PROPOSED DISPOSAL OF VERY-LOW-LEVEL CONTAMINATED MATERIALS FROM THE KEWAUNEE NUCLEAR POWER PLANT

July 28, 1989

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I. INTRODUCTION

Wisconsin Public Service Corporation requests approval for the disposal of very-low-level radioactively contaminated materials from the Kewaunee Nuclear Power Plant. This request has been prepared in keeping with the NRC guidance presented in the NRC Policy Statement on Radioactive Material Below Regulatory Concern, published in the August 29, 1986 Federal Register (Ref. 1). This guidance cites Section 10 of the Low-Level Waste Policy Act of 1985, which addresses disposal of wastes termed "below regulatory concern." Such waste would not need to be subject to regulatory control to assure adequate protection of the public health and safety because of its radioactive material content. Alternative disposal would conserve much needed space in the existing radwaste disposal sites while new sites are developed. The proposed disposal methods represent a negligible radiological impact while conserving space in the existing sites and thus serves in meeting the waste volume allocation limits set forth in the Act.

The NRC in its Information Notice 83-05 (Ref. 2) called attention to the provisions of 10 CFR 20.302, "Method for Obtaining Approval of Proposed Disposal Procedures," as a recommended means for the disposal of slightly contaminated materials in lieu of the costly and unwarranted disposal in a licensed radwaste burial site. In Information Notice 88-22 (Ref. 3), the NRC alerted the industry to the potential of sludges from onsite sewage treatment plants becoming contaminated and the applicability of the provisions of 10 CFR 20.302 for the disposal of these slightly contaminated sludges.

The Kewaunee Nuclear Power Plant (KNPP) is a single unit Westinghouse PWR located approximately 30 miles east-south-east of Green Bay, Wisconsin. The unit is a two loop plant with a rated capacity of 540 MW(e). During the routine operation of the plant the potential exists for certain materials from the non-radiological operations of the plant to become contaminated with very-low-levels of radioactive material. The levels of contamination are minor and typically lower than the natural levels of radioactivity in many common materials in our natural environment.

One category of waste that has the potential of becoming contaminated with very-low-levels of radioactive material is the sludges and resins from the normally non-radioactive waste processing streams of the plant. These waste streams are separated from the radioactive waste streams. However, due mainly to infrequent, minor system leaks and anticipated operational occurrences, the potential exists for these systems to become slightly contaminated. At KNPP the Secondary System Demineralizer resins, the Service Water Pre-Treatment System sludges, Make-up Water System resins, and the Sewage Treatment Plant sludges are waste streams that are subjected to the potential of very-low-level contamination.

Per the NRC guidance of its Policy Statement and its Information Notices (Ref. 1, 2, & 3), it is proposed that conventional disposal of these slightly contaminated materials be allowed based on the characterization and limits as described in Section IV of this report. This request is submitted in accordance with the provisions of 10 CFR 20.302.

A dose rate of 1 mrem per year has been used as the acceptance criterion for the proposed alternative disposal. This criterion is in keeping with the recommendations of the National Council on Radiation Protection and Measurements (NCRP) that established a "negligible individual risk level" (NIRL) at a dose rate of 1 mrem per year (Ref. 4). The NCRP defines a NIRL as, "A level of risk that can be dismissed. Namely, an annual risk of 10^{-7}. This risk is associated with an annual effective dose equivalent of 0.01 mSv (0.001 rem)." Additionally, the use of a 1 mrem/yr dose criterion is less than the "Below Regulatory Concern" (BRC) dose standard of 10 mrem per year that NRC recently issued for comment (Ref. 5). Therefore, the interim use of the 1 mrem per year criterion for addressing current disposal requirements is not expected to be in conflict with future regulations. Alternative waste disposal based on the 1 mrem/yr criterion of this submittal is expected to be well within the BRC guidelines as currently recommended by the NRC in its draft Policy Statement (Ref. 5).

A description of the chemical and radioactive material characteristics of the waste streams is provided in Section II of this submittal. Section III addresses the proposed disposal method and Section IV presents the evaluation of the radiological impact. An overall assessment of the environmental impact is provided in Section V. Appendices A through C provide supportive calculations and information.

II. DESCRIPTION OF WASTE STREAMS

The wastes that are applicable for alternative disposal are those materials for which the radioactive material content is so small that control of its radioactive material content is not required for protection of the public health and safety. At the KNPP, three potential sources of very-low-level contaminated sludges/resins that can be best disposed of in this manner are from the Sewage Treatment Plant, Steam Generator Blowdown Recovery System, and the Service Water Pretreatment System. These systems are normally non-radioactive systems. However, as a matter of routine plant operations, the potential exists for these systems to become slightly radioactively contaminated. Typically, the levels of contamination are expected to be minor - representative of a BRC type waste. The chemical, physical and radioactive material characteristics of each of the waste streams are addressed below.

II.1 Sewage Treatment System Sludges

II.1.1 Waste Generation. The Sewage Treatment System processes the waste waters from the onsite sewer system. The major inputs are from the plant sanitary and potable water systems, floor drains (from non-radiological areas), and some roof and storm sewer drains. The average input to the system is approximately 11,000 gallons per day.

The waste water is routed through the major sewer lines to the sanitary lift station located adjacent to the Sewage Treatment Plant. The waste waters are pumped to the equalization tank located in the Sewage Treatment Plant by ejector pumps. The waste is pumped through a comminutor that chops and cuts large sewage into smaller pieces able to be digested by the aerobic process. From the equalization tank, the waste is allowed to aerate for approximately 24 hours in the aeration tank. The waste then flows from the aeration tank to the settling tank. A surface skimmer removes scum from the top. A drive unit slowly stirs the settling tank contents with the sludges settling to the bottom. The decant is routed to the chlorination tank via a weir (although no chlorination of the decant is performed). The Wisconsin Department of Natural Resources restricts the total residual chlorine in discharges to Lake Michigan to less than 0.5 mgram per liter (0.5 ppm). From the chlorination tank the effluent is discharged to the lake via the creek alongside the access road.

The sludges from the settling tank are removed to the sludge storage tank. On the average, about 2,875 gallons per month of sludges are removed from the sludge tank. The sludges are removed by an authorized waste handler and transported in a closed sewage tank truck to the Green Bay Metropolitan Sewerage District (GBMSD) facilities located in Green Bay. The Sewage Treatment Pond, located adjacent the KNPP Sewage Treatment Plant, is no longer used for sewage processing.

The limited aerobic /settling processing of the waste at KNPP results in a concentrating of the waste (sludges) by a factor of approximately 100. As identified in the NRC Notice 88-22, it is this concentrating mechanism of a sewage treatment plant that results in the potential measurable contamination level in the sludges; the input streams themselves do not contain a measurable source of radioactive material. The mixing of this 100:1 concentrated sludge with the Green Bay Metropolitan Sewerage District waste will result in a net dilution of the waste. A detailed description of the waste treatment process at the GBMSD is provided in Section III.2.

II.1.2 Chemical Characteristics. The chemical characteristics of the KNPP Sewage Treatment Plant sludges are essentially the same as those from any sewage treatment facility. The sludge material is composed mainly of a combination of the input process waters, partially digested sewage waste and other silts and soil from the onsite runoff water to the storm sewers and roof drains. There are no sources or inputs of hazardous waste to the sewage plant: the sludge materials generated at the KNPP Sewage Treatment Plant represent a material acceptable for transport to the Green Bay Metropolitan Sewerage District for further processing.

II.1.3 Radioactive Material Characteristics. To date, the sludges from the Sewage Treatment Plant have not been contaminated with radioactive material from KNPP. Each batch of sludge is sampled and analyzed by gamma spectroscopy to ensure the absence of any measurable radionuclides of plant origin prior to release to the waste hauler. The potential for future contamination of the system is thought to be low considering the method of operation and the inputs to the system. However, based on the NRC information and guidance as presented in NRC Notice 88-22 (Ref. 3), it is recognized that the low-level contamination of the sludge is a potential and that provisions are necessary for addressing contaminated sludge should the situation arise. The evaluation of the radiological impact of disposing of contaminated Sewage Treatment Plant sludges is presented in Section IV.

II.2 Secondary Side Demineralizer Resins

II.2.1 Waste Generation. The Steam Generator Blowdown Recovery (SGBR) Demineralizers are the primary water processing systems to be used for maintaining water purity in the secondary-side of the plant. The Steam Generator Blowdown Recovery System is currently under construction and is expected to become operational in the Spring of 1990.

Water purity is essential for ensuring the reliable operation of the steam generators and turbine/generator. The secondary-side of the plant is normally non-radioactive, but steam generator tube leaks can introduce low-levels of radicactive material into the secondary system. This radioactive material will accumulate on the Steam Generator Blowdown Recovery Demineralizer resins.

KNPP uses mixed-bed, non-regenerative bead resins in the demineralizers. There are 2 demineralizer vessels; each vessel contains by design an approximate volume of between 20 to 35 cubic feet of resins. The design of the system is for an operating cycle of approximately 30 days per bed with typically one bed in service at any one time. For conservatism in the modeling, it has been assumed that every change-out of the beds results in 20 ft^3 of slightly contaminated resins (i.e., 20 ft^3 every 30 days).

The demineralizer resins will not be regenerated but will be disposed of upon depletion. The method of disposal will be by transfer to a lined (or leak tight) dumpster and transport to the Kewaunee County Landfill. The landfill disposal of depleted resins is the practice recommended by the Wisconsin Department of Natural Resources for the disposal of this type waste.

Infrequently, the Make-up Water System demineralizer resins are also changed-out. Each year, approximately 202 ft^3 of anion resins and 88 ft^3 of mixed-bed resins are removed and disposed of. Additionally, once every 5 years the cation demineralizer bed (650 ft^3) is changed-out. The potential for radioactive material contamination of these resins is unlikely; however, their treatment and disposal will be performed in conjunction with the SGBR demineralizer resins. Therefore, for completeness, the disposal of these resins is included in this evaluation.

II.2.2 <u>Chemical Characteristics</u>. The resins to be used in the SGBR demineralizers are typical of those used throughout the industry. The chemical composition is an inert, porous copolymer, such as a styrene/divinyl benzene. These resin beads are chemically altered to give ion exchange capabilities. The hydrogen form (H-OH) mixed-bed resins will be used. Resins are considered a non-toxic and non-hazardous material as typified by their use for drinking water purification and their acceptable disposal in a sanitary landfill. The Material Safety Data Sheet representative of these type resins is contained in Appendix A.

II.2.3 Radioactive Material Characteristics. The SGBR demineralizers are to be operational in the Spring of 1990. Therefore, there has been no generation of depleted resins from this system to date.

The accumulation of low-level radioactive material on these resins in the future is expected. The frequency of the contamination under most situations will be associated with primary-to-secondary leakage. However, it is a known phenomenon that following a leak low-level contamination of the secondary-side resins will continue over an extended period of time. These levels are expected to be low - however, measurable. Because of the minor steam generator tube leaks experienced at KNPP over the past years, the potential exists for low-level contamination to periodically occur on the resins when the system is initially placed in service. Particularly, following plant shutdown and startup (or other thermal transients), the residual radioactive material on the pipe and system walls of the secondary system will potentially become soluble (or resuspended) in the secondary water where it will be removed by the SGBR demineralizer resins. This potential residual contamination of the secondary system and the potential for future steam generator tube leaks creates the need for addressing alternative disposal for this waste stream.

The radionuclide distribution expected for the low-level contamination of the SGBR resins is presented in Section IV.2 along with the radiological impact and limits for alternative disposal.

II.3 Service Water Pretreatment System Sludges

II.3.1 Waste Generation. The Service Water Pretreatment System (SWPT) is used for water purification prior to its use in the plant systems. The water from Lake Michigan is routed from the intake structure to the SWPT flocculator. A coagulating chemical (ferric sulfate) is added to the water. The calcium, magnesium and bicarbonate ions in the water react with the ferric sulfate, forming a floc that settles to the bottom of the tank. Lime is also added as a preconditioning water softener. The water is then routed through the SWPT mechanical filters where additional suspended materials are removed.

The water is further processed by Make-up Water System demineralizers, that remove ionic impurities from the water by the ion exchange properties of the demineralizer resins. The resins used in the demineralizer beds are of the mixed anion and cation characteristics in the H-OH form.

The flocculent from the SWPT System is periodically pumped to the on-site SWPT settling lagoons that are located adjacent to the Sewage Treatment Plant (see Fiqure 1). The floc/sludges are pumped to the lagoons typically four (4) times a day. Additionally, the process filters are also backwashed typically twice a day.

Sodium hydroxide (NaOH) is used for the regeneration of the anion resins; sulfuric acid (H_2SO_4) is used for the cation resins. All regenerant wastes are neutralized and pumped to the Service Water Pretreatment Lagoons.

The flocculent and the regeneration backwash are allowed to settle in the lagoons. Periodically, the lagoons are dredged to ensure continued functionality for receiving the flocculent and backwash from the Service Water Pretreatment System. The dredgings are disposed of in the Kewaunee County Landfill. Depending on moisture content of the dredgings, sawdust is added to the sludges upon removal to provide a mixture containing no free-standing water, thereby meeting the criteria for acceptable disposal in the county landfill. Based on past experience, it is estimated that approximately 22,000 cubic feet of sludge and sawdust mixture will be disposed of each year in the Kewaunee County landfill.

II.3.2 Chemical Characteristics. The chemical composition of the dewatered sludges is essentially that of the inputs to the lagoon - the ferric sulfate and lime floc, the regenerative salts and lake silts. The Material Safety Data Sheet for the ferric sulfate is included in Appendix A. Also, chemical analyses for past dredgings of the dewatered sludges are included in Appendix D.

II.3.3 Radioactive Material Characteristics. The lagoon that is nearest the Sewage Treatment Plant (referred to as the Sewage Treatment Lagoon) contains approximately 15,000 cubic feet of slightly contaminated SWPT sludge. The lagoon is approximately fifty (50) feet by one hundred (100) feet in size with an average sludge depth of approximately three (3) feet. This lagoon is not currently available for use. Final closure of the lagoon is pending the dredging and disposal of the bottoms. The dredging and disposal of this sludge is also a condition of its permitting by the Wisconsin Department of Natural Resources.

There are two potential sources of the radioactive material contamination. One source is believed to be past releases from the Turbine Building sump to the lagoon during the steam generator tube leak that occurred in 1985. (The Turbine Building sump normally is not discharged to the onsite lagoons.) The other is the potential recycle of plant liquid effluent to the lake back through the plant intake structure. The intake of the liquid effluents from the Point Beach Nuclear Plant is another potential source as is also atmospheric fallout.

Future contamination of the lagoons is also a possibility. Provisions are needed for addressing the alternative disposal of additional contaminated sludges from the lagoons should the situation arise.

The evaluation of the radiological impact of disposing of the existing 15,000 cubic feet of contaminated sludge is presented in Section IV. Criteria for future disposals of 22,000 cubic feet per year of potentially contaminated sludges are also presented in Section IV.

III. DESCRIPTION OF DISPOSAL METHOD

III.1 Disposal at the Kewaunee County Landfill

III.1.1 Disposal Facility Description. The routine method of disposing of the dredged sludges from the lagoons is landfilling in the Kewaunee County Landfill. This facility is a solid waste landfill licensed by the Wisconsin Department of Natural Resources for the receipt of residential, commercial and industrial solid wastes. Industrial process residues, such as fly ash or paper mill sludges, are not acceptable without a specific permit from the Wisconsin Department of Natural Resources. Wisconsin Public Service Corporation has received a permit for the disposal of the dredgings from the lagoons at the landfill.

The landfill is located approximately 13 miles from the Kewaunee Nuclear Power Plant in the town of West Kewaunee situated off County Road C and Maple Lane. It is licensed by the Wisconsin Department of Natural Resources with its initial licensing in February 1983. The landfill is owned and operated by the County of Kewaunee. The facility consists of a licensed disposal area of 14.8 acres with a capacity of 516,000 cubic yards and a design operating life of 30 years.

The facility is an engineered, state-of-the-art solid waste landfill. The active disposal area consists of approximately a two (2) acre parcel. Each 2 acre site has an expected operating life of between 2 to 5 years. This area is prepared prior to the receipt of waste with a three (3) foot compacted clay liner. A leachate collection system and gas venting system are included. The solid wastes upon receipt at the site are processed by a baler. The waste is compacted into a 30"X45"X60" bale and bound by wire. This bound bale is placed in the active disposal area. The industrial wastes (and other materials in bulk form that do not lend themselves to baling) are used to fill areas within the disposal area that are not easily filled by the baled waste.

At the end of each day, a one (1) foot clay cap is placed on top of the waste received during that day. Also, any leachate collected from the disposal site is transported to the City of Kewaunee sanitary sewage facilities and processed as a sewage waste.

The annual volume of waste currently being received and disposed of at the landfill is around 13,000 cubic yards with an average density of 1200 lbs/yd^3. Around 8,000 tons of waste are disposed of each year. This waste volume is not significantly different from the initial design basis for the facility.

When a disposal area (approximate 2 acre parcel) becomes filled, a three (3) foot clay cap is added as a part of the final closure.

III.1.2 Transport of Waste to Kewaunee County Landfill. The sludges from the KNPP lagoons are mixed with sawdust to achieve a moist consistency (no free standing water) and loaded into a 30 cubic yard truck (typical) for transport to the landfill. For the transport of any low-level radioactively contaminated lagoon sludges, a plastic liner (6 mil PVC or polyethylene, typical) and a suitable cover will be used to limit any significant dispersion of the sludge and sawdust mixture during transport.

During last year, approximately 800 cubic yards (22,000 ft^3) of non-contaminated lagoon sludges (with sawdust mixture) were disposed of from KNPP at the Kewaunee landfill. The typical density of this mixture was around 1.0 g/ml.

The SGBR demineralizer resins and the Make-up Water System resins are to be loaded into a 10 cubic yard closed top container (typical); the resins will be dewatered and transported to the Kewaunee Landfill. Approximately two to three times a year, the dewatered resins will be disposed of at the landfill.

III.2 Disposal at the Green Bay Metropolitan Sewerage District

The sludges from the Sewage Treatment Plant at KNPP are transported to the Green Bay Metropolitan Sewerage District (GBMSD) facilities for processing and disposal. These sludges are mixed with the other sewage waste inputs to the GBMSD and processed through the facility's waste treatment equipment.

The normal method of transferring the sludge from the sludge storage tank to the sewage truck at KNPP is by vacuum extraction. The sewage tank truck consists of a 4500 gallon (typical), sealed tank permanently mounted on the truck framing. The tank is placed under a negative pressure prior to transport to the site. This vacuum is then used to extract the sludge from the sludge tank. Direct contact with the waste is not required and potential spills and leaks are limited by the use of a negative pressure system for the transfer.

Upon delivery to the GBMSD, the sludge is pumped into a drainage system that goes to the head end of the primary processing system. No human contact occurs. At the head end, the KNPP sludge is mixed with other input waste to the facility. The input of waste waters into the facility averages 25 million gallons per day.

The GBMSD facility uses a multiphased processing system consisting of aerobic digestion, thermal reduction of water content and a final incineration of the sludges. The waste is initially processed through an aerobic digester. Next, the sludge is heated to around 380 degrees Fahrenheit, thereby reducing the water content and the volume. The waste is then processed by vacuum filtration. The filtrate is incinerated. The incinerator residue is buried in the Brown County Landfill.

The daily input of 25 million gallons of waste waters into the system results in an output of ≈ 20 cubic yards of incinerated ash. The overall efficiency of the system is roughly 90%: there is a 10% carryover of suspended solids from the influent into the final effluent. (Ref. 6)

The maximum concentrating mechanism for the KNPP sludges would be for all the radioactive material in a single 3,000 gallon transfer to accumulate into a single 20 cubic yard volume of the incinerator ash. The result would be that the concentration of radioactive material in the incinerator ash would be slightly lower than the initial input concentration of the KNPP sludge. In practicality, the residence time of the waste waters in the treatment facility (several days) and the recycling of the sludges within the various treatment cycles can be expected to provide significantly larger dilution factors.

IV. RADIOLOGICAL EVALUATION

In keeping with the NRC guidance presented in their policy statement on alternative disposal of BRC type waste (Ref. 1), the evaluation of the potential pathways of exposure and the resulting maximum individual and population doses has been performed based on the calculational methods of the NRC computer code IMPACTS-BRC (Ref. 7 & 8). Site specific parameters have been incorporated into the modeling as appropriate to ensure overall conservatism and applicability to the proposed disposal methods.

Based on these evaluations, the controlling pathway of exposure is the direct exposure to the waste during the preparation and transport for disposal. This conclusion is in keeping with past studies (Ref. 9 & 10), that have identified the direct exposure to the transport worker as contributing essentially all of the calculated dose from the gamma emitting radionuclides. The other exposure pathways evaluated (e.g., intrusion - agriculture, intrusion - construction, and groundwater) are insignificant, being several orders of magnitude less than the direct exposure pathway. Appendix B provides a more detailed description of the pathways evaluated.

The same pathway (direct exposure) is controlling for each of the disposal methods (Kewaunee Landfill or Green Bay Metropolitan Sewerage District). Therefore, it is possible to derive a single set of acceptance criteria for the alternative disposal of the slightly contaminated sludges from KNPP, whether the disposal is at the Kewaunee Landfill or the Green Bay Metropolitan Sewerage District.

To ensure overall conservatism, the combined waste volumes have been used for the pathway modeling. The longer exposure times (considering the handling and transport of the waste to the receptors) have been included in the evaluations. Also, the larger volume of the sludge/sawdust mixture has been used for modeling the transport volume. Overall, the determination of the limiting concentrations for acceptable alternative disposal have been based on a conservative modeling collectively considering the pathway modeling for the disposal at the Kewaunee Landfill and the Green Bay Metropolitan Sewerage District. The following subsections provide the results of these evaluations. Details of the application of this modeling to the KNPP specifics for disposal are presented in the Appendix B.

IV.1 Radioactivity Limits

The IMPACTS-BRC code has been used to determine the radioactive material levels of the lagoon sludges, resins and the sewage sludges that are acceptable for alternative disposal at the Kewaunee Landfill or the Green Bay Metropolitan Sewerage District. Concentration limits have been derived on a nuclide-by-nuclide basis, corresponding to a maximum allowed dose rate of 1 mrem per year. The controlling pathways of exposure on a nuclide-by-nuclide basis and individual radionuclide concentrations (corresponding to 1 mrem per year) are presented in Table 1.

To derive these limits, the IMPACTS-BRC code was run using individual radionuclide input concentrations of 1 μCi/ml. A typical density of 1.0 g/ml was assumed. A total annual waste volume of 27,000 ft^3/yr was used, representing the combined annual estimated waste volumes from all input waste streams - 4,700 ft^3 of Sewage Treatment System sludges, 240 ft^3 of SGBR resins, 290 ft^3 of Make-up Water System resins, and 22,000 ft^3 of SWPT lagoon sludges (and sawdust). The results were then used to determine each radionuclide concentration which produces a 1 mrem per year dose rate in the controlling exposure pathway for that nuclide. These resulting concentrations are the limits presented as the allowable BRC disposal concentrations presented in Table 1.

This approach incorporates substantial conservatism by choosing the most restrictive pathway for each radionuclide as the basis for BRC limits. These analyses clearly show that exposure to the worker during preparation and transport of the waste to the landfill is the most restrictive pathway. The IMPACTS-BRC computer code modeling is discussed in Appendix B; the code results (output data) for these determinations are presented in Appendix C. These limiting concentrations of Table 1 are used for determining the acceptable disposal in the landfill. Controls on this determination are discussed later.

The modeling has conservatively assumed that all of the SWPT lagoon sludges, Steam Generator Blowdown Recovery demineralizer resins, Make-up Water demineralizer resins, and sewage sludges will be contaminated at the limiting concentrations. Only sludges and resins with radionuclide concentrations below the limiting concentration will be disposed in the landfill. This conservatism in the modeling provides added assurance that no individual will receive a dose from the disposal of these resins and sludges in excess of the 1 mrem per year BRC dose rate criterion.

A radionuclide distribution typical of the sludges and resins was evaluated to identify the key isotopes for classifying these materials as BRC. (The inverse is that such an evaluation also identifies those radionuclides which are not significant and consequently may be disregarded in the analysis.) The typical distribution used came from the Kewaunee USAR, Table D.4-1, with a 60 day decayed spectrum and the addition of the 10 CFR 61 radionuclides as needed to reflect a complete listing of the key radionuclides. In calculating dose contributions for this evaluation, the limiting pathway was assumed for each radionuclide, resulting in the highest potential dose being calculated. The distribution and the resulting dose contributions are presented in Table 2.

Based on this evaluation the following key observations can be made:

- the readily identifiable gamma-emitting isotopes contribute greater than 99% of the total dose; and
- non-gamma-emitters, especially the transuranics are not significant dose contributors.

The conclusion from these observations is that adequate control of the lagoon sludges, resins, and sewage sludges can be established on the basis of a gamma spectral analysis of a sample. Accounting of the non-gamma emitters separately is not required to assure proper control.

IV.2 Radiological Evaluation - Existing Contaminated Lagoon Sludges

The maximum potential individual dose resulting from the disposal of the existing 15,000 ft^3 of lagoon sludges is 0.03 mrem. This dose is calculated to be received by the worker transporting the waste to the landfill. The potential dose to the landfill operator is less than 0.01 mrem. And, the hypothetical dose rates in the future due to intrusion are also less than 0.01 mrem per year.

The radioactive material concentration and total content of the sludge is the following:

Nuclide	Concentration	Total Activity
Co-60	1.8E-07 μCi/ml	76 μCi
Cs-137	2.2E-07 μCi/ml	94 μCi

The same, conservative modeling as discussed above in Section IV.1 has been used for evaluating the potential doses from the disposal of this material. The use of the IMPACTS-BRC computer code modeling is discussed in Appendix B; and the code results for this evaluation are presented in Appendix C.

IV.3 Radiological Controls

Controls will be established to assure that the alternative offsite disposal of any radioactively contaminated KNPP Sanitary Sewage Plant sludges, Steam Generator Blowdown Recovery Demineralizer resins, Make-up Water System resins, and lagoon sludges will be in keeping with the established limits.

Samples will be collected and analyzed by gamma spectroscopy to evaluate the potential for radioactive material contamination. The results of these analyses will be used to ensure that any detectable levels of radioactive material are within the limits for acceptable offsite disposal. Any materials with detectable levels of radioactive material above the prescribed limits (and of plant origin) will be treated as a radioactive waste and appropriately controlled.

If the samples of the waste identify plant related radioactive material, the detected levels will be compared with the limits of Table 1. The sum-of-the-fractions rule will be used to evaluate acceptable disposal if more than one radionuclide is detected.

For the transport to the disposal facility, the waste will be controlled to prevent the spread or inadvertent release during transit. The particulars of the transport method are discussed in Section III.

Also, all necessary state, county and local requirements will be complied with for the disposal of these waste materials. As required, chemical analyses will be performed to verify the acceptability of the waste materials at the receiving facility.

Records will be maintained of all materials disposed of as a BRC type waste. These records will include date of shipment, destination, transporter, volumes of waste, sample analyses, comparisons with limits, and total radioactive material disposed.

V. ENVIRONMENTAL IMPACT

The disposal of very-low-level radioactive materials at the Kewaunee County Landfill or the Green Bay Metropolitan Sewerage District represents a negligible radiological impact. Evaluations have been performed and controls established to assure that the exposure to any member of the public will be less than 1 mrem per year. This proposal is in keeping with the recommendations of the National Council on Radiation Protection and Measurements (NCRP), specifying a "negligible individual risk level" (NIRL) of 1 mrem per year from any single source (Ref. 4). Also, the 1 mrem dose criterion is less than the BRC dose standard that the NRC recently issued for comment in their policy statement (Ref. 5).

The alternative disposal of these low-level contaminated wastes provides the following benefits:

- reduces volume demands on existing low level waste disposal sites;
- reduces operational costs and occupational radiation exposure associated with processing, packaging and transportation of very low level radioactive wastes; and
- minimizes the overall costs of radioactive waste disposal.

The cost savings associated with disposing of these materials in the local landfill are estimated to be in excess of $1,000,000 per year. The disposal of the existing material in storage will result in a savings in excess of $500,000.

The additional volume added to the Kewaunee County Landfill or the Green Bay Metropolitan Sewerage District by disposal of these wastes will have negligible impact on the facility operation and will not appreciably shorten its expected operating life (particularly considering that this means of disposal is the current method). And, as shown in Section IV., the administrative controls for this proposed use alternative disposal will assure that radiation exposure is limited to less than 1 mrem per year.

As a comparison, the levels of radioactive material for alternative disposal as proposed are similar to common sources found in the environment. Consider the following examples:

- Granite rock - a major source of natural radioactivity in building materials, typically contains on the order of 4E-05 µCi/g of uranium- 238, thorium-232, and potassium-40 (Ref. 11).
- Beach sand, not thought of as a source of natural environmental radioactivity, has levels of 5E-06 µCi/g.
- The human body content of naturally occurring potassium-40 is 2E-06 µCi/g (Ref. 11).

It is also of interest to note that levels of naturally occurring radioactive material have been measured in the existing lagoon sludges. Potassium (K)-40 was measured at a concentration of 3.1E-06 µCi/ml; lead (Pb)-212 at 1.1E-07 µCi/ml; Pb-214 at 2.0E-07 µCi/ml; and bismuth (Bi)-214 at 1.5E-07 µCi/ml. Radium (Ra)-226 and thorium (Th)-232 have also been measured at concentrations of 3E-07 µCi/g. The levels of the naturally occurring radionuclides in the existing sludge are greater than the plant related contamination.

Figure 1

Kewaunee Nuclear Power Plant Site Area Map

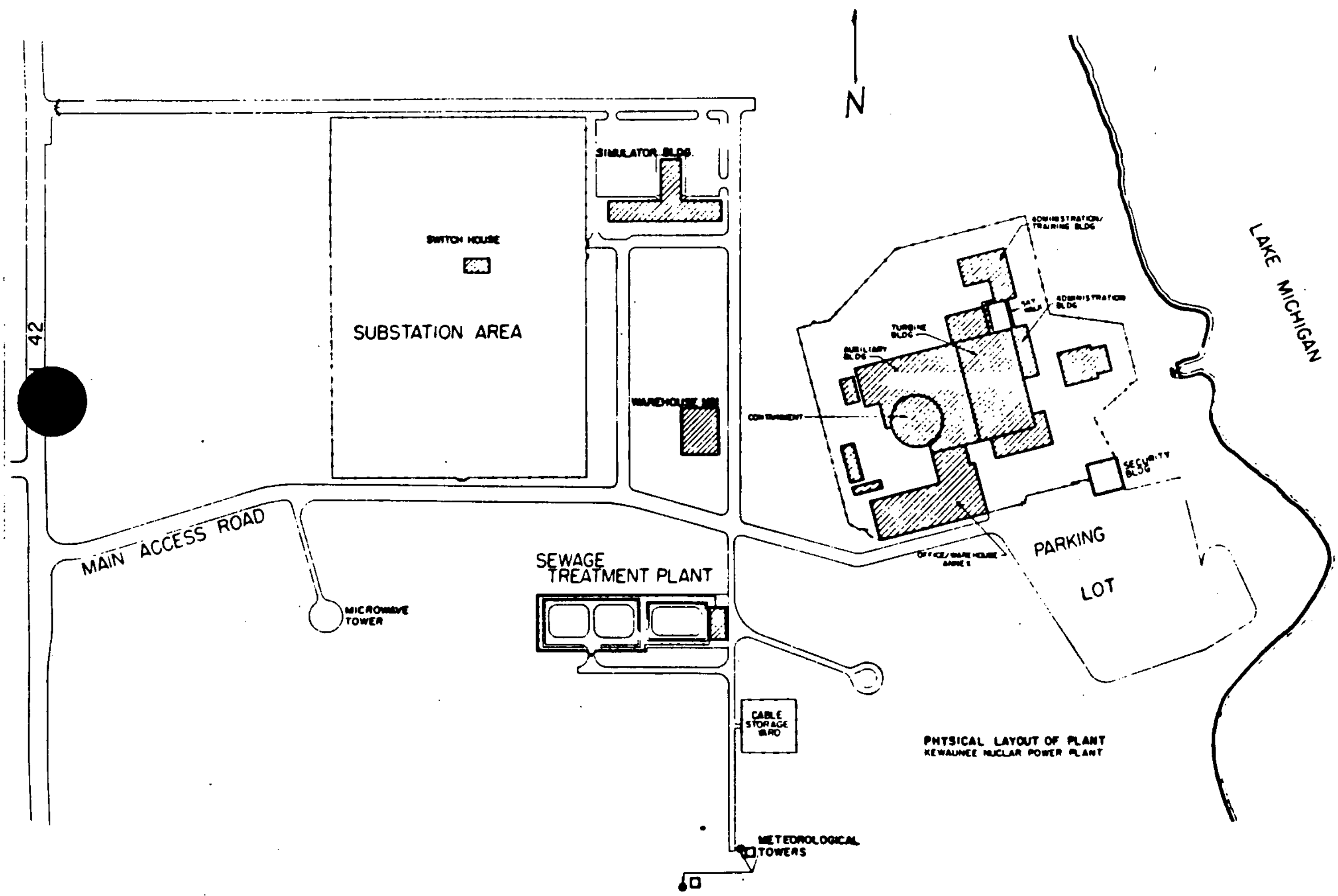

Table 1

Individual Radionuclide Limiting Concentrations
for Alternative Disposal of Low-Level Contaminated
Sludges Corresponding to 1 mrem Annual Dose

Nuclide	Limiting Concentration (μCi/ml)	Pathway
H-3	9.65E-04	Intruder - Agriculture
C-14	4.55E-05	Intruder - Well
Cr-51	3.13E-04	Transportation
Mn-54	1.14E-05	Transportation
Fe-55	1.00E-02 (Note 4)	Intruder - Well
Fe-59	7.90E-06	Transportation
Co-58	1.16E-05	Transportation
Co-60	3.74E-06	Transportation
Ni-63	1.00E-02 (Note 4)	Intruder - Well
Sr-90	3.45E-03	Intruder - Well
Zr-95	6.28E-06	Transportation
Nb-95	1.23E-05	Transportation
Mo-99	6.73E-05	Transportation
Tc-99	2.70E-04	Intruder - Well
I-129	2.50E-06	Intruder - Well
I-131	2.68E-05	Transportation
Cs-134	6.16E-06	Transportation
Cs-137	1.71E-05	Transportation
Ba-140	5.52E-05	Transportation
La-140	4.17E-06	Transportation
Transuranics		
TRU (T1/2 >5 yrs.)	8.91E-05	Intruder - Air
Pu-241	2.85E-03	Intruder - Air
Cm-242	1.00E-02 (Note 4)	Intruder - Air

Table Notes:

1. Limiting concentration corresponds to a calculated annual dose of 1 mrem based on modeling of the NRC computer code IMPACTS-BRC.
2. For multiple radionuclides, the determination of the limiting concentration is based on the "sum of fraction" rule (i.e., $\Sigma C_i/LC_i < 1$, where C_i = concentration of radionuclide (i) and LC_i = limiting concentration of radionuclide (i)).
3. The TRU limit has been based on a weighted average of the individual TRU radionuclides.
4. A value of 1.0E-02 μCi/ml has been used as an upper limit for the limiting concentration for any single radionuclide. Any radionuclide for which the calculated limiting concentration exceeds 1.0E-02 μCi/ml has been limited to this value. Actual limiting concentrations corresponding to 1 mrem per year may be obtained from the data in Appendix C.
5. Any radionuclide not listed above shall be limited to 1.0E-05 μCi/ml.

Table 2

Typical Radionuclide Distribution of Sludges and Dose Contribution at BRC Limit of 1 mrem Per Year

Nuclide	Fractional Abundance	Estimated Concentration at BRC Limit (μCi/ml)	Dose Contribution (mrem/y)
H-3	3.2E-03	4.4E-08	<1.0E-03
C-14	6.1E-06	8.4E-11	<1.0E-03
Mn-54	7.3E-03	1.0E-07	8.8E-03
Fe-55	6.4E-04	8.8E-09	<1.0E-03
Fe-59	1.4E-03	1.9E-08	2.4E-03
Co-58	8.9E-03	1.2E-07	1.1E-02
Co-60	2.8E-03	3.9E-08	1.0E-02
Ni-63	1.1E-03	1.5E-08	<1.0E-03
Sr-90	8.7E-05	1.2E-09	<1.0E-03
Zr-95	5.2E-04	7.2E-09	1.1E-03
Nb-95	5.2E-04	7.2E-09	<1.0E-03
Tc-99	7.1E-04	9.8E-09	<1.0E-03
I-129	1.7E-05	2.3E-10	<1.0E-03
Cs-134	1.3E-01	1.8E-06	2.9E-01
Cs-137	8.4E-01	1.2E-05	6.8E-01
Transuranics			
TRU (T1/2 >5 yrs.)*	9.3E-05	1.3E-09	<1.0E-03
Pu-241	3.0E-03	4.1E-08	<1.0E-03
Cm-242	1.1E-05	1.5E-10	<1.0E-03
TOTAL	1.0	1.4E-05	1.0

* Alpha emitting transuranics with greater than 5 year half-lives have been grouped consistent with the philosophy of the limits of 10 CFR 61.55. The individual radionuclide abundances are as follows: Pu-238 (4.6E-05), Pu-239 (4.8E-06), Pu-240 (6.4E-06), Pu-242 (1.9E-08), Am-241 (2.0E-06), Am-243 (1.6E-07), Cm-243 (4.6E-08), and Cm-244 (3.3E-05) (Ref. 12).

Table 3

Radiation Doses Associated with Disposal of Existing Low-Level Contaminated Sludge*

Pathway of Exposure	Maximum Individual Dose
Transport Worker	0.034 mrem
Landfill Operator	0.008 mrem
Intruder (Agriculture)	0.007 mrem/y

* Appendix B provides a description of the exposure pathways modeling and assumptions: Appendix C provides the IMPACTS-BRC code results for the dose evaluation.

REFERENCES

1. Federal Register, Vol. 51, "Radioactive Waste Below Regulatory Concern", August 29, 1986 (51FR30839)

2. US Nuclear Regulatory Commission, Information Notice 83-05, "Obtaining Approval for Disposing of Very-Low-Level Radioactive Waste - 10 CFR 20.302," February 24, 1983

3. US Nuclear Regulatory Commission, Information Notice 88-22, "Disposal of Sludge from Onsite Sewage Treatment Facilities at Nuclear Power Stations," May 12, 1988

4. National Council on Radiation Protection and Measurements, NCRP Report No. 91, Recommendations on Limits for Exposure to Ionizing Radiation, June, 1987.

5. Federal Register, Vol. 53, No. 238, "Policy Statement on Exemption From Regulatory Control", December 12, 1988 (53FR49886)

6. Green Bay Metropolitan Sewerage District, Annual Report, 1987

7. US Nuclear Regulatory Commission, "De minimis Waste Impacts Analysis Methodology, IMPACTS-BRC User's Guide and Methodology for Radioactive Waste Below Regulatory Concern", Draft Report for Comment, NUREG/CR- 3585, Vol. 2, 1986.

8. US Nuclear Regulatory Commission, "De minimis Waste Impacts Analysis Methodology", NUREG/CR-3585, 1984.

9. Texas Low Level Radioactive Waste Disposal Authority, Disposal of Short-Lived Radionuclide Wastes in a Sanitary Landfill: Final Report, February, 1987

10. National Environmental Studies Project, Report AIF/NESP-035, Evaluation of the Potential for De-Regulated Disposal of Very Low Level Wastes from Nuclear Power Plants, May, 1986

11. National Council on Radiation Protection and Measurements, Report No. 45, Natural Background Radiation in the United States, November, 1975

12. Electric Power Research Institute, EPRI NP-1494, Activity Levels of Transuranic Nuclides in Low-Level Solid Wastes from U. S. Power Reactors, August, 1980

July 28,1989

Appendix A

Material Safety Data Sheets

MATERIAL SAFETY DATA SHEET

3149

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME	Tennessee Chemical Company	REGULAR TELEPHONE NO. (404) 239-6700 EMERGENCY TELEPHONE NO. Chemtrec 800-424-	
ADDRESS	3400 Peachtree Rd. NE, Suite 401 Atlanta, Georgia 30326		
TRADE NAME	Ferri-Floc		
SYNONYMS	Ferric Sulfate		
SHIPPING NAME[1]	DOT: Ferric sulfate, crude NA 9121 ORM-E RQ=1000 lbs. IATA:		

II HAZARDOUS INGREDIENTS[2]

MATERIAL OR COMPONENT	CAS NO.	%	HAZARD DATA
Ferric sulfate	100-28-22-5	89.0	Health hazard: Produc corrosive to the eye, i
Residual sulfuric acid	7664-93-9	2.7	not toxic dermally nor inhalation or orally, a
			does not irritate the sk Aquatic toxicity: Prod
			is listed as toxic to aq life. Category C. 40 C
			Parts 116 - 118. TLV-TWA (Nuisance d
			5 mg/m^3 respirable du 10 mg/m^3 total dust. (C and ACGIH)

III PHYSICAL DATA

BOILING POINT, 760 MM HG	N.A. *	MELTING POINT	N.A.
SPECIFIC GRAVITY (H_2O = 1)	56 - 60 lbs/ft^3	VAPOR PRESSURE	N.A.
VAPOR DENSITY (AIR = 1)	N.A.	SOLUBILITY IN H_2O % BY WT	55% by weight
% VOLATILES BY VOL.	None	EVAPORATION RATE (BUTYL ACETATE = 1)	N.A.
APPEARANCE AND ODOR	Grey to brown dry powder to granule.	Ph (AS IS) Ph (1% SOLN.)	N.A. - dry powder (distilled water pH 4.8) a 1% wgt. solution in distilled water has pH 2.1.

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	None	AUTOIGNITION TEMPERATURE	None known		
FLAMMABLE LIMITS IN AIR, % BY VOL.		LOWER	N.A.	UPPER	N.A.
EXTINGUISHING MEDIA	Product does not burn. If product is present in a fire, water, CO_2, or dry chemical may be used.				
SPECIAL FIRE FIGHTING PROCEDURES	If water is used, the product is water soluble and water may be acid, an water should not be allowed to enter a navigable stream. At temperature above 600° C, product decomposes to iron oxide and sulfur trioxide.				
UNUSUAL FIRE AND EXPLOSION HAZARD	None known.				

1. See references 1 and 2. 2. See instructions and references 1 to 8.

* N.A. = Not Applicable

CONDITIONS CONTRIBUTING TO INSTABILITY

FERRI FLOC PAGE 2/4

None known.

I[...]ATIBILITY None known. Product is highly water soluble and solution is highly corrosiv[e] mild steel, copper, copper alloys, and galvanized steel. Strong solutions m[...] corrosive to paints, enamels, and concrete.

HAZARDOUS DECOMPOSITION PRODUCTS

None normally. At temperatures above 600° C, sulfur trioxide may be released.

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

None known.

VII DISPOSAL, SPILL OR LEAK PROCEDURES

AQUATIC TOXICITY (E.G. 96 HR. TLM):

No data are known to be available. EPA has rated product in Category C in the Water Programs hazardous substances list in 40 CFR Parts 116 - 118.

WASTE DISPOSAL METHOD

Remove dry product to approved land fill. If solution, neutralize with lime, soda ash, or bicarbonate and remove to approved land fill.

[...] TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

If spill is dry product, sweep up spill and dispose in approved land fill and wa[...] down spill area with water. If spill is a solution containing product, neutrali[...] remove to approved land fill. Wash down spill area with water. Check with [...] treatment plant before flushing down large amounts of spilled product.

NEUTRALIZING CHEMICALS

Lime, soda ash, or bicarbonate.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

Product is a nuisance ~~acid~~ dust. Normal ventilation is suggested as product is irritating to the eyes and mucous membranes. If sufficient product is placed in eye, it may be corrosive to the eye.

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) While not required, a chemical dust mask is suggested.

EYE Chemical goggles are recommended when handling product because dust is irritating and corrosive if in eyes.

[...]OVES Chemical or rubber gloves may be worn. Product is not irritating to the skin nor is it toxic dermally.

OTHER CLOTHING AND EQUIPMENT

No other special clothing or equipment than normally used.

FERRI FLOC ...

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA	HAZARD CLASSIFICATION	BASIS FOR CLASSIFICATION	SOURCE
ROUTES OF EXPOSURE INHALATION	Not toxic by inhalation according to OSHA regulations.	Test results on product. Acute inhalation LC_{50} (rats) = In excess of 147.9 mg/l of air.	Determined Toxicological Laboratory on product.
SKIN CONTACT	Not irritating to the skin. In accordance with OSHA regulations.	Test results on product. Skin irritation index (rabbits) = 0.	Determined Toxicological Laboratory on product.
SKIN ABSORPTION	Not toxic dermally. In accordance with OSHA regulations.	Test results on product. Acute dermal LD_{50} (rabbits) (Male) In excess of 2 g/kg body wt. (Female) 2.0 g/kg body wt.	Determined Toxicological Laboratory on product.
EYE CONTACT	Corrosive to the eye. In accordance with OSHA regulations.	Test results on product. Eye irritation scores: 24 hrs. 45.2; 72 hrs. 56.3; 48 hrs. 56.2; 7 days 63.4	Determined Toxicological Laboratory on product.
INGESTION	Not toxic orally according to OSHA regulations.	Test results on product. Acute oral LD_{50} (rats) = Between 1 - 2.5 g/kg body wt.	Determined Toxicological Laboratory on product.

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE: Dusty. May cause coughing and irritate lungs. May be corrosive to the eye if not removed by washing. Also see Section V above.

CHRONIC OVEREXPOSURE: None known except as listed above. Prolonged dust inhalation may cause lung mottling and irritation.

EMERGENCY AND FIRST AID PROCEDURES

EYES: Irrigate eyes with large amounts of water for at least 15 minutes. Hold eyelids apart during irrigation. Send patient to a physician immediately.

SKIN: Wash with water. Remove shoes if in a shower. Remove and wash clothes before reuse.

INHALATION: Remove worker from exposure and seek medical aid.

INGESTION: Treat as a corrosive liquid. Drink large quantities of water or milk to reduce concentration. Seek medical aid immediately.

NOTES TO PHYSICIAN

PRECAUTIONARY STATEMENTS

None on product. If in solution, product is corrosive.

OTHER HANDLING AND STORAGE REQUIREMENTS

Store product in a dry place.
While product has been determined not to be irritating to the skin, it is an acid salt and may cause some irritation to the skin as it picks up moisture. Dust accumulations on hands, face, and body should be removed by washing or showering periodically as necessary.

ADDITIONAL REGULATORY CONCERNS

FEDERAL:

FDA

USDA

CPSC

TSCA IS THIS PRODUCT, OR ALL ITS INGREDIENTS, BEING CERTIFIED FOR INCLUSION ON THE TOXIC SUBSTANCES CONTR INVENTORY OF CHEMICAL SUBSTANCES? Yes

OTHER Product meets American Water Works Association standard for ferric sulfate in potable water. B 406.

STATE:

OSHA: Product is a hazardous material as defined by 29 CFR § 1910.1200 because it is corrosive to the eye, and a nuisance dust.
Product is not listed by the National Toxicology Program, the International Agency for Research on Cancer, nor the Registry of Toxic Effects of Chemica Substances (1981-82) as a carcinogen or potential carcinogen.

PREPARED BY: Arthur F. Gohlke, Ph.D.

TITLE: Technical Service Specialist

COMPANY: Tennessee Chemical Company

ADDRESS: 3400 Peachtree Rd. NE, Suite 401
Atlanta, Georgia 30326

The above information is believ to be correct. However, Ten Chemical Company makes no w and assumes no liability as to t accuracy or completeness.

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R[illegible]d
3-28-85
10-22-86

Material Safety Data Sheet	U.S. Department of Labor
May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.	Occupational Safety and Health Administration (Non-Mandatory Form) Form Approved OMB No. 1218-0072

IDENTITY (As Used on Label and List)	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.
(Pure Cal) Western High Calcium Hydrated Lime	

Section I

Manufacturer's Name: The Western Lime & Cement Company	Emergency Telephone Number: 1-414-334-3005
Address (Number, Street, City, State, and ZIP Code): 141 N. Main Street	Telephone Number for Information: 1-414-334-3005
West Bend, WI 53095	Date Prepared: June 9, 1987
	Signature of Preparer (optional)

Section II — Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optio
None				

Section III — Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_2O = 1)	2.4-2.
Vapor Pressure (mm Hg.)	N/A	Melting Point	Non-Volati
Vapor Density (AIR = 1)	Non-Vaporous	Evaporation Rate (Butyl Acetate = 1)	N/A

Solubility in Water

Insoluble in water

Appearance and Odor

Dry white powder with a faint earth odor

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
N/A Non-explosive	N/A	N/A	N/A

Extinguishing Media

N/A Non-combustible

Special Fire Fighting Procedures

N/A

N/A

Unusual Fire and Explosion Hazards

N/A

(Reproduce locally)

Section V — Reactivity Data

Stability			Conditions to Avoid
	Unstable		N/A
	Stable	X	

Incompatibility (*Materials to Avoid*) Acids; water (promotes causticity); corrosive to alumi

Hazardous Decomposition or Byproducts None

Hazardous Polymerization			Conditions to Avoid
	May Occur		N/A
	Will Not Occur	X	

Section VI — Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
	Avoid: Wear respirator	Avoid: Wear gloves	Avoid

Health Hazards (*Acute and Chronic*)
Lime can be irritating to eyes and moist skin since it is alkaline. Tight-fitting goggles should be worn for eye protection; an approved ty dust respirator is also required.

Carcinogenicity:	NTP?	IARC Monographs?	OSHA Regulated?
None	N/A	N/A	N/A

Signs and Symptoms of Exposure N/A

Medical Conditions
Generally Aggravated by Exposure Irritated tissue

Emergency and First Aid Procedures Call physician immediately

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material Is Released or Spilled
Waterways - Recovery is futile
Land Spills - Recover by scooping from land

Waste Disposal Method
Waterways - Agitate the water
Land Spills - Neutralize acid waste; use as fertilizer; discharge into sewer with sewage plant's approval

Precautions to Be Taken in Handling and Storing
Keep dry

Other Precautions
None

Section VIII — Control Measures

Respiratory Protection (*Specify Type*)
3M 8500 Particulate Dust Mask

Ventilation	Local Exhaust	Special
	Normal	
	Mechanical (*General*)	Other

Protective Gloves Gauntlet

Eye Protection Goggles or glasses w/side shields

Other Protective Clothing or Equipment Long-sleeved shirt for continuous handling

Work/Hygienic Practices No extraordinary measures

U.S.G.P.O. 1986-491-529/457

July 28,1989

Appendix B

Overview of IMPACTS-BRC Modeling

C-WPS.BRC

July 28,1989

APPENDIX B

Overview of IMPACTS-BRC Modeling

The evaluation of the potential radiation exposures has been based on the NRC computer code IMPACTS-BRC (NUREG/CR-3585, Ref. 8). This code presents the NRC calculational methods used for evaluating the application of their Policy Statement, "Radioactive Waste Below Regulatory Concern" as published in the Federal Register (51FR30839, August 29, 1986, Ref. 1).

The modeling of the IMPACTS-BRC code is conservatively applicable to the proposed alternative disposal of the very-low-level radioactively contaminated sludges from the Kewaunee Nuclear Power Plant. Because of the inherent conservatism of the code, the generic modeling parameters, such as meteorological dispersion, water table and ground water flow, have been used. The amount of non-BRC waste disposed of in the landfill has been based on actual Kewaunee County landfill data. The IMPACTS-BRC generic landfill disposal volume is 2.9E+04 m^3/y: a value of 9.9E+03 m^3/y has been used to reflect actual landfill operation.

An overview of the pathway modeling as employed by the IMPACTS-BRC code is presented in the following sections of this Appendix. More specific details can be obtained from NUREG/CR-3585 (Ref. 7 & 8).

A. Radiation Exposure During Transport

The IMPACTS-BRC modeling of the radiation exposure of the truck driver during transport assumes a transport time of three (3) hours per shipment. The driver is assumed to be located in the cab of the truck for 2 hours of the shipment, inspecting the shipment for 0.5 hour and remotely located for the remaining 0.5 hour (i.e., not exposed to the waste). For the exposures while in the cab and during inspection, the driver is located at 1 meter from the waste. No shielding by either the waste container or the truck is considered (which would further reduce any actual doses). For the actual transport of the sludges from the KNPP to the Kewaunee County landfill (or the Green Bay Metropolitan Sewerage District), the transport time is not expected to be significantly different than the generic value of 3 hours.

Five (5) tons of waste material are transported per trip to the landfill. The total exposure time of the transport worker is determined by the total number of trips required to transport the total mass of the BRC waste. An exposure time of 2.5 hours per trip and the total number of trips defines the total exposure time. For the KNPP wastes, a total of 167 trips at 5 tons per trip has been assumed, resulting in a total exposure time of 460 hours.

B. Radiation Exposure to Landfill Operator

The landfill operator is assumed to be exposed by the pathways of direct gamma exposure and inhalation exposure. Direct gamma exposures to both uncovered and covered waste are included. The inhalation exposure is based on the resuspension of the waste material during the landfill operation.

The landfill operator is exposed to a high ambient dust loading of 400 $\mu g/m^3$. This dust loading is assumed to be comprised totally of the mixed BRC and non-BRC (or all other waste disposed of) waste. The worker is exposed 8 hours per work day (or 2000 hr/y).

The direct exposure to the waste considers the exposed, open face deposited waste (awaiting coverage) and the covered waste. For the exposed waste, the landfill operator is assumed to be exposed to the diluted waste (BRC and non-BRC) at a distance of 1 meter throughout the work day (i.e., 8 hours per day, 5 days per week, 50 weeks per year).

For the covered waste, the exposure is attenuated by an average of 0.75 foot of soil. Again, exposure distance is 1 meter and work time exposure is assumed.

C. Post Disposal Exposure - Intruder Scenario

The potential exposures to individuals in the future after closure of the landfill are addressed by the code. The IMPACTS-BRC model considers the exposure of an individual assuming loss of institutional control over the landfill and the inadvertent intrusion into the waste. An institutional control period of 10 years has been conservatively assumed for the landfill disposal of the KNPP waste. The intruder exposure pathways include an intruder/construction scenario and an intruder/agriculture scenario. For the construction scenario, the intruder excavates the site and constructs a building. The construction worker is exposed to airborne radioactive material (resulting from resuspension) and to the uncovered waste (direct exposure).

Upon excavation during construction, the BRC material is assumed to be mixed with other wastes in the landfill and the disposal trench cover. The construction worker is exposed for a total of 500 hours with ambient work area dust loading of 565 ug/m^3.

For the intruder/agriculture scenario, the maximum exposed individual lives in the house constructed by the intruder/construction scenario. The individual is exposed to an ambient airborne source (resulting from resuspension of the waste), and to a direct source from the excavated materials (also used as backfill for the house). The individual also grows one-half of his food products in a local garden.

D. Post Disposal Exposure - Intruder Well

For the ground water pathway, the IMPACTS-BRC modeling assumes a well in the unconfined aquifer beneath the landfill. The well is located at the edge of the landfill. The transfer of the radioactive material to the groundwater is based on 100% ground water saturation of the waste. For added conservatism, no consideration has been given to the soil retardation of the migration.

A travel time of 5.4 years is used in the IMPACTS-BRC modeling for the time required for the material to initially migrate to the well located near the edge of the disposal area. The exposed individual consumes drinking water at a rate of 370 liters per year (approximately 1 liter per day). Also included in the dose modeling are the pathways of food crops grown on irrigated soil and meat consumption for animals raised on irrigated crops.

E. Exposed Waste Scenario

In this scenario, the earthen cover over the disposed waste is assumed to be totally removed. The uncovered waste is available for dispersal by the wind or water. Two radiological exposure mechanisms are considered: 1) the suspension and airborne dispersal of contaminated particulates to the surrounding area; and 2) the transport of the radionuclides via surface water runoff to an offsite surface water body. For the airborne dispersal the primary exposure pathway is the inhalation of the suspended radionuclides. For the surface water erosion, the primary exposure pathways are drinking water, irrigation of crops, and fish consumption.

Appendix C

IMPACTS-BRC Computer Code Results

KNPP BRC EVALUATION FOR EXISTING SLUDGES - TAPE2.DAT DATA

DENSITY @ 1 GM/ML FILE: LGN2.DAT DATE: 03/13/89

7.400E-02	1.0	34.0	18.0	500.0	1000.0	0.0	0.0	0.0	0.0
7.400E-02	1.0	34.0	18.0	500.0	1000.0	0.0	0.0	0.0	0.0
0.074	1.0	91.0	46.5	500.0	1000.0	0.0	0.0	0.0	0.0
3.600E-02	1.0	4.550E+02	2.375E+02	2.500E+03	5.000E+03	0.0	0.0	0.0	0.0
7.400E-02	1.0	91.0	46.5	500.0	1000.0	0.0	0.0	0.0	0.0
9.180E-12	2.960E-11	7.700E+03	2.000E+05	4.500E+06	5.050E-10	1.510E-09	1.110E-07	2.280E+03	7.060E-05
4.610E+00	9.680E-11	5.530E-07	5.530E-07	2.030E-06					
1									
1.800E-01	1.0	6.8	4.4	100.0	200.0	0.0	0.0	0.0	0.0
1.800E-01	1.0	6.8	4.4	100.0	200.0	0.0	0.0	0.0	0.0
0.18	1.0	18.2	10.1	100.0	200.0	0.0	0.0	0.0	0.0
3.000E-02	1.0	7.280E+01	4.640E+01	4.000E+02	8.000E+02	0.0	0.0	0.0	0.0
1.800E-01	1.0	18.2	10.1	100.0	200.0	0.0	0.0	0.0	0.0
2.010E-11	3.180E-11	7.700E+03	2.000E+05	4.500E+06	1.750E-10	5.250E-10	1.110E-07	6.100E+02	7.060E-05
3.610E+00	1.400E-10	1.540E-08	1.540E-08	2.500E-06					
1									
1.000E-03	1.0	3.400E+00	11.7	300.0	0.0	0.0	0.0	0.0	0.0
1.000E-03	1.0	3.400E+00	11.7	300.0	0.0	0.0	0.0	0.0	0.0
1.000E-03	1.0	9.100E+00	14.5	300.0	0.0	0.0	0.0	0.0	0.0
1.000E-03	1.0	9.100E+00	2.800E+02	5.800E+02	8.800E+02	0.0	0.0	0.0	0.0
1.000E-03	1.0	9.100E+00	14.5	300.0	0.0	0.0	0.0	0.0	0.0
2.640E-10	8.060E-11	7.700E+03	2.000E+05	4.500E+05	1.330E-11	3.990E-11	0.000E+00	6.000E+01	3.920E-05
8.670E+00	4.110E-11	7.950E-06	7.950E-06	6.840E-05					
1									
4.500E+01	2.000E+01	0.00E+00	9.100E-11	0.000E-00	1.000E-00	9.930E+03	9.100E-11	3.000E-01	1.00
1.000E-10	2.000E-10	4.000E-10	1.7E-10	3.39E-10	6.78E-10	86.0	71.0	15.0	5.900E-01
0.8	7.31	1.000E+00	1.000E+03	100.0	5.0E-05				
100.0	2.000E+01	4.280E+05	1.600E-13	3.330E-01	2.700E-01	2.960E+04	9.100E-11	3.330E-01	5.900E-01
3.700E-10	7.410E-10	1.480E-09	1.700E-10	3.390E-10	6.780E-10	8.600E+01	7.100E+01	1.500E+01	5.900E-01
8.000E-01	7.310E+00	1.000E+00	1.000E+03						
1.000E+02	2.000E+01	2.540E+04	9.100E-11	3.330E-01	1.0	9.135E+04	9.100E-11	3.330E-01	1.0
1.000E-10	2.000E-10	4.000E-10	1.000E-10	2.000E-10	4.000E-10	3.840E+02	3.640E+02	1.710E+01	4.100E-01
0.75	4.37	0.9	1.000E+03	100.0	5.0E-05				
1.000E+02	3.500E+01	2.540E+04	1.600E-13	3.330E-01	1.000E+00	9.135E+04	9.100E-11	3.330E-01	1.000E+00
1.000E-10	2.000E-10	4.000E-10	1.000E-10	2.000E-10	4.000E-10	3.840E+02	3.840E+02	1.710E+02	4.100E-01
7.500E-01	4.370E+00	9.000E-01	1.000E+03						
1.000E+02	3.500E+01	2.540E+04	1.800E-13	3.330E-01	1.000E+00	9.135E+04	9.100E-11	3.330E-01	1.000E+00
1.000E-10	2.000E-10	4.000E-10	1.000E-10	2.000E-10	4.000E-10	3.840E+02	3.840E+02	1.710E+02	4.100E-01
7.500E-01	4.370E+00	9.000E-01	1.000E+03						
0.180	1.0	1.7	1.85	25.0	50.0	0.0	0.0	0.00	0.000
2.64E-10	8.06E-11	110.0	2.00E+05	4.50E+06	6.67	1.4E-10	7.95E-06		
1									

KNPP BRC EVALUATION FOR EXISTING LAGOON SLUDGES - TAPE5.DAT DATA
MEASURED RADIONUCLIDE CONCENTRATION DENSITY @ 1 GM/ML FILE:LGN5.DAT DATE: 03/13/89

```
  2  0  1  1  2 30 10  0
LAGN SLDG      425.0      1.00      425.0
    3    1    0    0    1              1  100    1    1
CO-60  Y  1.80E-07  CS-137 D  2.20E-07
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KNPP BRC EVALUATION FOR EXISTING LAGOON SLUDGES - TAPE6.OUT RESULTS
DENSITY @ 1 GM/ML FILE: LGN6.OUT DATE: 03/13/89

IMPACTS-BRC VERSION 1.0

ONSITE INC, S. LANDF

LIFE= 30 OVFL= 0 NSTR= 1
REGN= 2 DATA= 0
IPOP= 2 INST= 10

WASTE: LAGN SLDG WEIGHT: 4.25E+02 MT DENSITY: 1.00E+00 MT/M3

ID= 3 IA= 1 IK1= 0 IK2= 0 PROCESS= 1
IXS= 1 100 1 1
ICS= 0 0 0 0

TRANSPORTATION IMPACTS TR-MAX = 3.39E-02 MREM/YR
TR-OCC = 6.78E-02 PERSON-MREM/YR
TR-POP = 2.00E-01 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03
INT-AG	7.30E-03	7.29E-03	7.30E-03	7.29E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.29E-03	7.30E-03

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	7.95E-06	1.86E-06	2.49E-06	3.42E-06	5.24E-06	5.40E-06	5.04E-06	5.41E-06	4.65E-06	5.82E-08
ER-AIR	7.88E-16	1.94E-16	2.26E-16	3.98E-16	6.36E-18	6.46E-16	6.09E-16	6.60E-16	5.62E-16	6.71E-16
IN-WAT	1.67E-07	3.68E-08	4.99E-08	8.35E-08	1.29E-07	1.32E-07	1.24E-07	1.34E-07	1.13E-07	1.38E-07
ER-WAT	1.15E-15	2.58E-16	3.04E-16	5.71E-16	8.92E-16	9.07E-16	8.52E-16	9.23E-16	7.79E-16	9.45E-16

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
IC-IND	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
IC-WOR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
IC-MWR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
OP-POP	1.18E-05	2.62E-06	4.03E-06	4.19E-06	5.99E-06	6.31E-06	5.80E-06	8.12E-06	5.34E-06	7.20E-06
OP-IND	1.85E-07	4.09E-08	6.29E-08	6.53E-08	9.34E-08	9.85E-08	9.04E-08	9.55E-08	8.33E-08	1.12E-07
OP-WOR	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03
OP-MWR	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	8.15E-03	6.15E-03	8.15E-03

LEACHATE ACCUMULATION IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
LA-OVF	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
LA-AIR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

1

GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	1.51E-05	8.60E-06	2.36E-05	1.06E-05	1.24E-05	1.27E-05	1.22E-05	1.23E-05	1.09E-05	1.54E-05
40YR	8.96E-06	2.84E-06	5.25E-06	4.96E-06	7.08E-06	7.20E-06	6.82E-06	7.26E-06	6.25E-06	7.83E-06
60YR	7.40E-06	1.83E-06	2.34E-06	3.79E-06	5.77E-06	5.86E-06	5.53E-06	5.98E-06	5.10E-06	6.15E-06
80YR	5.09E-06	1.21E-06	1.43E-06	2.58E-06	3.97E-06	4.03E-06	3.80E-06	4.11E-06	3.50E-06	4.21E-06
100YR	3.20E-06	7.60E-07	8.87E-07	1.62E-06	2.49E-06	2.53E-06	2.39E-06	2.59E-06	2.20E-06	2.64E-06
120YR	2.02E-06	4.79E-07	5.58E-07	1.02E-06	1.57E-06	1.60E-06	1.50E-06	1.63E-06	1.39E-06	1.67E-06
160YR	8.01E-07	1.90E-07	2.21E-07	4.06E-07	6.23E-07	6.33E-07	5.97E-07	6.47E-07	5.51E-07	6.61E-07
200YR	3.18E-07	7.54E-08	8.79E-08	1.61E-07	2.47E-07	2.51E-07	2.37E-07	2.57E-07	2.19E-07	2.62E-07
400YR	3.13E-09	7.43E-10	8.66E-10	1.59E-09	2.44E-09	2.48E-09	2.33E-09	2.53E-09	2.15E-09	2.59E-09
600YR	3.08E-11	7.32E-12	8.53E-12	1.56E-11	2.40E-11	2.44E-11	2.30E-11	2.49E-11	2.12E-11	2.55E-11
800YR	3.04E-13	7.21E-14	8.41E-14	1.54E-13	2.37E-13	2.40E-13	2.27E-13	2.46E-13	2.09E-13	2.51E-13
1K YR	2.99E-15	7.11E-16	8.28E-16	1.52E-15	2.33E-15	2.37E-15	2.23E-15	2.42E-15	2.06E-15	2.47E-15
2K YR	2.78E-25	6.60E-26	7.89E-26	1.41E-25	2.17E-25	2.20E-25	2.07E-25	2.25E-25	1.91E-25	2.30E-25
5K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
10K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
20K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
40YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
60YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
80YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
100YR	1.47E-08	3.49E-09	4.07E-09	7.44E-09	1.14E-08	1.16E-08	1.09E-08	1.19E-08	1.01E-08	1.21E-08
120YR	2.77E-08	8.58E-09	7.67E-09	1.41E-08	2.16E-08	2.19E-08	2.07E-08	2.24E-08	1.91E-08	2.29E-08
160YR	3.30E-08	7.84E-09	9.14E-09	1.67E-08	2.57E-08	2.61E-08	2.48E-08	2.67E-08	2.27E-08	2.73E-08
200YR	1.46E-08	3.46E-09	4.03E-09	7.38E-09	1.13E-08	1.15E-08	1.09E-08	1.18E-08	1.00E-08	1.20E-08
400YR	1.44E-10	3.41E-11	3.97E-11	7.27E-11	1.12E-10	1.14E-10	1.07E-10	1.16E-10	9.87E-11	1.19E-10
600YR	1.41E-12	3.36E-13	3.91E-13	7.17E-13	1.10E-12	1.12E-12	1.05E-12	1.14E-12	9.73E-13	1.17E-12
800YR	1.39E-14	3.31E-15	3.85E-15	7.06E-15	1.08E-14	1.10E-14	1.04E-14	1.13E-14	9.59E-15	1.15E-14
1K YR	1.37E-16	3.26E-17	3.80E-17	8.96E-17	1.07E-16	1.09E-16	1.02E-16	1.11E-16	9.44E-17	1.13E-16
2K YR	1.27E-26	3.02E-27	3.53E-27	6.46E-27	9.93E-27	1.01E-26	9.50E-27	1.03E-26	8.77E-27	1.05E-26
5K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
10K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
20K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
40YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
60YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
80YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
100YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

120YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
160YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
200YR	2.07E-10	4.63E-11	5.47E-11	1.02E-10	1.60E-10	1.63E-10	1.53E-10	1.86E-10	1.40E-10	1.70E-10
400YR	2.04E-11	4.58E-12	5.39E-12	1.01E-11	1.58E-11	1.60E-11	1.51E-11	1.63E-11	1.38E-11	1.67E-11
600YR	2.01E-13	4.49E-14	5.31E-14	9.95E-14	1.55E-13	1.58E-13	1.49E-13	1.61E-13	1.36E-13	1.65E-13
800YR	1.98E-15	4.43E-16	5.23E-16	9.80E-16	1.53E-15	1.56E-15	1.46E-15	1.58E-15	1.34E-15	1.62E-15
1K YR	1.95E-17	4.36E-18	5.15E-18	9.66E-18	1.51E-17	1.53E-17	1.44E-17	1.56E-17	1.32E-17	1.60E-17
2K YR	1.81E-27	4.05E-28	4.78E-28	8.97E-28	1.40E-27	1.43E-27	1.34E-27	1.45E-27	1.22E-27	1.48E-27
5K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
10K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
20K YR	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

KNPP BRC EVALUATION FOR EXISTING LAGOON SLUDGES - TAPE10.OUT RESULTS
DENSITY @ 1 GM/ML FILE: LGN10.OUT DATE: 03/13/89

IMPACTS-BRC VERSION 1.0

ONSITE INC, S. LANDF

LAGN SLDG

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
CO-60	2.676E-02
CS-137	7.153E-03

TOTAL TRANSPORTATION IMPACTS = 3.391E-02

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	AGRICULTURE
CO-60	1.455E-03	4.066E-03
CS-137	1.155E-03	3.230E-03
RADON		.000E+00

TOTAL NON-NORMALIZED INTRUDER IMPACTS

	2.610E-03	7.295E-03

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
CO-60	6.405E-07	.000E+00	2.992E-09	.000E+00
CS-137	5.177E-06	6.710E-16	1.347E-07	9.450E-16

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS

	5.817E-06	6.710E-16	1.377E-07	9.450E-16

GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

FIRST ROW IS INTRUDER WELL

SECOND ROW IS POPULATION WELL

THIRD ROW IS SURFACE WATER

20YR	40YR	60YR	80YR	100YR	120YR	160YR	200YR	400YR	600YR	800YR	1K YR	2K YR	5K YR	10K YR
CO-60														
1.0E-05	1.5E-06	1.6E-07	1.3E-08	9.0E-10	6.4E-11	3.3E-13	1.7E-15	5.7E-27	2.0E-38	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	4.1E-12	8.8E-13	1.3E-14	7.6E-17	2.8E-28	9.0E-40	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	3.6E-19	1.2E-29	4.2E-41	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CS-137														
5.0E-06	8.3E-06	8.0E-06	4.2E-06	2.6E-06	1.7E-06	8.8E-07	2.8E-07	2.6E-09	2.5E-11	2.5E-13	2.5E-15	2.3E-25	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	1.2E-08	2.3E-08	2.7E-08	1.2E-08	1.2E-10	1.2E-12	1.2E-14	1.1E-16	1.1E-26	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	1.7E-10	1.7E-11	1.6E-13	1.6E-15	1.6E-17	1.5E-27	.0E+00	.0E+00

TOTAL NON-NORMALIZED GROUNDWATER IMPACTS

1.5E-05	7.8E-06	6.2E-06	4.2E-06	2.6E-06	1.7E-08	6.6E-07	2.6E-07	2.6E-09	2.5E-11	2.5E-13	2.5E-15	2.3E-25	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	1.2E-08	2.3E-08	2.7E-08	1.2E-08	1.2E-10	1.2E-12	1.2E-14	1.1E-18	1.1E-26	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	1.7E-10	1.7E-11	1.6E-13	1.6E-15	1.6E-17	1.5E-27	.0E+00	.0E+00

KNPP BRC EVALUATION FOR FUTURE SLUDGES AND RESINS - TAPE2.DAT DATA

ALL RADIONUCLIDES @ 1 uCi/ml DENSITY @ 1 gm/ml FILE KNPP2.DAT DATE 03/13/89

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7.400E-02        1.0      34.0      18.0     500.0    1000.0       0.0       0.0       0.0       0.0
7.400E-02        1.0      34.0      18.0     500.0    1000.0       0.0       0.0       0.0       0.0
    0.074        1.0      91.0      46.5     500.0    1000.0       0.0       0.0       0.0       0.0
3.600E-02        1.0 4.550E+02 2.375E+02 2.500E+03 5.000E+03       0.0       0.0       0.0       0.0
7.400E-02        1.0      91.0      46.5     500.0    1000.0       0.0       0.0       0.0       0.0
9.180E-12 2.960E-11 7.700E+03 2.000E+05 4.500E+06 5.050E-10 1.510E-09 1.110E-07 2.280E+03 7.060E-05
4.810E+00 9.880E-11 5.530E-07 5.530E-07 2.030E-06
   1
1.800E-01        1.0       6.8       4.4     100.0     200.0       0.0       0.0       0.0       0.0
1.800E-01        1.0       6.8       4.4     100.0     200.0       0.0       0.0       0.0       0.0
     0.18        1.0      18.2      10.1     100.0     200.0       0.0       0.0       0.0       0.0
3.000E-02        1.0 7.280E+01 4.640E+01 4.000E+02 8.000E+02       0.0       0.0       0.0       0.0
1.800E-01        1.0      18.2      10.1     100.0     200.0       0.0       0.0       0.0       0.0
2.010E-11 3.180E-11 7.700E+03 2.000E+05 4.500E+06 1.750E-10 5.250E-10 1.110E-07 6.100E+02 7.060E-05
3.610E+00 1.400E-10 1.540E-08 1.540E-08 2.500E-06
   1
1.000E-03        1.0 3.400E+00      11.7     300.0       0.0       0.0       0.0       0.0       0.0
1.000E-03        1.0 3.400E+00      11.7     300.0       0.0       0.0       0.0       0.0       0.0
1.000E-03        1.0 9.100E+00      14.5     300.0       0.0       0.0       0.0       0.0       0.0
1.000E-03        1.0 9.100E+00 2.800E+02 5.800E+02 8.800E+02       0.0       0.0       0.0       0.0
1.000E-03        1.0 9.100E+00      14.5     300.0       0.0       0.0       0.0       0.0       0.0
2.640E-10 8.060E-11 7.700E+03 2.000E+05 4.500E+05 1.330E-11 3.990E-11 0.000E+00 6.000E+01 3.920E-05
8.670E+00 4.110E-11 7.950E-06 7.950E-06 6.840E-05
   1
4.500E+01 2.000E+01  0.00E+00 9.100E-11 0.000E-00 1.000E-00 9.930E+03 9.100E-11 3.000E-01      1.00
1.000E-10 2.000E-10 4.000E-10   1.7E-10  3.39E-10  6.78E-10      86.0      71.0      15.0 5.900E-01
      0.8      7.31 1.000E+00 1.000E+03     100.0   5.0E-05
    100.0 2.000E+01 4.280E+05 1.600E-13 3.330E-01 2.700E-01 2.960E+04 9.100E-11 3.330E-01 5.900E-01
3.700E-10 7.410E-10 1.480E-09 1.700E-10 3.390E-10 6.780E-10 8.600E+01 7.100E+01 1.500E+01 5.900E-01
8.000E-01 7.310E+00 1.000E+00 1.000E+03
1.000E+02 2.000E+01 2.540E+04 9.100E-11 3.330E-01       1.0 9.135E+04 9.100E-11 3.330E-01       1.0
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+01 4.100E-01
     0.75      4.37       0.9 1.000E+03     100.0   5.0E-05
1.000E+02 3.500E+01 2.540E+04 1.600E-13 3.330E-01 1.000E+00 9.135E+04 9.100E-11 3.330E-01 1.000E+00
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+02 4.100E-01
7.500E-01 4.370E+00 9.000E-01 1.000E+03
1.000E+02 3.500E+01 2.540E+04 1.600E-13 3.330E-01 1.000E+00 9.135E+04 9.100E-11 3.330E-01 1.000E+00
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+02 4.100E-01
7.500E-01 4.370E+00 9.000E-01 1.000E+03
    0.180        1.0       1.7      1.85      25.0      50.0       0.0       0.0      0.00     0.000
 2.64E-10  8.06E-11     110.0  2.00E+05  4.50E+06      6.67   1.4E-10  7.95E-06
   1
```

KNPP BRC EVALUATION FOR FUTURE SLUDGES AND RESINS - TAPE5.DAT DATA
ALL RADIONUCLIDES @ 1 uCi/ml DENSITY @ 1 gm/ml FILE: KNPP5.DAT DATE: 03/13/89

```
  2  0  1  1  2 30 10  0
KNPP SLDG    7.64E+02        1.0  7.64E+02
    3    1    0    0    1                1  100    1    1
H-3    *  1.00E-00  C-14   *  1.00E-00  GR-51  Y  1.00E-00  MN-54  W  1.00E-00  FE-55  Y  1.00E-00
FE-59  Y  1.00E-00  CO-58  Y  1.00E-00  CO-60  Y  1.00E-00  NI-63  W  1.00E-00  ZN-65  Y  1.00E-00
SR-90  Y  1.00E-00  ZR-95  Y  1.00E-00  NB-95  Y  1.00E-00  MO-99  Y  1.00E-00  TC-99  W  1.00E-00
I-129  D  1.00E-00  I-131  D  1.00E-00  CS-134 D  1.00E-00  CS-137 D  1.00E-00  BA-140 D  1.00E-00
LA-140 W  1.00E-00  PU-236 Y  1.00E-00  PU-238 Y  1.00E-00  FU-239 Y  1.00E-00  PU-240 Y  1.00E-00
PU-241 Y  1.00E-00  PU-242 Y  1.00E-00  AM-241 Y  1.00E-00  AM-243 Y  1.00E-00  CM-242 Y  1.00E-00
CM-243 Y  1.00E-00  CM-244 Y  1.00E-00
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KNPP BRC EVALUATION FOR FUTURE.SLUDGES AND RESINS -TAFE10.OUT
ALL RADIONUCLIDES @ 1 uCi/ml DENSITY @ 1 gm/ml FILE: KNPP10.OUT DATE: 03/13/89

IMPACTS-BRC VERSION 1.0

ONSITE INC, S. LANDF

KNPP SLDG

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
H-3	.000E+00
C-14	.000E+00
CR-51	3.190E+03
MN-54	8.783E+04
FE-55	.000E+00
FE-59	1.266E+05
CO-58	8.638E+04
CO-60	2.872E+05
NI-63	.000E+00
ZN-65	6.035E+04
SR-90	3.310E-03
ZR-95	1.591E+05
NB-95	8.104E+04
MO-99	1.486E+04
TC-99	2.397E-04
I-129	2.776E+02
I-131	3.724E+04
CS-134	1.622E+05
CS-137	5.845E+04
BA-140	1.810E+04
LA-140	2.397E+05
PU-236	2.517E+00
PU-238	1.879E+00
PU-239	.000E+00
PU-240	2.276E+00
PU-241	2.362E-02
PU-242	2.224E+00
AM-241	1.319E+03
AM-243	1.622E+04
CM-242	8.293E+00
CM-243	9.569E+03
CM-244	1.024E+00

TOTAL TRANSPORTATION IMPACTS = 1.430E+06

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	ACRICULTURE
H-3	7.085E-04	1.036E+03
C-14	1.078E-04	4.149E+03
CR-51	.000E+00	.000E+00
MN-54	4.230E+00	1.182E+01
FE-55	2.716E-03	9.896E-03
FE-59	2.030E-20	5.673E-20
CO-58	6.722E-12	1.879E-11
CO-60	1.453E+04	4.060E+04
NI-63	2.111E-02	4.529E-01
ZN-65	4.130E-01	1.164E+00
SR-90	1.121E+01	2.610E+01
ZR-95	5.048E-13	1.411E-12
NB-95	6.572E-28	1.837E-27
MO-99	2.577E-09	1.502E-05
TC-99	7.180E-02	4.184E+02
I-129	5.802E+01	8.776E+02
I-131	.000E+00	.000E+00
CS-134	1.124E+03	3.142E+03
CS-137	9.441E+03	2.639E+04
BA-140	.000E+00	.000E+00
LA-140	.000E+00	.000E+00
PU-236	1.115E+03	2.715E+03
PU-238	2.805E+03	2.629E+03
PU-239	3.433E+03	3.218E+03
PU-240	3.421E+03	3.207E+03
PU-241	7.476E+01	8.329E+01
PU-242	3.326E+03	3.118E+03
AM-241	3.657E+03	4.544E+03
AM-243	6.790E+03	1.315E+04
CM-242	1.449E+01	1.359E+01
CM-243	3.528E+03	6.403E+03
CM-244	1.371E+03	1.408E+03
RADON		.000E+00

TOTAL NON-NORMALIZED INTRUDER IMPACTS

	5.470E+04	1.171E+05

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
H-3	2.054E-01	1.282E-25	1.621E-03	5.476E-26
C-14	8.848E+00	8.897E+00	1.232E-01	6.551E+00
CR-51	.000E+00	.000E+00	.000E+00	.000E+00
MN-54	1.033E-03	.000E+00	6.282E-05	.000E+00
FE-55	4.315E-02	.000E+00	4.392E-04	.000E+00
FE-59	6.764E-24	.000E+00	7.053E-26	.000E+00
CO-58	2.012E-15	.000E+00	1.522E-17	.000E+00
CO-60	6.396E+00	.000E+00	2.988E-02	.000E+00
NI-63	3.229E-01	2.071E-04	2.317E-03	8.039E-05
ZN-65	1.286E-03	.000E+00	2.333E-05	.000E+00
SR-90	5.504E+01	1.464E-09	3.560E-02	5.123E-11
ZR-95	9.017E-17	.000E+00	6.167E-19	.000E+00
NB-95	4.228E-31	.000E+00	2.117E-32	.000E+00
MO-99	5.733E-08	6.332E-08	3.783E-10	2.261E-08
TC-99	1.587E+00	1.764E+00	1.054E-02	6.298E-01
I-129	1.655E+03	1.834E+03	1.156E+00	6.928E+01
I-131	.000E+00	.000E+00	.000E+00	.000E+00
CS-134	2.562E+00	.000E+00	6.521E-02	.000E+00
CS-137	4.230E+01	5.483E-09	1.101E+00	7.722E-09
BA-140	.000E+00	.000E+00	.000E+00	.000E+00
LA-140	.000E+00	.000E+00	.000E+00	.000E+00
PU-236	1.000E+03	6.339E-02	7.902E-02	3.510E-04
PU-238	1.285E+04	7.056E+00	4.611E-01	1.357E-02
PU-239	1.574E+04	1.695E+04	5.722E-01	3.336E+01
PU-240	1.568E+04	1.566E+04	5.718E-01	3.090E+01
PU-241	3.503E+02	1.282E+02	3.243E-01	1.072E+01
PU-242	1.524E+04	1.686E+04	5.578E-01	3.338E+01
AM-241	1.741E+04	4.329E+03	2.891E+01	3.620E+02
AM-243	1.795E+04	1.870E+04	2.813E+01	1.548E+03
CM-242	6.642E+01	3.641E-02	2.383E-03	7.000E-05
CM-243	9.862E+03	2.222E+01	1.023E+01	4.372E-02
CM-244	6.863E+03	4.184E+01	6.778E+00	8.256E-02

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS

1.148E+05	7.454E+04	7.714E+01	2.095E+03

GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

	20YR	40YR	60YR	80YR	100YR	120YR	160YR	200YR	400YR	600YR	800YR	1K YR	2K YR	5K YR	10K YR
H-3															
	9.8E+02	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	1.6E-01	1.6E-01	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	2.6E-05	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
C-14															
	6.7E+03	1.3E+04	2.0E+04	2.2E+04	2.2E+04	2.2E+04	2.2E+04	2.2E+04	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	1.0E+02	3.0E+02	9.1E+02	1.0E+03	9.8E+02	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	7.8E+00	7.6E+01	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CR-51															
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
MN-54															
	.0E+00	.0E+00	2.2E-21	1.2E-28	6.9E-36	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
FE-55															
	2.5E-01	2.4E-03	1.7E-05	9.2E-08	4.4E-10	2.1E-12	4.9E-17	1.1E-21	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	2.0E-12	2.9E-14	2.0E-18	5.1E-23	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	3.8E-25	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
FE-59															
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CO-58															
	7.7E-29	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CO-60															
	1.0E+02	1.5E+01	1.6E+00	1.3E-01	9.0E-03	6.4E-04	3.3E-06	1.7E-08	5.7E-20	2.0E-31	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	4.1E-05	8.8E-06	1.3E-07	7.6E-10	2.8E-21	8.9E-33	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	3.6E-12	1.2E-22	4.2E-34	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
NI-63															
	2.5E+01	4.3E+01	5.5E+01	5.3E+01	4.5E+01	3.9E+01	2.9E+01	2.1E+01	4.7E+00	1.1E+00	2.3E-01	5.2E-02	2.8E-05	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	2.1E-01	5.4E-01	1.2E+00	9.8E-01	2.2E-01	4.8E-02	1.1E-02	2.4E-03	1.3E-06	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	5.1E-03	1.1E-02	2.5E-03	5.6E-04	1.2E-04	6.7E-08	.0E+00	.0E+00
ZN-65															
	4.8E-06	1.1E-14	1.8E-23	2.3E-32	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
SR-90															
	2.4E+02	2.9E+02	2.6E+02	1.8E+02	1.1E+02	8.7E+01	2.5E+01	9.3E+00	6.6E-02	4.7E-04	3.4E-06	2.4E-08	4.5E-19	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	5.0E-01	9.2E-01	1.0E+00	4.2E-01	3.0E-03	2.2E-05	1.6E-07	1.1E-09	2.1E-20	.0E+00	.0E+00
	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	2.0E-03	1.4E-04	1.0E-06	7.4E-09	5.3E-11	9.9E-22	.0E+00	.0E+00
ZR-95															

```
8.7E-32  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
NB-95
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
MO-99
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
TC-99
1.1E+03 2.2E+03 3.3E+03 3.7E+03 3.7E+03 3.7E+03 3.7E+03 3.7E+03  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00 1.7E+01 5.1E+01 1.5E+02 1.7E+02  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 7.6E-01 7.6E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
I-129
1.2E+05 2.4E+05 3.6E+05 4.0E+05 4.0E+05 4.0E+05 4.0E+05 4.0E+05  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00 1.8E+03 5.5E+03 1.7E+04 1.8E+04  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 8.3E+01 8.3E+02  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
I-131
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
CS-134
1.1E-01 2.5E-04 4.3E-07 5.5E-10 6.4E-13 7.4E-16 1.0E-21 1.3E-27  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00 2.9E-15 1.0E-17 4.1E-23 6.2E-29  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 8.5E-31  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
CS-137
4.1E+01 5.2E+01 4.9E+01 3.4E+01 2.2E+01 1.4E+01 5.4E+00 2.1E+00 2.1E-02 2.1E-04 2.1E-06 2.0E-08 1.9E-18  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00 9.9E-02 1.9E-01 2.2E-01 9.8E-02 9.7E-04 9.5E-06 9.4E-08 9.3E-10 8.6E-20  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 1.4E-03 1.4E-04 1.3E-06 1.3E-08 1.3E-10 1.2E-20  .0E+00  .0E+00
BA-140
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
LA-140
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
PU-236
 .0E+00  .0E+00 7.6E-06 5.9E-08 4.5E-10 7.0E-12 4.2E-16 3.8E-20  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00
PU-238
 .0E+00  .0E+00 4.2E+01 3.5E+01 3.0E+01 5.1E+01 3.7E+01 4.1E+01 1.6E+01 4.9E+00 1.1E+00 2.2E-01 7.3E-05 2.6E-15 9.9E-33
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 1.0E-03 3.3E-06 1.2E-16 4.6E-34
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 1.6E-08 5.6E-18 2.2E-35
PU-239
 .0E+00  .0E+00 7.7E+01 7.7E+01 7.7E+01 1.5E+02 1.5E+02 2.3E+02 4.6E+02 6.8E+02 7.5E+02 7.5E+02 7.3E+02 6.7E+02 5.8E+02
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 3.4E+00 3.3E+01 3.1E+01 2.7E+01
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 1.6E-01 1.5E+00 1.3E+00
PU-240
 .0E+00  .0E+00 7.7E+01 7.6E+01 7.6E+01 1.5E+02 1.5E+02 2.3E+02 4.4E+02 6.5E+02 7.1E+02 6.9E+02 6.2E+02 4.6E+02 2.7E+02
 .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00  .0E+00 3.2E+00 2.9E+01 2.1E+01 1.2E+01
```

.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	1.4E-01	9.9E-01	5.9E-01
PU-241														
.0E+00	.0E+00	5.8E-02	2.0E-02	7.2E-03	5.0E-03	6.1E-04	1.1E-04	6.2E-09	2.6E-13	7.8E-18	2.2E-22	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	8.9E-25	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
PU-242														
.0E+00	.0E+00	7.5E+01	7.5E+01	7.5E+01	1.5E+02	1.5E+02	2.3E+02	4.5E+02	6.7E+02	7.5E+02	7.5E+02	7.5E+02	7.4E+02	7.4E+02
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	3.4E+00	3.4E+01	3.4E+01	3.4E+01
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	1.6E-01	1.6E+00	1.6E+00
AM-241														
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	8.6E+03	6.4E+03	4.7E+03	3.1E+03	7.8E+01	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	2.7E-04
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
AM-243														
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	2.1E+04	2.0E+04	2.0E+04	5.5E+04	9.8E+04	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	4.2E+02
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CM-242														
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CM-243														
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	2.0E-16	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
CM-244														
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	6.7E-32	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00

TOTAL NON-NORMALIZED CROUNDWATER IMPACTS

1.3E+05	2.6E+05	3.8E+05	4.3E+05	4.3E+05	4.3E+05	4.3E+05	4.3E+05	1.4E+03	3.1E+04	2.9E+04	2.7E+04	6.1E+04	1.0E+05	1.6E+03
.0E+00	.0E+00	.0E+00	.0E+00	2.0E+03	5.9E+03	1.8E+04	2.0E+04	9.8E+02	4.8E-02	1.1E-02	1.0E+01	9.6E+01	8.6E+01	4.9E+02
.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	9.2E+01	9.2E+02	2.5E-03	5.6E-04	1.2E-04	4.6E-01	4.1E+00	3.4E+00

Appendix D

Chemical Analyses of Previous Lagoon Dredgings

ROBERT E. LEE & ASSOCIATES
LABORATORY SERVICES
STATE CERTIFICATION NUMBER 405043870

HAZARDOUS WASTE CHARACTERISTICS
DATE: 09/01/87
WISC. PUBLIC SERVICE SLUDGE

TEST NAME	RESULT	UNITS	RCRA HAZARDOUS LIMIT
CADMIUM	.016	MG/L	1.0
CHROMIUM	.17	MG/L	5.0
MERCURY	.0026	MG/L	.2
ARSENIC	<.00012	MG/L	5.0
LEAD	.26	MG/L	5.0
pH	7.41	SU	2-12.5
SELENIUM	.0187	MG/L	1.0
SILVER	<.0004	MG/L	5.0
BARIUM	.055	MG/L	100.0