Report to the City of West Chicago:

Summary of Geological Considerations Regarding

The Kerr-McGee Stabilization Plan of 1979

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This report represents comments regarding the Kerr-McGee Stabilization Plan for their West Chicago site. Four areas of concern are addressed: 1) the nature of the clay to be used in this setting, 2) the integrity of the clay barrier, 3) the interaction of the waste materals with ground water and 4) the monitoring of the site. Concluding comments are also given. All aspects have been directly or indirectly considered by previous reviewers of the plan (eg. Argonne National Laboratory, Thomas M. Johnson and Robert E. Bergstrom of the Illinois State Geological Survey, and many others). It is important to note, however, that many statements made regarding these aspects have implications that would not ordinarily be understood by a non-geologist. The decision on the acceptibility of the plan may be made by persons without geological backgrounds and hence, it is imperative that these implications be considered and understood. The purpose of this report is to consider some of the geological implications of the Kerr-McGee plan in non-technical language in an organized manner. References are made to letters submitted by various reviewers of this plan (or its predecessor plan(s) if the comments are still appropriate).

1. The nature of the clay to be used at the site. The Kerr-McGee plan does not specifically identify the clay to be used. In this regard, Kerr-McGee suggests a clay type (montmorillonite), permeability standards and apparently because of cost considerations, that the clay should be

locally derived. The requirement of low permeability clay appears obvious; it is necessary to separate the pollutants from the ground water and to restrict rain water from entering the debris pile. Several comments regarding the suitability of such a clay seal have been made. The Illinois Environmental Protection Agency[1] maintains that conventional land fill sites must have a ten foot thick clay liner of naturally located clay of suitably low ($1x10^{-8}$ cm/sec) permeability. Artificial clay liners are prohibited. Such clay liners must be compacted whereas clay deposits have naturally undergone compaction over thousands or millions of years. Conventional land fill sites are required to have clay liners on the bottom and sides, unlike the Kerr-McGee plan. This deficiency has also been expressed by others[2,3]. Kerr-McGee has suggested that not all the debris is of a suitably hazardous nature to require a complete clay liner.

The type of clay mineral used in the project is also important. Kerr-McGee has specified that montmorillonite clay be used and it is generally agreed that this type of clay has superior retardation properties. This clay is known as an "expandable clay" because atomic layers in the material readily separate to retard water, inorganic cations (perhaps Th) and organic molecules. Kerr-McGee has not specified where the clay is to come from but has included certain analyses of locally-derived clays. Unfortunately, this clay does not meet Kerr-McGee's specifications regarding clay type nor the Illinois EPA's. The Illinois Geological Survey[4] has indicated that clay from the West Chicago vicinity is illite based and therefore, has poor exchange (or retardation) characteristics. Table 1 taken from a report by Isherwood[5] shows the tremendous variability in ion exchange distribution coefficients for a range of materials. High values of the distribution coefficient indicate the nuclide is strongly partitioned into the solid phase and therefore has high retardation with

Table 1

	Thorium	
Nishiwaki, et al., 1972	40 - 130	med. sand, pH 8.15
	310 - 470	v. f. sand, pH 8.15
	2700 - 10^4	silt/clay, pH 8.15
Rancon, 1973	8	schist soil, pH 3.2, $1g/_1$ Th.
	60	schist soil, pH 3.2, $1g/_1$ Th.
	120	illite, pH 3.2, 1 $g/_1$ Th.
	10^3	illite, pH 3.2, 1 $g/_1$ th.
	$\geq 10^5$	illite, pH >6, $.1g/_1$ Th.
Dahlman, et al., 1975	1.6×10^5	clay soil, pH 6.5, 5 mM $Ca(NO_3)_2$
Bondietti, et al., 1976	1.6×10^5	silt loam, pH 6.5, Ca sat. clay
	4×10^5	montmorillonite, pH 6.5, Ca sat. clay

respect to the fluid flow. Low values indicate that the velocity of the nuclide approaches the velocity of the groundwater. Clearly, the type of clay, its composition and its physical and chemical properties are important factors. Kerr-McGee must demonstrate that the clay to be used meets all these standards.

2. <u>The Effectiveness of an Artificial Liner</u>

Assuming that the objections to an artificial clay liner can be overcome, could such a clay liner be effective? What are the objectives of such a liner, and what happens if the objectives are not met? The plan calls for only a partial liner under the more contaminated factory machinery. A clay cover is proposed to cover the entire site.

It would be expected that a properly maintained clay cover would perhaps not prevent the passage of water but would inhibit it. Conventional land fill sites monitor leacheates from wells and two such wells are proposed by Kerr-McGee. However, the nature of the landfill pollutants are different and such wells may act as radon vents.[7]

The Illinois Division of Nuclear Safety[2] has suggested that wet materials will increase the possibility of subsidence. Although building material may appear dense, pore spaces always form between debris pieces. Compaction and settling would certainly effect the clay cover. Both the U.S. EPA[7] and the Illinois Geological Survey[4] further suggest that long term maintenance would be required for as long as the cover should be protective. Who is to be responsible for such maintenance?

Other potential problems may involve the integrity of the clay cover and underlay. No effort is made to prevent the debris from piercing the clay liner. In addition, the long term behavior of clay has not been considered. Clay has essentially no strength and will flow under directed stress if not under confinement. The clay sealer at the bottom of the debris pile may either migrate laterally away because of pressure from overburden, or upward into the interior through pore space. In either case, the seal liner could be effectively compromised. A natural clay liner that has undergone compaction through geologic time would be less mobile.

If the clay cover is not maintained it would be expected to rapidly deteriorate due to general down slope movement ("mass wasting") caused by gravity. In addition, the top soil cover would also be involved in mass wasting and this would be accelerated by water re-directed away from, but running parallel to the clay cover. Freezing and thawing of the moist clay, or the freezing of water that pools on the clay surface would also deteriorate the cover. Uncontrolled foliage with root systems greater than three feet, decomposing vegetation, rodents and insects will all participate in the deterioration of the cover even with intensive efforts to try to control these factors. At this time it is not clear whether any of these additional problems will be significant. More research is needed to determine if they are important.

Since few believe that a clay cover can completely isolate the contents of the debris mound, and the possibility that even with maintenance some water will enter the system from above, further studies are needed relating to geology. The most serious questions relate to how groundwater will interact with the waste and this is discussed below.

3. <u>The interaction of the waste materials with ground water</u>.

Uncertainties with regard to the effectiveness of the proposed clay barrier dictates that the effects of groundwater interaction with the waste material need to be investigated. Necessary investigations may be grouped into two general categories: (1) leaching of contaminants from the factory residues and other waste material and (2) transport of the contaminants from the site by groundwater flow. Specifically, the former is concerned with whether the thorium and thorium oxides can be readily leached from the buried materials whereas the latter involves whether local hydrologic conditions will allow the waste material to reach the shallow aquifer and below.

The latest decommission plan of 1979 indicates that leachibility tests were conducted by Kerr-McGee. Although the text indicates that the detailed procedures for the tests are included in the report as appendices, no such additions are included. Apparently, the first test involved using concentrated acids to remove nearly all soluble material. The second test involves leaching tests at a pH of 4.9 to 5.2 that produced leachates which did not exceed 10 times the drinking water standards of the proposed Resource Conservation and Recovery Act. However, evidence given below suggest that additional work is necessary before it may be concluded that there is little possibility of significant groundwater pollution.

There is already evidence that chemical pollution (and perhaps radioactive pollution) has been found in both shallow ground water and an underlying dolomite aquifer. Kerr-McGee indicates that well B-2 showed anomalous readings and surface contamination, but this interpretation has not been adequately substantiated. The Illinois Geological Survey[4] indicates that subsequent analyses prove that contamination of well B-2 is not from surface or "accidental" contamination. If pollution is proven in the subsurface water, then the leachability tests done by Kerr-McGee are insufficient to explain the potential hazards[4,7]. In addition, comments from Argonne National Laboratories[6] indicate that although the present groundwater quality may be acceptable to the Kerr-McGee Corporation, other agencies (and hydrologists) would find the same water unacceptable. Furthermore, even though ground water quality is improving because liquid discharges have ceased, leaching has continued[4]. A stable condition as suggested by Kerr-McGee has not been proven. However, little radioactive pollution has moved from the site[10].

By placing large amounts of contaminated materials into a debris pile, the plan may allow natural processes to concentrate the radioactive pollutants. Demolition of the buildings may expose contaminated surfaces, once protected by the building, to the natural processes of erosion. In this regard, the effect of the total amount of potential radioactive pollutants (on the environment) needs to be considered. However, inconsistent U_3O_8 estimated weights are given in the plan[6]. It should also be pointed out that ground water movement may help "flush out" dissolved pollutants, although it is not clear that enough hydrologic or geologic information is available to determine this. (It should be noted that it is contrary to NRC policy to allow radioactive materials to be dispersed in the environment as a means to reduce their effect by dilution.) The need to know more about the geohydrology of the area has been expressed[6,8]. Hydrologic modeling could be used to anticipate long term effects of ground water movement if adequate geohydrologic information is obtained.

The Illinois State Geological Survey[9] has considered the possibility of the leaching of thorium and thorium oxides from the factory residues. In addition to the possible presence of carbonates, pH and sodium were suggested as factors affecting the potential for leaching. They further suggest that clay minerals would adsorb thorium from "pure solutions, especially at pH values above 6. This implies that if an adequate thickness of calcareous clayey material were placed between the waste and the ground water, no contamination of the ground water should occur". They caution, however, that thorium complexed with fluoride and/or organics will migrate through clay materials more rapidly.

Since the clay cover cannot be completely effective in stopping water from entering the mound, the possibility of the occurrence of leachate springs forming at the base of the mound has been suggested[4,9]. In addition, little attention has been given to the effects of a rise in groundwater[2].

4. Monitoring of the site. The most significant geologic questions regarding the monitoring of the site are: 1) How long? and, 2) Of what? (Montoring during stabilization proceedings is not included in this report.) It seems reasonable that perpetual care of the site should be required. Such a view is consistent with the philosophy of secure repositories for radioactive waste. The proposed monitoring of the site by Kerr-McGee for three years is therefore not adequate. Many of the important nuclides can be expected to remain significant pollutants for time frames on the order of 10,000 to 1,000,000 years. As mentioned above, the clay cover will require maintenance for as long as it is to be effective. A perpetual care fund should be created that clearly establishes responsibility for maintenance and site monitoring by an independent and capable organization.

Regarding the latter question, reviewers have suggested monitoring shallow ground water[8], clay cover,[7] offsite water[6] and the underlying dolomite aquifer[4,6]. No suggestion regarding the monitoring of the partial clay liner has been made because of the difficulty in doing this. Kerr-McGee has suggested that quarterly sampling of ground water from the six monitor wells, two sample points over the encapsulated area, and the surge pond be made. Individual isotopes will be analyzed for these samples once a year and gross alpha each quarter. Gamma scans over the surface of the area will also be made although their frequency is not discussed in the plan. Kerr-McGee's monitoring plan is not nearly as comprehensive as the reviewers would like to see.

The purpose of the monitoring procedures of either Kerr-McGee or the reviewers is uncertain. The implication of monitoring is that some action would be proposed if the quality of the environment significant deterioration. Some governing body must be established to decide what constitutes a significant environmental deterioration, what steps are to be taken to correct the problem, and to whom legal responsibility belongs.

Concluding comments

Some of the major points may be summarized:

(1) While it is possible to define an ideal clay for containment based on composition and permeability, it is not clear that the clay would be locally available for the liner. Deviations from the ideal type could be highly significant with regard to long term waste isolation.

(2) The effectiveness of an artifical liner is subject to much uncertainty. As proposed, this barrier can not be relied upon to keep the wastes from interacting with percolating rainwater and local groundwater.

(3) The leaching of contaminants from the waste material and the subsequent migration is a function of many parameters including pH, presence of carbonates, presence of fluoride, etc. In order to adequately assess relative mobility of the nuclides it will be necessary to carry out more experiments and carefully moniter the composition and chemical nature of the waste form.

(4) Hydrologic conditions are not well enough known to accurately assess the possible long term migration of the waste material from the site. The dolomite aquifer responds rapidly to changes in pumping. Alternative use scenarios must be quantitatively evaluated before accurate projections can be made.

(5) It is encouraging that little of the radioactive material has moved from the site[10]. However because of the nature of the waste, a wide range of leach tests must be run before this conclusion can be projected to the

long time frame.

(6) Quantitative estimates of the volume of both the non radioactive and radioactive waste material and its distribution in place at the site, in the glacial drift, and in the aquifer would help to assess the long term health risk of the site.

(7) The deep aquifer is not immediately threatened by the site. Any use of the shallow aquifer in the vicinity of the site should be <u>very</u> carefully monitored.

(8) The geological uncertainties associated with this site dictate that alternative sites be carefully considered and evaluated. A suitable site near the facility meeting geological standards is not likely to be found.

From the review given above, enough critical points remain that we seriously question the feasibility of successfully containing the pollutants. In a densely populated area as West Chicago, such a proposal must be designed to insure the safety of the community. The geological objections based on the available data clearly indicates caution. The expense of obtaining additional data and then producing a plan that will meet all reasonable objections will be considerable.

References

1. Letter dated 12/6/79 from Thomas E. Cavanagh (Illinois E.P.A.) to William Nixon (N.R.C.)

2. Letter dated 11/19/79 from Gary N. Wright (Division of Nuclear Saftey, Illinois Department of Health) to J. Luis Saguinsin

3. Letter dated 10/19/79 from Dean Hansell (Assist. Att. General, Environmental Control Division, Illinois) to William Nixon (N.R.C.)

4. Letter dated 9/28/79 from Thomas M. Johnson (Assistant Geologist, State Geological Survey, Illinois) to J. Luis Saguinsin.

5. Isherwood, D. (1977) Preliminary report on retardation factors and radionuclide migration. Lawrence Livermore Laboratory. UCID-17551, 22 p.

6. ANL Comments on the Kerr-McGee Stabilization Plan dated August 15, 1979, no date given, 5 p.

7. Comments on Radiological Aspects of Kerr-McGee Stabilization Plan, Larry Jensen, U.S. E.P.A. (9/19/79)

8. Attachment to letter dated 3/6/79 from John S. Moore (Manager, Division of Land/Noise Pollution Control, E.P.A., Illinois) to William Nixon.

9. Letter dated 8/5/76 from Robert E. Bergstrom (Principal Geologist, Geological Group, State Geological Survey, Illinois) to Gary Wright (Div. of Radiological Health, Dept. of Public Health, Illinois). Comments may be those of Robert A. Griffin of the Geochemistry Section, State Geological Survey which were also included in the letter.

10. Environmental Assessment related to Kerr-McGee Chemical Corporation, West Chicago: Characterization of Geohydrology and Subsurface Chemistry. Argonne National Laboratory, July 1977, 67 p.