for a non-technical type (like Sen. Dole) to appreciate the problem.

I would urge all panelists who comment on the AEC statement to be sure to get a copy of ORNL-4451 "Siting of Fuel Reprocessing Plants and Waste Management Facilities." It's the best job I've seen; furthermore, it is an excellent source of data on spent fuel rod radioactivities.

I'm off to the west coast for two weeks.

Sincerely,

R.E. Lapp

To: Dick Royce 8 Feb 71

From: R.E.Lapp

RE: Sen. Dole's Request for comments on Radwaste disposal in salt mines.

I'll be turning in some comments on this request by Feb. 12th.

I suggest that others who comment ought to be sure to have on hand:

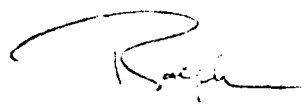
DISPOSAL OF SOLID RADIOACTIVE WASTES IN BEDDED SALT DEPOSITS
A Report by the Committee on Radioactive Waste Management
National Academy of Sciences Nov. 1970

ENVIRONMENTAL STATEMENT: Radioactive Waste Repository
Environmental Protection Agency

CIVILIAN NUCLEAR POWER Potential Nuclear Power Growth Patterns
U.S.A.E.C. (Draft July 1970) WASH 1098 UC-80

Since Sen. Dole might ask what other nations are planning to do with their spent fuel, it would be helpful if someone on the staff could make a quick survey of repository planning by Great Britain, France, Japan, Italy, Spain, Belgium and Japan. Soviet plans would be worth knowing.

Japan, to my knowledge, has not the proper geology for underground disposal and it would appear will have to go to a mausoleum type "burial" or arrange with some other country to accept its wastes.



THE UNIVERSITY OF UTAH

SALT LAKE CITY 84112

DEPARTMENT OF CHEMISTRY
CHEMISTRY BUILDING

February 16, 1971

Mr. Richard B. Royce
Chief Clerk and Staff Director
United States Senate Committee
on Public Works
Washington, D. C. 20510

Dear Dick:

In response to your letter of January 13, I am submitting some comments on the "Draft Environmental Statement," prepared by the Atomic Energy Commission relating to the repository for radioactive wastes proposed for construction at Lyons, Kansas. In general, I am favorably impressed with the document; it appears to me that the Atomic Energy Commission has done a careful study of the several ramifications of constructing this repository. In fact, I am optimistic that they have done a substantially better job in this regard than they have done in establishing temporary repositories for wastes generated by existing facilities - particularly those at Rocky Flats in Colorado and at the Hanford and Savannah River Plants. The questions that are stimulated by reading the report are of a technical nature and simply request some additional details for reassurance that the planning has been as thorough as the summary report suggests.

On page 2 of the report they state that the temperature rise at the surface will be 1° F, approximately 100 years after waste burial. I would like to see the calculations which substantiate this estimate in order that I might judge how speculative this result is. On page 3, they state that a minor aquifer is located 100 feet below the site surface and that another one is located about 285 feet below the surface. This is a bit surprising, since one of the reasons for choosing a salt bed deposit is that such deposits are not expected to have any aquifers present in them. They also state that they are making the pessimistic assumption that the aquifer is stagnant. Actually this would appear to be a very optimisitc assumption, because, if the aquifer is not stagnant, it will permit a means of communicating any leached radioactivity from the repository to the surrounding strata. It seems to me that this point should be very well established before the final decision is made to go ahead with the repository. Since there is some apparent possibility of communicating through aquifers, I would like to be reassured that the AEC has made solubility measurements for the chemical forms of the radioactive elements which are of significance, in particular plutonium, samarium, cesium, and strontium - the major biological hazards.

On page 5, they state that the site will be maintained in the perpetual care of the Federal Government, and I would like more details on how this will be carried out for the thousands of years for which surveillance may well be required. I would also like to see as constituent of the master plan that the solubility measurements will continue to be made for all of the possible solid waste forms which will be established in the future.

On page 6, the final paragraph implies that a consensus has evolved on the method of waste disposal. I would like to see this point documented to make sure that a consensus has actually been reached, including the opinions of scientific and technical personnel outside of the nuclear energy community.

On page 10, salt domes as contrasted to bedded salt are considered and rejected in two sentences. I would like to know the reasons for that, since there are many salt domes in different parts of the country, and since they represent a geological formation which is at least as contiguous and self-contained as bedded salt.

On page 35, the report states that the workings will be designed so that the support pilars will deform and enclose all openings. This is a cute trick and probably can be done, but I would like to see this point elaborated somewhat further. On page 2 of the appendix, it is implied that several solid forms of wastes are approved and I would reemphasize that it is necessary to carry out the detail physical measurements of solubility in terms of the equilibrium constants for solution of radioactive elements in order to assure that an unexpected catastrophe involving water breakthrough which communicates to other strata will not have disastrous consequences. On page 4 of the appendix, it states that salt deposits are free of circulating ground waters and completely isolated from underground aquifers, whereas earlier in the report it is stated that there are two aquifers in the proposed site area.

In addition to these specific points, there are two larger questions raised by the report which I would like to throw out for your consideration. One of these is the fact that there are some 80 million gallons of radioactive wastes now stored in a temporary fashion at the Hanford and Savannah River Works. Thus far, there does not appear to be a reliable plan for the permanent disposal of these wastes. Until something technically sound and feasible can be done with these wastes, we have a rather frightening potential catastrophe hazard on our hands. I think that the AEC should be prodded somehow into solving this problem with all deliberate speed.

Another question raised by the report is the projection of the quantity of radioactive wastes for which we must find some ultimate disposal. Presumably, the figures within the report are logical projections from the number of nuclear power plants which have been constructed, which are projected for the future, and are fully realistic, including the consideration that a ten-year delay period is involved in the conversion of radioactive wastes to a solid form. Consequently I believe that further research into the question of radioactive waste disposal should be encouraged in some fashion. In particular, it seems to me patently absurd to discard a number of valuable radioactive and non-radioactive fission products along with the biologically hazardous materials whose disposal is the prime objective. The more logical approach, it seems to me, is to develop selective chemical precipitation agents which would remove the longlived radioactivities which together constitute a very small percentage of the total volume of radioactive wastes, but which constitute almost the entire biological hazard. If this could be done, then a very much smaller storage area would be involved and we would at the same time retain for future recovery some very valuable mineral resources. The principle of recycling which we as a panel have stated as a general goal would thereby be served, and it is conceivable that we might avoid the morbid necessity of establishing these small wastelands of perpetual care for radioactive wastes. It might even be feasible, if the volume could be reduced through the strategy which I suggest, to concoct some exotic disposal scheme such as flying the wastes into the sun by rockets at a cost which may be very much less than the infinite storage concept.

As a point of information, I might mention that the above ideas are entirely my own but that I have also spent a couple of hours talking with Mr. C. Wayne Bills, Director of the Nuclear Technology Division of the Idaho Office of the Atomic Energy Commission, about questions of radioactive waste disposal both at the Idaho site and with regard to the general problem from the AEC viewpoint. These talks were quite informative and I took advantage of a visit to Idaho Falls as a consultant to the National Science Foundation on the question of reactivating the Materials Testing Reactor, to confer with Mr. Bills. His briefing on the general procedures of the AEC relating to the question of ultimate disposal of radioactive wastes was both informative and reassuring.

Very best regards,

Jean H. Futrell
Professor of Chemistry

JHF:dkb

Cornell University
PROGRAM ON SCIENCE, TECHNOLOGY AND SOCIETY
632 CLARK HALL
ITHACA, NEW YORK 14850
TELEPHONE 607/256-3810

11 February 1971

MEMORANDUM FOR THE RECORD

FROM: F. A. Long FL

TOPIC: Comments on Proposed AEC Radioactive Waste Repository in Lyons, Kansas.

A basic assumption of this proposal is that nuclear power from fission reactions is inevitable and unavoidable in meeting the United States energy needs. If one accepts this statement, and it seems persuasive, then one immediately faces the problem of disposal of radioactive wastes. The proposed procedure seems like the most reasonable solution to this problem, both in broad outline and in specific details. It is consistent with the recommendations of thoughtful studies of the problem.

There are, of course, some risks associated with this proposed procedure. There would, of course, be risks attached to any other procedure also. Indeed, one must think of the utilization of nuclear power as itself involving an assessment of relative risks. The question is whether the basic risks of nuclear power are tolerable and that decision has presumably been made. One then turns to whether the risks in this particular storage system are acceptable. My own reaction is that they are.

These risks are both short-term and long. The long-term risk has to do with whether in the distant future there will be some kind of geological shift or some kind of slow percolation which will distribute these radioactive materials to the harm of inhabitants. It is very hard, indeed, to assess this long-term risk in detail, but it does seem safe to conclude as this report does, that this risk is very low.

The question of short-range risks involves the danger of some accident in the transportation or handling of these radioactive wastes which would release materials that could do harm to the nearby inhabitants.

One can believe that the AEC procedures for transportation and for handling of these materials are such that the risk of an accident is very small. That does not, however, mean that the risks are zero. From this standpoint, in my mind, the principal drawback to the site is its closeness to the small village of Lyons. Were I from this village, I would like a careful analysis of handling procedures to try to gain assurance that the risk of accident was indeed, very very small. If I were not persuaded, I would be inclined to recommend that a site more distant from the community be located. To summarize, with only the possible exception of the adjacency to the village of Lyons, this overall proposal for dis-

posal of radioactive wastes seems a sensible and indeed, preferred response to what is a very significant present and coming problem.

FAL:mwk

Geologic Analysis of the Draft Environmental Statement, Radioactive Waste Depository, Lyons, Kansas

Robert R. Curry
Environmental Geologist

Section 1

General:

The concept of underground storage of high and low-level radioactive wastes in bedded salt formations is, in my opinion, completely sound. Not only can no readily feasible alternatives be found in other safer sites on earth, but the salt burial concept is intrinsically the safest of all known methods of radioactive waste disposal, even including the rocketing of the materials to the sun since accidents could put such materials into earth orbit or misfires could place them at uncontrolled areas of the earth's surface, including the least desirable of disposal sites - the oceans.

In addition to the long periods of geologic stability implied by bedded salt deposits, two other geologic criteria are of importance for consideration. These are seismic activity and potential for groundwater contamination. I shall discuss these points separately but feel that with the exception of a few statements that I find patently false, the draft Environmental Impact Statement does, in general, adequately cover the potential hazards contemplated. There is one serious omission, however, in that the impact statement does not reveal that once such a facility is established, much of the southeastern portion of the state's groundwater and surface water regimes should not be altered by human use because alteration could affect the stability of the salt beds themselves and risk contamination of

the lower Arkansas River Valley aquifer and potentially endangering residents of Wichita, Kansas, and northeastern Oklahoma. This omission will be dealt with specifically in section 4 of this report.

Section 2. Geologic history and the stability of the salt deposits:

I concur with the Section 2.1 (p.7 ff) that salt is the most suitable alternative and that bedded salt deposits are indeed an indication of long periods of absence of solution by underground waters. I further agree that fractures that may from time to time occur in such salt beds through normal release of accumulated strain in the earth's crust are quickly sealed through flow of the salt and its recrystallization under pressure of overlying rock materials (called lithostatic pressure). However, this ceases to be the case once a vault or mine is opened up at depth. Not all kinds of fractures above such a vault would seal as quickly as before such a vault were constructed, since the separate blocks of overlying salt and other materials can then yield by flow toward the vault - both by gravity and by slow flowage from zones of higher lithostatic pressures alongside of the vault itself. Thus, by the very nature of salt as a slowly flowing substance beneath the earth's surface, once a hole is opened up, it fills from the top and sides of the cavity, and may cause the formation of cracks along which infiltrating downward percolating waters may flow to dissolve larger cavities. On page 34, Section 5.3, we learn that such underground leaching of the salt beds has gone on about 25 miles from the depository site and are told that this occurred at a slow rate of five miles of retreat of of the leaching front in the last 1 million years. This occurred, you will

note, at a time when no one lived in Kansas, no vaults were mined in the salt, and no human alteration of the surface and subsurface water flows occurred. In the hydrological section (section 4 of this report) I shall point out that this past rate of geologic solution is not necessarily valid for the future.

As the salt flows into the vault and mine areas, there will be a surface depression, forming a closed depression on the land surface above the mines. Such a depression may fill with water, localizing a zone of solution and forming a subsidence pond - a sort of vicious cycle in which the more the solution, the more water accumulates and the more solution occurs. We are told, (p. 36) that thermal expansion due to the heating effects of the radioactive wastes upon the salt will counteract the subsidence - the the time constants are all wrong here. Subsidence begins immediately, even before the facility is abandoned, yet heat generation throughout the rock column does not reach a maximum for 800 years. On page 36 it is stated that the two counteracting processes will take place simultaneously, but no supporting evidence is given and I seriously doubt that this is true. The last paragraph of Section 5.3 seems indeed to be painted with a rather broad rosey brush and I believe scepticism is in order.

I also disagree that all salt beds are shielded by impermeable shale beds. If this were indeed the case, one would not have to worry about the effects of surface subsidence and changes in land use and the hydrogeologic regimes and their combined effects on salt solution. However, if solution of the salt is occurring 25 miles from the site, why should we believe that solution is not possible under the right hydrogeologic conditions at the site? It is indeed true that the Hutchinson salt beds have remained

undissolved for about 250 million years and are overlain by a shale, but to say that said shale is impermeable, even where fractured due to subsidence, is not scientifically prudent. I suspect that these shales are not water bearing, in the sense of producing water for wells, but this does not mean that they are impermeable. Rather, it means that they have few void spaces and that aquifers such as the Stone Corral dolomite above the overlying shale can, over most of their aerial extent, be depended upon to be a good source of water since water fills the aquifer faster than it flows through the shale into deeper layers. This would not be the case for an area with vertical fracturing within the shale due to subsidence.

Section 3. Siesmic Risk

It is true that this Lyons, Kansas, site lies in a low seismic risk part of the United States. In general, our seismic risk data are based upon periods of observation of the area with seismographic instruments to measure the intensity and location of earth movements. Since such instrumentation has generally been available for fifty years or less, most nuclear reactor and disposal siting studies rely heavily upon detecting visual evidences of past unrecorded faulting within the rocks. Such faults would be very hard to detect in salt, since it flows and heals such faulting. Thus, an adequate site study would have to expose several thousand linear feet of overlying shales or higher units to allow detection of faults to see if such could occur in the future.

The seismic risk map shown in the impact statement (p. 26) after S.T. Algermissen, 1969, Seismic Risk Studies in the United States: U.S. Dept. of Commerce/ESSA, is a prime example of how little we know about the seismicity of Kansas. The zone 2 and zone 1 delineations are based upon

very little data and I include Algermissen's figure 2 from that same report as an example. In my opinion, I believe that based upon available data, the Zone two risk contour could as well be drawn to incluce Lyons, Kansas as any other way. The shape of the Kansas Zone 2 contour is a natural interpretation of our geologic understanding of underground structures in eastern Kansas and Oklahoma which we believe are responsible for the crustal adjustments going on there today. From Algermissen's figure 2, (enclosed), one can see that indeed historic data for the period 1900-1965 suggest more energy being released in central Kansas and central Oklahoma than along the central eastern boundary of Kansas. Indeed, I contend, that the map in the Impact Statement is a gross generalization. In point of fact, Algermissen has calculated the earthquake recurrence formulae for central Kansas and finds an expected statistical frequency of 1.2 modified-Mercalli-Scale-VIII earthquakes every 100 yeras (VIII = damage considerable in ordinary structures, upset of water levels in wells). What this means is that we would have probable collapse of the vault pillers with possible immediate and direct expression of this at the land surface.

In summary, the seismic risks are higher than stated in the Impact Statement but not so high as to render the site impractical assuming no faults are noted in the overlying rock beds. In the event of a damaging earthquake the site would have to be abandoned or remined and a berm thrown up around the surface concavity over the collapsed vault. Such a berm could be constructed in a few months by bulldozing several hundred acres of topsoil from outside the borders of the site to the surface site. It would be ugly and render the land pretty useless agriculturally, but that would be about the only disadvantage.

Section 4. Hydrology and hydrologeologic considerations:

The hydrology section (4.3, p. 23 ff) is, in my opinion one of the weakest yet most important of the impact considerations. As stated, the site area has a groundwater table at an average depth of 25 feet with good producing aquifers in the surface 45 feet, in the sandstones 45-120 feet below the surface, and in the Stone Corral dolomite 270-285 feet below the surface. The "impermeable" shale extends thence from 285 feet down to the salt at about 800 feet.

Among the most serious hydrologic considerations is that of subsidence and fracturing of the rock units above the salt, allowing waters in the top 285 feet to penetrate to the salt and mix with wastes deposited there. As stated earlier, once such subsidence begins, where water is available, solution proceeds and more collapse occurs and collapse structures known as sink holes form - forming direct avenues for atmospheric venting of wastes that become exposed. Two-hundred seventy thousand megacuries of wastes by the year 2000 is an impressive volume. Even though most of this would not be in a form for potential release to the atmosphere if the vault collapses and venting occurs, time and oxidation and rusting under influence of meteoric waters could result in danger and containment vessles should be designed for such conditions, in my opinion, to protect the local populace.

The report states that a berm or protective barrier to dispel inflowing surface waters could be built so that surface flooding and all but local rain would not flow into the collapse depression. However, little can be done about the interrupted groundwater aquifers and their subsurface flow would be added to the top of the salt beds at a combined flow rate of

perhaps a few cubic feet per second, if large enough fractures developed in the shale beds.

Persons living down-aquifer from the site will no doubt have some diminution or disruption of their domestic water supplies, although it may not occur until collapse begins. These water supplies are not, it is true, large enough for industrial or public water supply use but are more than adequate for domestic use and are, by admission of the report, in present use. Twenty gallons per minute from the Cretaceous sandstone is a perfectly respectable water supply for domestic and minor irrigation purposes. Most towns in the region do rely upon wells for water supplies. According to the report these wells are for the most part located in the overlying alluvial or gravel beds, formed from the outwash of the ice sheets that extended into Kansas in the last few hundred thousand years. These alluvial deposits filled the river beds and valleys of the preglacial topography of Kansas and regraded its surface to its present flatter higher grades. The result is that there are buried channels and valleys that contain abundant readily available fresh water. Nothing that I can find will tell me if such a valley-aquifer may overlie the proposed disposal site but if it should, the consequences of collapse could be grave indeed. The Lyons townsite wells are located in this gravel about 2½ miles south of the disposal site and since these gravels may contain hundreds of millions of gallons of water and serve many persons, I would want to be very certain that no significant groundwater flow occurred over the locations of the present and proposed evacuations.

The risks here, it should be remembered, are not just of contamination of water supplies by radioactive wastes but of disruption of water supplies

by collapse structures and ultimate rendering of the disposal site as unusable land with a hot (thermally and radioactively) lake located upon it. Careful hydrogeologic mapping would be in order here to protect the residents of Kansas, and, indeed, the report alludes to such work in progress. would request to see this report when available.

As the overlying aquifers become heated, even if collapse does not occur, these warmer waters will act as a heat conductor for the waste depository (in marked contrast to the statement on page 30 that all heat will go to the surface directly above the site). Such thermally polluted aquifers probably are of little consequence but this sort of thing has never happened before so we simply do not know. The warmest such waters could get, according to the graph in Fig. 6 (p. 30A) would be 100 degrees F 800 years after burial. Even with very slow groundwater flow, this sort of heat flux would not, in my opinion be expected to raise surface temperatures but would rather raise groundwater temperatures over an area many times the size of the repository. In other words, even assuming very slow flow, the moving groundwaters will carry at least some of the radiogenic heat away from the site. The heating of the shale will be a potentially good thing in that any fractures that may develop as subsidence begins may be evident by steam escape during the first 100 years of the disposal sites' history. Temperatures at the bottom of the shale will rise to nearly 250°F and if water begins to seep down to that lower shale, surface steaming similar to that observed around areas of underground burning coal mines might be expected.

Another hydrologic consideration is that of the land use patterns of Kansas as a whole. Since the central part of the state relies heavily upon

groundwater supplies for its economic wellbeing, and since in both Kansas and Nebraska, these supplies are in some places being used at rates much greater than their natural rates of recharge, it seems imperative to maintain consideration of changes in water use patterns for this part of this country. The very presence of the bedded salt deposits in the central part of the state indicate that hydrologic regimes have varied rather little in the past except for the great surface flooding down the course of the Arkansas river during the melting of glacial ice. When one begins to consider operations such as irrigation of areas far from river courses, large scale pumping of groundwater reserves in localized areas, and import of water into the region from outside the immediate watersheds by ditches or canals; one begins to alter the regime of flow or cycle of the surface and groundwaters in the area. One could speculate endlessly on what could happen, but most simply, it would seem prudent to essentially insure that ultimate use of lands over and around the depository are not infringed or restricted. I strongly question the statement on p. 5 of the Impact Statement that..."essentially all of the surface could be returned to virtually unrestricted use." Watch carefully those modifiers "essentially" and "virtually". If it is a depression on the surface of the earth, can it be used to hold water? Would you have any choice? Could wells be placed upon it? Could fields located thereon be irrigated if subsurface drainage occurred?

The site itself will be under the perpetual care of the federal government, but it is the adjacent lands that I worry about. In the case of the disposal site at Arco, Idaho, upon which I have been working for some time, the government has released highly toxic and radioactive liquid wastes into

the aquifer and they are already proceeding out of touch and control toward the town of Idaho Falls. That it will take 100 or more years for the water to get there seems of little consolation to future residents.

Section 5. Summary:

Based upon my work in Idaho and Washington on nuclear waste problems and based upon the premise that such wastes are inevitable, I do favor disposal in the Kansas repository and feel that this is indeed the least of several evils. I firmly believe that it is your legislative responsibility to see that all possible precautions are taken and that safeguards are met in perpetuity. This means that the AEC "geohydrologic" study should be reviewed carefully, the consequences of higher than predicted seismic risks should be explored, and full consideration should be given to future and present land use and water use to the south and east of the site for a distance of several 10's of miles.

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(406) 243-0211

DEPARTMENT OF GEOLOGY

February 16, 1971

Senator Robert Dole
United States Senate
Washington, D.C. 20510

Dear Senator Dole:

As you know, Richard Royce has asked several of the members of the Scientific Advisory panel to Senate Public Works to comment upon the Draft Environmental Statement for the Lyons, Kansas radioactive waste depository. My comments (attached) cover very briefly the geologic considerations of such a repository. If I can be of further assistance in this matter, please contact me through Mr. Richard Grundy of the Public Works staff.

Sincerely,

Robert R. Curry
Assistant Professor.
Environmental Geology

RRC:lb

cc. Richard Grundy

UNIVERSITY OF CALIFORNIA, SAN DIEGO

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DEPARTMENT OF CHEMISTRY
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LA JOLLA, CALIFORNIA 92037

January 25, 1971

Mr. Richard D. Grundy
United States Senate
Committee on Public Works
Washington, D. C. 20510

Dear Dick:

After our conversation this morning I recall that none of us have seen a copy of the Muskie Bill which the hearings are to be concerned with. Might I have a half-dozen copies for distribution?

The rest of this letter concerns the AEC Environmental Statement which you sent us early in the month.

My overall reaction is that it is a pretty good effort. That is, the statement covers most of the questions that one could ask, and the answers are reasonably sensible. I am left with a few questions, which are as follows:

Page 5, Transportation---The possibility of accidents in transport is not discussed. Perhaps it is concentrated outside the scope of the report, but since we are talking about a complete system I would not agree with this. The last sentence of this section does not satisfy me.

Page 5---"It is planned that the site will be maintained in the perpetual care of the Federal Government----." I am sure that this will seem hilariously funny to future historians, if there are any. If the United States lasts 800 years it will join no more than four or five nations in human history who have achieved that sort of longevity.

Page 18---Probably the most serious deficiency of the report is that it does not discuss the effect of spills in the high-level mine. Such a discussion seems absolutely essential to me.

Page 20---Reference is made here to a working mine "no closer than 1500 feet" to the storage site. What is the evidence that no undesirable material can make its way into this active mine?

Page 24---The depth of the wells involved in the public water supplies should be given.

Page 31---"The airborne concentrations of these radioisotopes---------- The sentence is incomprehensible.

Page 33---The statements in the last paragraph should be clearer and more detailed. Is the standard level referred to the present level of fallout concentration in this region? Are the isotopes the same?

The appendices seem to be appropriate.

I would be interested to compare similar statements from other agencies. While the proposed facility is in principle much more threatening than most projects, I would be surprised and pleased to find that other government agencies could do as good a job as this for any project.

Sincerely yours,

James R. Arnold

JRA/fk

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 4 1971

Dr. Arthur H. Wolff
Acting Deputy Commissioner
Radiation Office
Environmental Protection Agency
Washington, D. C. 20460

Dear Dr. Wolff:

Thank you for your letter of April 29, 1971, containing the Environmental Protection Agency's comments on the Atomic Energy Commission's Draft Environmental Statement for the proposed radioactive waste repository near Lyons, Kansas. We have made numerous revisions and additions in response to comments from other agencies and we believe that the enclosed statement conforms with the letter and spirit of the National Environmental Policy Act of 1969. Taking EPA's comments in the order presented in your letter, we submit these responses.

We are pleased that the EPA regards salt mine storage of radioactive waste as possible and practical and that disposal of radioactive wastes in salt formations constitutes the best method for such disposal presently known. We have added considerable additional material to the statement plus a bibliography which documents past research and development on this project which supports our conclusions on both environmental and safety aspects and which is responsive to your request for such documentation.

With regard to the comments concerning the ability of the salt to adequately contain the wastes for geologic periods of time, the statement has been revised to reflect the nature and scope of the studies directed towards confirming the present suitability of the site (Sec. V-A). Similarly, Sec. V-B of the statement presents an outline of the investigations being carried out to more precisely predict the response of the environment to the introduction of the waste. These data, when developed, will provide the necessary information upon which to fully support the safety of the facility.

The Commission's position on waste retrieval has been amplified (Sec. VI-E) and reiterates the fact that no waste will be irretrievably buried at Lyons until all pertinent safety considerations have been adequately addressed. During the demonstration phase of the facility's operation, all waste will be buried in a fully retrievable form. The demonstrational nature of the project, as well as the requirements for implementing environmental monitoring and surveillance programs, have been emphasized by the Commission on several occasions. The AEC's intentions, as regards these matters, have been appropriately referenced in the revised statement (Sec. VI-A and D).

With respect to your comment on major related operations, we consider solidification and transportation of radioactive materials to be well beyond the scope of this environmental statement, inasmuch as no specific actions pertaining to solidifications and transportation operations are being proposed. Waste solidification is an operation which will be carried out at licensed fuel reprocessing facilities. We believe that radiological safety and related environmental effects are adequately addressed in the licensing process, which includes a review by the Advisory Committee on Reactor Safeguards and a public hearing before the Atomic Safety and Licensing Board.

Similarly, we believe that the regulations under which all shipping systems for radioactive materials are reviewed and licensed adequately provide for the health and safety of the public. We would note that the shipment of radioactive waste will be similar in most respects to the shipment of spent nuclear reactor fuels. Shipments of these materials have been carried out safely for over twenty-five years and this experience and related technology provide a firm base for the design of safe and reliable systems for shipment of radioactive waste to the repository.

In response to your suggestion that the Environmental Statement be accompanied by a detailed report similar to a safety analysis report, this is to advise you that a Conceptual Design and Safety Report is in preparation, and will form the basis for the initial safety review of this project by the Advisory Committee on Reactor Safeguards. Prior to startup of the facility, a final Safety Analysis Report will be prepared and subjected to ACRS review. We do not consider a safety analysis report to be a proper part of an environmental statement. As you know, environmental statements are directly responsive to the National Environmental Policy Act of 1969, and must be prepared to support legislative action (authorization and funding) well in advance of proposed Federal actions, whereas safety analysis reports are responsive to safety requirements under the Atomic Energy Act and are prepared and reviewed well after authorization and funding and after there has been considerable expenditure toward facility design and safety analysis.

Your letter of April 29 also enclosed EPA's staff analysis and comments on our draft statement. Enclosed is a brief response to those specific comments. Copies of the other comments received on the statement are also enclosed.

Thank you for your review and comments.

Sincerely,

John A. Erlewine

John A. Erlewine
Assistant General Manager
for Operations

Enclosures:
1. Environmental Statement
2. Comments on Draft Statement
3. AEC Response to Comments

Comment - The proposed facility should, however, be considered as a demonstration one and operated accordingly until considerable operational experience indicates that no adverse environmental effects occur from this method of high-level disposal of radioactive wastes.

Response - This facility has been termed a demonstration facility from its inception. Many of the comments from EPA relate to matters which can only be addressed as part of the demonstration program which again points up the urgency of obtaining authorization and funding in order to permit adequate time for a meaningful demonstration program.

Comment - Radionuclide inventory assumptions and release modes used in estimating the discharge levels of the radioactive waste repository should be presented in the final environmental statement.

Response - The final statement will include the assumptions and release modes used for estimating discharge levels based on the conceptual design of the facility. These will be more thoroughly detailed in the Safety Analysis Report and confirmed during the demonstration program.

Comment - All discharges of radioactive material from the facility should be carefully measured and accurately recorded during the operation of the facility.

Response - This is planned; however, the details of accomplishing this are to be developed in the course of the design and development of the operational procedures for the facility.

Comment - The potential off-site population doses should be calculated and the results presented in the final environmental statement along with all pertinent assumptions.

Response - These doses and assumptions on which they are based will be included in the final environmental statement based on the conceptual design of the facility.

Comment - An effective environmental surveillance program for the site should be established and continued throughout operation of the repository. This program should also continue following decommissioning of the facility to determine whether radioactive material is being released to the environment.

Response - This has been planned from the outset and the recognition of the need for such an environmental surveillance program will be noted in the final report but the details of such a program will be developed in the course of the design and operational procedures for the repository in consultation with appropriate Federal and state agencies.

Comment - No information concerning emergency planning was presented in the draft environmental statement. Therefore we recommend that emergency planning be discussed in the final statement.

Response - The development of emergency plans will be made in the course of the design of the facility and details of such a plan would be included in the Safety Analysis Report.

Comment - Waste handling procedures and emplacement of wastes into the mine should be further discussed. The terms used for waste containers should be designed to give a better perspective of the operation. It should be pointed out if there is any limit on container size or the amount of activity per container of high-level waste. If not, spacing of holes for thermal control in the floor of the mine may need to be determined for each container. Additionally containers should not be placed next to beds of shale or anhydrite which contain gypsum, because shale and gypsum can yield moisture and corrode the container.

Response - The final statement will define the terms used. However, the container size, activity per container, spacing of containers in the mine, and location are needs that will be addressed in the course of the design and verified in the demonstration phase.

Comment - The nature of the vent through which the exhaust from the ventilation system will be discharged to the atmosphere should also be discussed.

Response - The ventilation system is discussed in the draft report to the extent feasible based on the conceptual design. However, the details of the system will be addressed in the course of the design of the facility and the performance specifications will be in the Safety Analysis Report.

Comment - Decontamination procedures, treatment of the resulting wastes, the mode of discharge of these wastes and controlling procedures should be adequately described.

Response - These are matters which will be detailed in the course of the design of the facility and documented in the Safety Analysis Report.

Comment - Consideration of the possible need for alternate or supplementary control facilities during operation of the facility is imperative.

Response - These facilities will be considered in the course of the design and development of the operational plans for the facility.

Comment - The AEC should also indicate the means by which the site and surrounding properties will be kept and maintained in perpetual care.

Response - Regulation (10 CFR 50) requires the Government to own the property on which Federal repositories are located. The nature and extent of perpetual care will be developed in the course of determining charges to the repository users of which perpetual care will be a part.

Comment - Page 5 of the EPA environmental impact review discusses matters previously commented on regarding the releases of radioactivity and need for an environmental surveillance program.

Response - These programs are planned including the development of baseline data, but they are as EPA recognizes in its comments practices in keeping with the demonstration nature of the facility.

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 29 1971

OFFICE OF THE
ADMINISTRATOR

Mr. John A. Erlewine
Assistant General Manager
for Operations
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Erlewine:

The enclosed report summarizes comments of the Environmental Protection Agency on the potential environmental impact of the Radioactive Waste Depository to be located at Lyons, Kansas. We appreciate the opportunity to comment on your draft environmental statement on this proposed facility.

The long-term disposal of high-level radioactive wastes is, of course, of great interest to this Agency, since a proper method of handling these wastes is vital to maintaining environmental quality as a result of the expected expansion of nuclear power generation. We recognize that the disposal or long-term storage of highly radioactive wastes in salt structures has been under rather extensive investigation by the AEC for over a decade. Although it appears that storage in salt formation offers, at least at this stage, the best method of such disposal, we do not believe the Commission has adequately developed or referenced in the environmental impact statement the results of work it has done on this problem and which presumably relate to the conclusions contained in the impact statement. Accordingly, it is not possible for us to assess fully the environmental impact of this proposed operation on the basis of the statement as received.

Because of the scope and nature of this proposed undertaking and its importance relative to the development of nuclear power in this country and the public interest and concern in this area, we believe a more detailed documentation of the environmental and safety aspects of the proposed activity is in order.

In addition to discussing more fully the basis for, and assumptions used in calculations and interpretation of experimental and field data, we think you should also develop:

1. The various factors relating to the long-term integrity of the salt formation and its ability adequately to contain the deposited radioactive material and to prevent contamination of terrestrial and hydrologic environments.

2. The need for contingency plans to recover the deposited material should this be required.

3. The demonstration nature of the project and the Commission's plans to evaluate periodically the technical progress of the project relative to actual environmental impact or geological changes that may have occurred.

4. The extent and nature of long-term environmental studies and a determination as to who will conduct such studies to assess discharges that might occur and their environmental effects.

Also, while we appreciate that the environmental aspects of the salt repository operation can be addressed without reference to other major phases of an overall waste management system, we believe that it would be highly desirable, if not essential, to consider, in detail, the environmental aspects of the two major related operations; namely, the waste solidification process at various locations and the transport of the solidified, encapsulated material. A description should also be included of how the interfaces between these three major parts of the total system will be managed so as to provide appropriate protection for the environment.

It would seem appropriate and useful for a proposed project of this scope and nature to be accompanied by a detailed report similar to the safety analysis report for a proposed nuclear reactor.

ENVIRONMENTAL IMPACT REVIEW

RADIOACTIVE WASTE REPOSITORY

Lyons, Kansas

ENVIRONMENTAL PROTECTION AGENCY
Radiation Office
Division of Technology Assessment
February 1971

INTRODUCTION AND CONCLUSIONS

The purpose of this report is to summarize the results of an evaluation by the Radiation Office and the Water Quality Office of the Environmental Protection Agency of the potential environmental effects of the Radioactive Waste Respository proposed to be located at Lyons, Kansas. The repository, a federally-owned facility, will utilize an existing 200-acre nonproducing salt mine about 1,000 feet underground and approximately 800 acres of the adjoining salt formation. It will be used for the ultimate disposal of both alpha waste and high-level waste. Alpha waste is material contaminated with plutonium and/or transuranic elements during nuclear fuel fabrication and will generally be at relatively low activity levels with a very long half life. High-level wastes are basically fission products separated from spent fuel at a fuel reprocessing plant and are characterized by high beta-gamma radioactivity levels and relatively long half-lives. All wastes are to be treated and stored as solid waste.

This evaluation is based upon the Environmental Statement[1] which was submitted by the Atomic Energy Commission for the proposed facility and a report by the Committee on Radioactive Waste Management entitled, "Disposal of Solid Radioactive Wastes in Bedded Salt Deposits."[2] The conclusions of this evaluation, based on the information presented, are as follows:

Our staff would be available to review further material that you develop on the above points, and we would be pleased to assist you in any other way in connection with this proposed project.

Sincerely yours,

Arthur H. Wolff

Arthur H. Wolff
Acting Deputy Commissioner
Radiation Office

1. Disposal of solid radioactive material in nonproducing salt mines is feasible, practicable, and has advantages over other considered methods of disposal. The proposed facility should, however, be considered as a demonstration one and operated accordingly until considerable operational experience indicates that no adverse environmental effects occur from this method of high-level disposal of radioactive wastes.

2. Radionuclide inventory assumptions and release modes used in estimating the discharge levels from the Radioactive Waste Repository should be presented in the final Environmental Statement.

3. All discharges of radioactive material from the facility should be carefully measured and accurately recorded during the operation of the facility.

4. The potential off-site population doses should be calculated and the results presented in the final Environmental Statement along with all pertinent assumptions.

5. An extensive environmental surveillance program for the site should be established and continued throughout operation of the repository. This program should also continue following decommissioning of the facility to determine whether radioactive material is being released to the environment.

6. No information concerning emergency planning was presented in the draft Environmental Statement; therefore, we recommend that emergency planning be discussed in the final Environmental

Statement for the Radioactive Waste Repository. Emergency plans should be established which could be initiated in the event of any foreseeable type of emergency situation, particularly the case of an in-transit accident involving a shipment of radwaste to the repository.

HANDLING, PROCESSING, AND DISPOSAL OF WASTES

The waste handling procedures and emplacement of wastes into the mine should be further discussed. The terms used for waste containers (casks, waste packages, high-level waste containers, etc.) should be defined to give a better perspective of the operation. It should be pointed out if there is any limit on container size or the amount of activity per container of high-level waste. If not, spacing of holes for thermal control in the floor of the mine may need to be determined for each container. Additionally, the containers should not be placed next to beds of shale or anhydrite that contain gypsum because shale and gypsum when heated can yield moisture and corrode the metal containers. Comments in this regard should be included in the Statement.

Air will be circulated through the facility from areas of low contamination potential to areas of successively higher contamination potential. Return ducts will be equipped with high efficiency particulate air filters, and all air will be routed through absolute filters before being discharged to the atmosphere.

Nevertheless, it is still expected that small amounts of gaseous and airborne particulate radioactive material will be discharged to the atmosphere and estimates of annual discharges are given on p. 32 of the Environmental Statement.(1) The assumptions made in estimating the annual discharge to the atmosphere from operation of the repository were not presented in the Environmental Statement.(1) Radionuclide inventory assumptions and release modes used in the estimated discharge levels should be presented in the final Environmental Statement so that an independent estimate of discharge levels can be made. The nature of the vent through which the exhaust from the ventilation system will be discharged to the atmosphere should also be discussed.

Since it is indicated(1) that decontamination facilities will be provided at the repository site, discharge levels of radioactive waste material resulting from decontamination operations should be included in the radionuclide discharge estimates for the facility. Decontamination procedures, the treatment of the resulting radioactive wastes, the mode of discharge of any of these wastes to the environment, and monitoring procedures should be adequately described.

Consideration of the possible need for alternate or supplementary control facilities during operation of the facility is imperative. It may be necessary to incorporate additional waste control facilities if unanticipated adverse environmental effects should be detected.

For these reasons, it should be shown that the processes provide sufficient flexibility so that protective and preventive measures can be taken. The Atomic Energy Commission should also indicate the means by which the site and surrounding property will be kept and maintained in perpetual care.

ENVIRONMENTAL IMPACT

In assessing the potential environmental impact due to radioactive discharges to the environment from the Radioactive Waste Repository, an estimate of radiation doses to the population during operation of the repository should be made for evaluating potential radiological effects. Average annual off-site concentrations resulting from repository effluents were presented in the Environmental Statement (1); however, the data necessary to verify these estimates were not included. Meteorological data that were utilized in calculating off-site dilution factors and air concentrations of gaseous radioactive effluents should be presented. Potential off-site population doses from these estimated air concentrations should be calculated and presented in the final Environmental Statement along with all pertinent assumptions.

Hydrologic studies being made should also determine the need to control man's activities on the surface from new agriculture development and industrial installations that may precipitate unintentional changes in the ground-water regime above the salt beds. Over several decades this could adversely affect salt storage areas.

ENVIRONMENTAL SURVEILLANCE

No mention is made in the Environmental Statement[1] of an off-site environmental surveillance program. Such a program is essential to confirm that the facility is operating as anticipated and to insure that the general public is not being unduly exposed to radiation originating at the site. Adequate surveillance should be done by the Atomic Energy Commission and the Kansas Department of Health to insure that there is no encroachment of radioactivity into drinking water supplies or other critical environmental pathways to man.

Since the site and its surroundings are principally agricultural areas, food crops produced in the area should be sampled regularly. Airborne particulate and gaseous samples should also be collected and analyzed as part of the surveillance program. All radioactive discharges from the site, including any wastes discharged as a result of decontamination procedures, should be monitored. The ventilation exhaust system should also be equipped with appropriate monitoring devices to measure ^{85}Kr, ^{3}H, and airborne particulate activity levels.

Surface water monitoring was not mentioned in the Statement. Although there is apparently no direct discharge of liquid radioactive wastes to surface waters, contamination could occur from waste discharges to the atmosphere or from surface drainage from the site.

Surveillance of the surface waters traversing the site should be undertaken, at least during the early stage of operation.

Salt is to be mined continuously during operation of the facility and much of the salt will be used for backfilling, but it is expected that there will be an excess of salt. One proposed use of this excess salt is to sell it commercially. Since salt mined from the repository could possibly be contaminated with radioactive material, any salt shipped off-site should be monitored carefully. The possibility of plutonium and/or other transuranic element contamination makes this particularly important. Precautions should be taken to assure that above ground storage of this excavated salt or other handling or disposal is conducted in such a way that the quality of surface or ground water is not impaired. It was stated that the repository would be insulated from the underground aquifers in the area. It was likewise mentioned that there were several wells for both human and livestock consumption in the vicinity of the repository. There is the possibility of induced movement of water in the aquifers resulting from increased temperatures caused by the decay of nuclear wastes. Although it is not anticipated that any radioactive material will permeate into these aquifers, water samples should still be taken and analyzed to confirm the absence of additions of radioactive materials to the aquifer water. This practice is in keeping with the demonstration nature of the facility. While water from the aquifers might not be used, the samples taken should show whether the water could be used if so

desired and as an indication that similar waste repositories could be operated in areas where there are active aquifers.

The surveillance program for the Radioactive Waste Repository should be established and initiated before operations at the facility begin. Preoperational data can establish the characteristic background levels which can be used as a base line to determine if operation of the repository is resulting in increased radiation levels in the environs. The surveillance program should also be continued after the decommissioning of the facility to confirm that the radioactive wastes are being contained in the repository with no releases of radioactivity.

EMERGENCY PLANNING

No information concerning emergency planning was presented in the draft Environmental Statement. The operation of the facility represents a potential for radiation incidents thus emergency planning should be discussed in the final Environmental Statement for the facility. Potential emergency situations may be divided into basically two categories: (1) On-site occurrences which could expose the surrounding off-site environs and general public to abnormal radiation levels, and (2) In-transit accidents involving radioactive material being transported to the site. Both of these types of emergencies should be considered and plans established to alleviate the effects of any possible accident before operations at the facility begin.

Emergency procedures should be established to protect the surrounding environs and minimize exposure of the general public in the event of an on-site accident involving radioactive material. Arrangements should be made by which the Atomic Energy Commission, the facility operator, will notify the Kansas Department of Health and local authorities in the event of an abnormal on-site occurrence which could affect off-site areas. The specific types and magnitudes of potential accidents should be determined and appropriate plans to protect both the general public and on-site personnel should be established.

All shipments of radioactive waste material to the repository will be conducted under appropriate Atomic Energy Commission and Department of Transportation regulations. However, the possibility of an accident involving the release of radioactive material during an in-transit accident should not be overlooked. Those States through which major shipping routes will cross should be informed as to the type of wastes that will be shipped and potential accidental situations that may result so that they will be able to respond if the accidental situation arises. The scope of such potential in-transit accidents should be anticipated, and the authority with which responsibility lies for protection of the general public and the handling of cleanup operations following an accident should be established and agreed upon by all parties involved before any shipments are made.

REFERENCES

1. United States Atomic Energy Commission, "Environmental Statement - Radioactivity Waste Repository - Lyons, Kansas - DRAFT," November, 1970.

2. Committee on Radioactive Waste Management, "Disposal of Solid Radioactive Wastes in Bedded Salt Deposite," National Academy of Sciences - National Research Council, Washington, D.C., November, 1970.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 4 1971

Mr. Hollis M. Dole
Assistant Secretary of the Interior
U. S. Department of the Interior
Office of the Secretary
Washington, D.C. 20240

Dear Mr. Dole:

Thank you for your letter of February 3, 1971, commenting on the Draft Environmental Statement on the Proposed Radioactive Waste Repository near Lyons, Kansas. The comments furnished by you have been thoroughly considered and to the maximum extent practicable they have been included in the preparation of the Final Environmental Statement. We have also made numerous additions and revisions to the statement based on comments made by other agencies and we believe that the enclosed statement conforms with the letter and spirit of the National Environmental Policy Act of 1969. Also enclosed is a copy of a report indicating the disposition of your specific comments. In this report we have not attempted to respond to specific comments but we have referenced the sections of the Environmental Statement which have been revised or amplified in response to your concerns. You will note that many of your comments call for information and answers which cannot be included in an environmental statement which must be prepared well in advance of doing the work which would provide the answers. Your own comments, in many instances, recognize that these answers are dependent upon the design of the facility, ongoing site studies and the development of operational procedures. However, we have indicated AEC's intention with respect to covering these areas in the Conceptual Design and Safety Report. In addition we have also included an extensive bibliography of published information on the salt mine concept, including related research and development.

We are pleased that your letter recognizes that this proposal is a major positive step for isolating radioactive wastes from man's environment, and in eliminating the problem of proliferating the

disposal sites of radioactive wastes in environmental situations whereby these products might reach water or other resources valuable to man.

We again thank you for your comments which have been most helpful to us in preparation of this Final Statement.

Sincerely,

John A. Erlewine

John A. Erlewine
Assistant General Manager
for Operations

Enclosures:
1. Final Environmental Statement
2. Comments on Draft Statement
3. AEC Response to Comments

AEC STAFF REPORT ON DEPARTMENT OF INTERIOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT FOR THE PROPOSED RADIOACTIVE WASTE REPOSITORY NEAR LYONS, KANSAS

Comment - We believe that additional significant studies and confirmatory data concerning the geology and hydrology of the salt deposits and overlying rocks . . . and the effects of the construction of the waste facility will be necessary to demonstrate conclusively that these deposits are indeed suitable for the final repository.

Response - Section V.B.1.d. of the final statement indicates that these additional studies will be carried out and that they will be documented in the Conceptual Design and Safety Report. An An evaluation of these studies will be made prior to a final safety determination regarding the suitability of the site.

Comment - Although the subject statement indicates that no significant impact on the environment is anticipated . . . it does not represent sufficient information to evaluate the potential impact of all aspects of the facility. Therefore, an endorsement of the establishment of the repository cannot be given on the basis of the environmental statement or the included report by the NAS-NRC. The NAS-NRC has given only qualified endorsement and has pointed out that special management problems and has prescribed continuing studies and development programs should be carried out before waste disposal operations begin. Most of these problems and investigations have a strong bearing on final decisions as to whether the project is feasible.

Response - The environmental statement does not purport to present the scientific justification for the facility. We agree that the studies and investigations to be carried out before waste disposal operations begin have a strong bearing as to whether the project is feasible. No final decision will be made until all the studies and investigations have been concluded and evaluated and no radioactive wastes will be permanently placed in the mine until this is accomplished.

Comment - It is noted that the statement does not provide an adequate specific description or analysis of the contemplated design of its high-level mine from which the effects of mining subsidence can be evaluated, even in a general qualitative manner.

Response - The design of the mine is only in a conceptual stage. However, anticipated subsidence is described in Section V.B.d.

Comment - It would be advisable to describe in more detail how the mined salt will be processed and utilized to increase its density for backfill to reduce subsidence and to specify the scheduling for backfilling operations.

Response - These matters will be considered in the course of the design and development of the operational plans for the facility.

Comment - The statement should derive and specify the expected earthquake and expected vibrational or other ground effects at the site and a definition of the potential hazard to mines or surface structure.

Response - Earthquake analysis will be included as part of the design phase of the facility and will be included in the Safety Analysis Report.

Comment - It should be pointed out that further analyses of thermal and other stresses on the heterogeneous rocks in the Hutchinson Salt Member at the site are warranted. These stresses, prolonged heat and exposure to radiation and subsidence and deformation with the mining and flow of salt, could result in fracturing in the rocks above the salt . . . convective water through salt reduced by heat through radioactive wastes could result in a long term cycle of dissolution of the salt and the eventual aqueous transport of radioactive wastes to the surface . . . these problems are not overwhelming but they are legitimate areas for final analysis and documentation.

Response - We agree that these problems should be further analyzed and documented. This will be done as part of the planned site studies. Section V.B.L. described the current status of these investigations and the type of planned studies.

Comment - The discussion of natural groundwater leaching of rock salt deposits states that the salt deposit ends abruptly about 25 miles east of the site . . . it is impossible to evaluate these rates of subsurface solution of the salt formation without specific and detailed information on the regional paleogeology and inferred paleohydrology and the methods used . . . .

Response - This information will be developed during the course of the site studies and will appear in the Conceptual Design and Safety Report. Section V.A.5.b. discusses the additional work to be done.

Comment - Page 4 of Mr. Dole's letter sets out eleven design criteria, operational procedures and studies . . . believed to be vital for the safe long term operation of the proposed facility.

Response - These are matters which will be developed during the course of the design and development of operational procedures for the facility. They will be presented in the Conceptual Design and Safety Report. We believe they are outside the scope of the environmental statement. To a limited extent, some of the issues are discussed in the Final Environmental Statement.

Comment - The waste handling procedures and emplacement of wastes into the mine should be further described. It should be pointed out if there is any limit on container size or the amount of activity per container of high-level waste. If not, the spacing of holes for thermal control in the floor of the mine may need to be determined for each container. Additionally, the containers should not be placed next to beds of shale or anhydrite that contain gypsum.

Response - The container size, activity per container, space of containers and location are matters that will be addressed in the course of the design and verified during the demonstration phase.

Comment - Hydrologic studies being made should also determine the need to control man's activities on the surface from new agriculture development and industrial installations that may precipitate unintentional changes in the groundwater regime above the salt beds.

Response - The question of necessary controls in order not to adversely affect the salt storage areas will be examined in the course of the design of the facility.

Comment - The problem area that is still under investigation . . . is the disposal of salt excavated from the repository.

Response - Section VI.B. provides additional information on this and it will be addressed in the course of the design and development of operational procedures for the facility.

Comment - The possibility of induced movement of water from the aquifers . . . emphasizes our previous comments on the need to sample groundwater and analyze the samples for radioactive components.

Response - Section VI.D.1. describes the radiology and monitoring programs which will be developed during the course of the design of the facility.

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

FEB - 3 1971

Dear Mr. Erlewine:

This is in response to your letter of November 30, 1970, requesting our comments on the draft environmental statement on the Atomic Energy Commission's proposed radioactive-waste repository near Lyons, Kansas. This draft environmental statement, and the included report on "Disposal of Solid Radioactive Wastes in Bedded Salt Deposits" by the Committee on Radioactive Waste Management of the National Academy of Sciences-National Research Council, have been reviewed by the several Bureaus within this Department that have special expertise with respect to the environmental impact of the project.

We believe that the proposal of the Atomic Energy Commission to establish a thoroughly investigated, underground, national repository in relatively impermeable rocks for solid, radioactive wastes on federally owned property is a major, positive step in isolating radioactive wastes from man's environment, and in eliminating the problem of proliferating the disposal sites of radioactive wastes in environmental situations whereby the products might reach water or other resources valuable to man. The research efforts of the AEC, and the utilization of various fields of scientific and engineering expertise over the past decade, to develop methods whereby highly radioactive wastes can be reduced to small volumes of encapsulated, relatively insoluble waste that can be transported safely from various fuel-element reprocessing plants to areas of ultimate disposal in relatively impermeable rocks, are commendable.

We agree with the general conceptual conclusions of the NAS-NRC Committee on Radioactive Waste Management, as expressed in their reviewed report (p. 1-2), that the use of bedded salt deposits for the disposal of radioactive wastes in bedded salt is the safest choice now available, provided that the wastes are in an appropriate form and that the salt beds meet necessary engineering-design and geological criteria. However, we believe that additional significant studies and confirmatory data concerning the geology and hydrology of the salt deposits and overlying rocks at and near Lyons, Kansas, and the effects of construction of the waste-disposal facility will be necessary to demonstrate, conclusively, that these deposits are indeed suitable for the "final repository" mentioned (on p. 2) in the draft environmental statement. Our concerns are based partly on the statements in the draft environmental statement (p. 18) that, although retrieval of the wastes is conceptually possible,

the emplacement of the wastes in the salt formation at Lyons would, actually, be regarded as "permanent storage". Such a permanent commitment of the wastes requires a very strong and scientifically convincing demonstration that the wastes will remain in a geologically relatively undisturbed and hydrologically isolated position for the several thousand years required for the decay of the high-level fuel-reprocessing wastes, and the several hundred thousand years required for the decay of the other "alpha-emitting" solid wastes (which contain long-lived isotopes such as plutonium). Such a scientific and engineering demonstration does not appear to be impossible at all, but it will require a more thorough and better-documented approach than is presented in the draft environmental statement. Our views concerning the Lyons, Kansas, site are generally similar to those of the NAS-NRC report which recommends (p. 7, item 4) that "additional studies and investigations, described below, be undertaken concurrently with planning and site acquisition. If these studies and investigations reveal problems or conditions that would jeopardize the safety and integrity of the storage site, the project should be reconsidered. However, based on research and development performed to date, the Committee does not anticipate any insurmountable problem."

Our specific comments on the draft environmental statement are provided below.

Although the subject environmental statement indicates in summary (p. 2) that no significant impact on the environment is anticipated from the construction or operation of the repository, it does not present sufficient information to evaluate the potential impact of all aspects of the facility. Therefore, an endorsement of the establishment of the repository cannot be given on the basis of the environmental statement, or the included report by the NAS-NRC Committee. The NAS-NRC Committee, of course, has given only a qualified endorsement (p. 6-7); has pointed out (p. 7-9) special management problems; and has prescribed (p. 9-16) continuing studies and development programs to be carried out before waste-disposal operations begin. Most of these problems and investigations have a strong bearing on final decisions as to whether the project is feasible.

We believe that there are inadequacies in the presentation of specific items in the draft statement that the Commission may wish to consider in preparing its final statement. It is noted that the statement (p. 18-19) does not provide an adequate specific description or analysis of the contemplated design of its "high-level mine" from which the effects of mining subsidence (p. 35-36) can be evaluated, even in a general, qualitative manner. For example, if multilevel mining is contemplated, such a process in a small area might produce entirely different effects in terms of subsidence and possible fracturing of overlying rocks (including possible ground-surface rupturing) than would mining at one level over a large area. Such unspecified effects could be critical to the location and safe operation of surface facilities; to the long-term integrity of the stored wastes; and to possible environmental changes at the land surface, such as stream-drainage changes, ponding, and poor soil drainage. Additionally, it would be advisable to describe in more detail how the mined salt will

be processed and utilized to increase its density for backfill to reduce subsidence in both the existing mine and the "high-level mine", and to specify the scheduling for backfilling operations. Criteria for backfilling in the areas of disposal of "alpha-emitting" solid wastes are especially desirable, since salt flowage and other deformations are presently occurring in the Carey Salt Mine.

A brief analysis of earthquake hazards is presented on pages 24-27 of the draft environmental statement. This analysis points out that, during the relatively brief historic record of the central stable region of the United States, earthquake activity has been relatively low, but that the earthquakes in this region have ranged up to intensity VI (Modified Mercalli). The geologic history of the region indicates tectonic stability for a very long period of time. Nevertheless, since earthquakes have occurred at many places in the Kansas-Nebraska region, they can be expected to occur in the future. Therefore, the statement should derive and specify the expected earthquake; the expected vibrational or other ground effects at the site; and a definition of the potential hazard to mines or surface structures. Presumably, the degree of conservatism in seismic design criteria should be based on an analysis of the potential radioactivity hazard presented by failure of man-made structures and their components at the site.

The environmental statement (p. 9) indicates that one of the most important features of salt deposits is that they are free of circulating ground water and are isolated from aquifers by essentially impermeable shale. The geologic history of these deposits indicates that such conditions have obtained for a very long period of time. However, we must stress that the conditions referred to apply only to the rocks in their natural state, undisturbed by man. Also, the tendency of fractures in salt to heal by plastic flow applies primarily to relatively pure salt, whereas the Hutchinson Salt Member of the Wellington Formation at the Lyons, Kansas, site contains a significant number of interbedded layers of shale. In a 1966 report, the National Academy of Sciences-National Research Council, Committee on Geologic Aspects of Radioactive Waste Disposal, included the suggestion that a study be made of, "the behavior of shale interbeds that will be subjected to long periods of elevated temperatures and radiation, in order to anticipate possible changes in wall, ceiling, and floor conformation (of the mine) additional to those caused by creep and flow of salt." Following the recommendations of the NAS-NRC, the AEC sponsored intensive investigations by Oak Ridge National Laboratory on these topics.✓ The results of these investigations are reported to be generally favorable in the existing mine workings. Nevertheless, in view of the above-stated concern related to the lack of data on the "high-level mine", it should be pointed out that further analyses of thermal and other stresses on the heterogeneous rocks in the Hutchinson Salt Member at the site are warranted. These stresses (prolonged heating and exposure to radiation, and subsidence and deformation associated with the mining and flow of salt) could result in fracturing of the rocks above the salt. If the system of induced fractures extends upward through the 500-foot-thick section of shales between the Hutchinson

salt and the Stone Corral dolomite, which is a fresh-water aquifer, ground water might move down to the salt. Sandstones of Cretaceous age, about 100 feet above the Stone Corral dolomite, are another source of fresh water which might be involved. Convective water circulation through fractures, induced by heat from the radioactive wastes, could result in a long-term cycle of dissolution of the salt and the eventual aqueous transport of radioactive wastes to the surface. In view of the fact that the "high-level" and "alpha-emitting" wastes will not have decayed to innocuous levels of activity for thousands of years (in the case of plutonium, hundreds of thousands of years), there would be adequate time for this circulation system to transport radioactive wastes to shallow aquifers or to the surface. These problems are not overwhelming, but they are legitimate areas for further analysis and documentation.

The discussion of natural, ground-water leaching of rock salt deposits (p. 34) states that the salt deposit ends abruptly about 25 miles east of the site and a series of subsidence ponds and salt-water springs overlie the present stratigraphic position of the salt member. The environmental statement indicates that, based on the "precise dating of subsidence features", the salt front has retreated westward five miles in the last one million years in Saline County, and 13 and 12 miles, respectively, in about five million years in McPherson and Harvey Counties. It is impossible to evaluate these rates of subsurface solution of the salt formation without specific and detailed information on the regional paleogeology and inferred paleohydrology, and on the methods used to date the subsidence features. Such information, presumably, will be developed by investigations in progress, such as those discussed under "Long-term research and development" on pages 14-16 of the MAS-IRC report.

The following design criteria, operational procedures, and studies that the Commission must have certainly considered while planning the repository are believed to be vital to the safe long-term operation of the proposed facility and therefore should be presented in the final detailed statement:

1. Studies to determine the deterioration rate of the stainless steel and high carbon steel canisters to be used for storing radioactive wastes in the salt environment of the mine;

2. Studies to determine the rupture strength of these canisters from internal gas and temperature build-up during the decay of the contained radioactive materials;

3. Provisions for continuous air monitoring to detect dangerous levels of radioactive gases and airborne particulate matter within the mine and at the mine ventilation exhaust port, both before and after filtration;

4. Provisions for rapid and automatic sealing of all mine openings in the event of a radiation accident, atmospheric contamination, destruction of support facilities (receiving buildings and hoisting), and loss of power (ventilation and monitoring);

5. Provisions for removal, storage, and treatment of water that may accidentally enter storage areas in the mine and become contaminated;

6. Provisions for drilling and instrumenting deep wells about the perimeter of the disposal site to monitor temperature and radiation levels in the Hutchinson and adjacent formations, and overlying aquifers;

7. Construction and posting of a personnel barricade around the perimeter of the repository;

8. Continuous ecological and other environmental monitoring within and immediately surrounding the site;

9. Provision for strategically located mine safety areas and/or shelters to which personnel could retreat in the event of a caving or radiation accident, and from which they can be rescued without bringing radioactive contaminants to the surface;

10. Provisions for installing radiation monitoring equipment and/or sealing of all existing oil, gas, and water wells within or surrounding the repository site;

11. Planned means for cleaning up radioactive waste spillage within the mine, receiving facilities, and along principal access routes.

Regardless of possible industrial or other uses, the area should be revegetated to the natural state as soon as possible in order to maintain the actual ecological niche of the general area.

The waste handling procedures and emplacement of wastes into the mine should be further described. The terms used for waste containers (casks, waste packages, high-level waste containers, etc.) should be defined to give a better perspective of the operation. It should be pointed out if there is any limit on container size or the amount of activity per container of high-level waste. If not, spacing of holes for thermal control in the floor of the mine may need to be determined for each container. Additionally, the containers should not be placed next to beds of shale or anhydrite that contain gypsum because shale

and gypsum when heated can yield moisture and corrode the metal containers. Comments in these regards should be embodied in the Statement.

Hydrologic studies being made should also determine the need to control man's activities on the surface from new agriculture development and industrial installations that may precipitate unintentional changes in the ground-water regimen above the salt beds. Over several decades this could adversely affect salt storage areas.

A problem area that is still under investigation by the Committee on Radioactive Waste Management is the disposal of salt excavated from the repository. Since this could affect the water quality of surface or ground-water in the site vicinity if incorrectly conducted, further mention should be included in the statement.

The possibility of induced movement of water in the aquifers resulting from increased temperatures caused by nuclear wastes further emphasizes our previous comments on the need to sample ground-water and analyze the samples for radioactive components.

We hope that our comments will be helpful in the development of a final environmental statement that gives full consideration to the areas of concern expressed above, and we note that the Geological Survey of this Department is participating, at the request of the Atomic Energy Commission, with the Kansas Geological Survey in evaluation of the geologic, hydrologic, and geophysical factors relevant to establishing a national repository for radioactive wastes in salt deposits near Lyons, Kansas. Accordingly, we look forward to the opportunity of reviewing the revised environmental statement.

Sincerely yours,

Hollis M. Dole
Assistant Secretary of the Interior

Mr. John A. Erlewine
Assistant General Manager for Operations
United States Atomic Energy Commission
Washington, D.C. 20545

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 4 1971

Mr. H. A. Solberg
Captain, U.S. Coast Guard
Acting Chief, Office of Public
and International Affairs
Department of Transportation
Washington, D. C. 20591

Dear Mr. Solberg:

Thank you for your letter of December 18, 1970, commenting on the draft Environmental Statement for the proposed radioactive waste repository near Lyons, Kansas. We have noted your comment that the impact upon transportation of the proposed project is minimal. We have, however, made numerous other additions and revisions in response to comments received from Federal agencies and others. We believe the enclosed Statement conforms with the letter and spirit of the National Environmental Policy Act of 1969.

The review of the draft Statement by the Department of Transportation is appreciated.

Sincerely,

John A. Erlewine
Assistant General Manager
for Operations

Enclosure:
Final Environmental Statement

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to
COMMANDANT (AVT-1)
U.S. COAST GUARD
WASHINGTON, D.C. 20591

18 DEC 1970

Mr. John A. Erlewine
Assistant General Manager for Operations
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Erlewine:

This is in response to your letter of 30 November 1970 addressed to Mr. Legate concerning the draft environmental statement for the proposed Radioactive Waste Repository project as Lyons, Kansas.

The concerned operating administrations of the Department of Transportation have reviewed the draft environmental statement. Other than to note all shipments of radioactive wastes to the proposed depository will conform with AEC and DOT regulations, the impact upon transportation of the proposed project is minimal. DOT has no objection to and makes no comment on the draft environmental statement.

The opportunity afforded the Department of Transportation to review the draft environmental statement for this proposed project is appreciated.

Sincerely,

H. A. [illegible]
Captain, U. S. Coast Guard
Acting Chief, Office of Public and International Affairs

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 4 1971

Dr. Roger O. Egeberg
Assistant Secretary for
Health and Scientific Affairs
Department of Health, Education
and Welfare
Office of the Secretary
Washington, D. C. 20201

Dear Dr. Egeberg:

Thank you for your comments of February 25, 1971, on the Atomic Energy Commission's Draft Environmental Statement covering the Proposed Radioactive Waste Repository at Lyons, Kansas. We have made numerous revisions and additions to the Environmental Statement taking into account the comments received from other agencies on the draft.

With regard to the Department of Health, Education and Welfare's comments, we have noted that you recommend that the Final Statement contain adequate documentation and reference to previous work that supports our conclusions that all radioactive material will be sealed within the salt formation and will not leak into the environment. You will note in Sections III. and V. of the Environmental Statement, we have carefully described the waste characteristics and the amount of such materials we expect to dispose in the Lyons facility, have indicated the suitability of the present salt formation for containing these materials, and the impact that these waste materials are expected to impose upon the subsurface environment in the Lyons vicinity. Further, we have added a bibliography of relevant information which supports our conclusions.

The demonstration nature of the project has been emphasized in the Environmental Statement and in numerous statements before the Congress, as well. You will note that we expect the demonstration phase to extend through the first several years operation during which time considerable additional physical and environmental information will be developed. We indicated in the Environmental Statement the extremely low-level of radioactive effluents expected from the facility and the resultant low radiation doses predicted for the general public in that vicinity. As further assurance, the facility will be operated with a stringent onsite radiation monitoring program, plus a general radiation and environmental monitoring program offsite as summarized in Section VI.D.1. of the Environmental Statement.

We have noted your suggestion for consideration of the potential for environmental radioactive contamination in connection with the waste solidification process and in connection with transportation systems. However, we consider these matters to be beyond the scope of this Environmental Statement inasmuch as no specific actions pertaining to the solidification process or the transportation operations are being proposed.

Waste solidification is an operation which will be carried out at licensed fuel reprocessing facilities. We believe that radiological safety and related environmental effects are adequately addressed in the licensing process, which includes a review by the Advisory Committee on Reactor Safeguards and a public hearing before the Atomic Safety and Licensing Board. Similarly, we believe that the regulations under which all shipping systems for radioactive materials are reviewed and licensed adequately provide for the health and safety of the public. We would note that the shipment of radioactive waste will be similar in most respects to the shipment of spent nuclear reactor fuels. Shipments of these materials have been carried out safely for over twenty-five years and this experience and related technology provides a firm base for the design of safe and reliable systems for shipment of radioactive waste to the repository.

Enclosed are copies of our Final Environmental Statement, copies of all comments received on the Draft Statement and our responses, as requested.

Thank you for your assistance.

Sincerely,

John A. Erlewine

John A. Erlewine
Assistant General Manager
for Operations

Enclosures:
1. Final Environmental Statement
2. Comments on Draft Statement
3. AEC Response to Comments

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

OFFICE OF THE SECRETARY

WASHINGTON, D.C. 20201

FEB 25 1971

Mr. John A. Erlewine
Assistant General Manager
for Operations
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Erlewine:

Your letter of November 30, 1970, to Mr. Roger Strelow requesting comments on the Radioactive Waste Repository to be located at Lyons, Kansas, has been referred to me. We apologize for the lateness of our reply, but our review of nuclear activities has been somewhat interrupted by the recent reorganization of the bulk of these activities into the Environmental Protection Agency.

We are generally of the opinion that conversion to solids and storage in salt formations offers the best long-term approach for public health protection from wastes from the nuclear industry. We do not believe the Atomic Energy Commission has included in its environmental statement adequate documentation or reference of the work it has sponsored in this area over the years. We strongly urge you to do so in your detailed statement on the repository, giving particular emphasis to the basic work that supports the conclusion that all radioactive material will be sealed within the salt formation and will not leak to the environment.

The facility should be considered as a demonstration project and operated accordingly. Programs should be developed to determine the effect of operating the facility on radiation doses to the public. These programs should utilize the most sensitive radiological surveillance methods, since expected discharges would be small.

The effect of operating the facility has not only local but nationwide implications. The potential to contaminate local environments where the waste is converted from a liquid to a solid form should be considered, but just as important are the potential risks of environmental contamination and possible public exposure from transporting the waste to the repository. These points should be assessed and plans developed to mitigate population exposure or environmental contamination during transit.

We would appreciate receiving your compilation of comments by other agencies when it is completed. If this Department can assist you further in this matter, we would be happy to do so.

Sincerely yours,

Roger O. Egeberg, M.D.
Assistant Secretary for
Health and Scientific Affairs

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