ACCELERATED DISTRIBUTION DEMONSTRATION SYSTEM

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9110170088 DOC.DATE: 91/10/09 NOTARIZED: NO DOCKET #
FACIL:50-315 Donald C. Cook Nuclear Power Plant, Unit 1, Indiana M 05000315
50-316 Donald C. Cook Nuclear Power Plant, Unit 2, Indiana M 05000316
AUTH.NAME AUTHOR AFFILIATION
FITZPATRICK,E. Indiana Michigan Power Co. (formerly Indiana & Michigan Ele
RECIP.NAME RECIPIENT AFFILIATION
MURLEY,T.E. Office of Nuclear Reactor Regulation, Director (Post 870411

SUBJECT: Submits application for disposal of licensed radioactive matl on plant site,addressing situation where approx 942 cubic meters of slightly contaminated sludge removed from turbine room sump absorption pond & pumped to parking lot.

DISTRIBUTION CODE: A001D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 3.8
TITLE: OR Submittal: General Distribution

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD3-1 LA	1	1	PD3-1 PD	1	1
	COLBURN,T.	2	2			
INTERNAL:	NRR/DET/ECMB 7D	1	1	NRR/DET/ESGB	1	1
	NRR/DOEA/OTSB11	1	1	NRR/DST 8E2	1	1
	NRR/DST/SELB 7E	1	1	NRR/DST/SICB8H7	1	1
	NRR/DST/SRXB 8E	1	1	NUDOCS-ABSTRACT	1	1
	OC/LFMB	1	0	OGC/HDS2	1	0
	REG FILE 01	1	1	RES/DSIR/EIB	1	1
EXTERNAL:	NRC PDR	1	1	NSIC	1	1

NOTE TO ALL "RIDS" RECIPIENTS:

PLEASE HELP US TO REDUCE WASTE! CONTACT THE DOCUMENT CONTROL DESK, ROOM P1-37 (EXT. 20079) TO ELIMINATE YOUR NAME FROM DISTRIBUTION LISTS FOR DOCUMENTS YOU DON'T NEED!

TOTAL NUMBER OF COPIES REQUIRED: LTTR 18 ENCL 16

A/A-2

RIDS/ADDS

RIDS/ADDS

RIDS/ADDS

Indiana Michigan
Power Company
P.O. Box 16631
Columbus, OH 43216

AEP
INDIANA
MICHIGAN
POWER

AEP:NRC:1154
10 CFR 20.302

Donald C. Cook Nuclear Plant Units 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
APPLICATION FOR ALTERNATIVE DISPOSAL
TURBINE ROOM SUMP ABSORPTION POND SLUDGE

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Attn: T. E. Murley

October 9, 1991

Dear Dr. Murley:

Indiana Michigan Power Company (I&M) submits this application pursuant to Title 10, Code of Federal Regulations, Section 20.302, for the disposal of licensed radioactive material on the Donald C. Cook Nuclear Plant site. The proposed method of disposal is not currently authorized by the Cook Nuclear Plant operating license. Our application is the result of a recent NRC inspection, in which we were requested to present the information described in the attachments to this document in the form of a 10 CFR 20.302 submittal. Specifically, this application addresses a situation in which approximately 942 cubic meters of slightly contaminated sludge were removed from the turbine room sump absorption pond and pumped in late 1981/early 1982 to the upper parking lot located within the Cook Nuclear Plant's exclusion area.

The determination of the impact on public health and safety and the environment resulting from the on-site disposal of the absorption pond sludge is provided in Attachment 1. In making this determination, various potential exposure pathways to the general public and exposure scenarios were analyzed.

Our evaluations of potential dose to the public incorporated extremely conservative assumptions. For example, in evaluating dose involving the ingestion of surface water we assumed that all of the initial radioactivity was transported into Lake Michigan with none being dispersed elsewhere. The other pathway analyses

A001

apply similarly conservative assumptions. However, even applying these stringent assumptions our calculated total body doses to any critical population group through any exposure pathway to the public are all well below 1.0 mRem per year. For internal exposures, the highest calculated annual organ dose to a critical population group is 1.27 mRem to the lung for a teen through the intruder scenario. This is consistent with the statement in Volume 2 of NUREG 1101 (Onsite Disposal of Radioactive Waste) requiring the doses resulting from the disposal be "conservatively estimated to be no greater than a few millirem per year to offsite individuals". This calculated dose is a small fraction of the dose received from natural background radiation. Consequently, we are confident that the activity addressed in this 10 CFR 20.302 application results in no adverse impact on the health and safety of the public or on the environment. It should be noted that doses that could be received by a member of the public after the loss of institutional control (i.e., following the end of decommissioning) will be addressed separately in the future as a part of our decommissioning plan.

This document has been prepared following Corporate procedures which incorporate a reasonable set of controls to ensure its accuracy and completeness prior to signature by the undersigned.

Sincerely,

E. E. Fitzpatrick
Vice President

ldp

Attachments

cc: D. H. Williams, Jr.
A. A. Blind - Bridgman
G. Charnoff
J. R. Padgett
A. B. Davis - Region III
NFEM Section Chief
NRC Resident Inspector - Bridgman

ATTACHMENT 1

Donald C. Cook Nuclear Plant

Turbine Room Sump Absorption Pond Dredging

Impact Determination

1.0 Introduction

Indiana Michigan Power Company submits this application, pursuant to 10 CFR 20.302, for the disposal of licensed radioactive material on the Donald C. Cook Nuclear Plant site. The method of disposal, described below, is not currently authorized by the Cook Nuclear Plant operating license.

The subject material contains small quantities of the following radioactive isotopes:

Cesium 134
Cesium 136
Cesium 137
Cobalt 60
Iodine 131

The activity is distributed throughout approximately 942 cubic meters of sludge that was dredged from the turbine room sump absorption pond located on the Cook Nuclear Plant site.

The potential radiological and environmental impacts of the proposed disposal have been evaluated and are presented in Attachment 2 to this submittal. The references for the calculations are presented in Attachment 3. Indiana Michigan Power Company concludes, based on the information presented here, that the described method of disposal presents no significant impact or hazard to the public health and safety or to the environment.

2.0 Justification

The subject disposal has already occurred. Attachments 4 and 5 show that there are not any toxic and/or radiological hazards associated with the sludge. Therefore, it is concluded that the best alternative is to allow the sludge to remain in its present location.

3.0 Description of Waste

The turbine room sump absorption pond is a collection place for water released from the Cook Nuclear Plant turbine room sump. The pond experienced a buildup of sludge consisting mainly of leaves and roots mixed with sand. As a result of the buildup of the sludge, a decision was made in 1981 to dredge the pond.

The sludge removed by the dredging activities was pumped to a containment area also located on the Cook Nuclear Plant site. The sludge was spread over an area of approximately 4.7 acres. Sludge samples were analyzed for radioactivity content, percent solids, sulfate, boron, oil, and grease. In addition, an EPA toxicity test was performed on the sludge. The results of these analyses are shown on Attachment 4 to this submittal. The results of the analysis of samples taken recently in the area are presented in Attachment 5, along with maps showing the location of the disposal

site. As can be seen in Attachment 5, there is presently no detectable radioactivity other than naturally occurring radionuclides in the area in question.

The sludge removed was originally slightly contaminated with radioactive material. One background sample and nine (9) samples were analyzed for isotopic content. The average concentration calculated for each isotope is shown below:

Cs-134	2.48E-06 μCi/cc
Cs-136	3.27E-07 μCi/cc
Cs-137	5.93E-06 μCi/cc
Co-60	9.52E-07 μCi/cc
I-131	2.81E-07 μCi/cc

Attachment 2 presents the radiological consequences of these activities.

It should be noted that this was an isolated activity. No similar burials have taken place since the noted burial.

4.0 Burial Location & Site Description

As noted above, the area in which the disposal took place is shown on maps contained in Attachment 5. The area is located well within the Cook Nuclear Plant property lines. Attachment 2 decribes the conservative assumptions used in the radiological assessment to characterize the nature of the burial site.

5.0 Institutional Controls

The disposal site is located within the Cook Nuclear Plant exclusion area. Access will be controlled in this area until after the decomissioning of the plant. This is not expected to occur until after the year 2017.

6.0 Radiological Safety

As shown in the samples contained in Attachment 5, the radiation levels in the disposal site area are well within background levels. Therefore, no additional radiation safety procedures are to be enacted.

7.0 State of Michigan Approval

A letter from the State of Michigan Department of Natural Resources confirming their acceptance of the plan to dispose of the sludge in the manner described above (referred to as the Residuals Management Plan) is included as Attachment 6.

8.0 Summary and Conclusions

The calculations in Attachment 2 show the following annual doses:

External Exposure - General Public (maximum)

Intruder 0.94 mRem whole body

Internal Organ Exposure - General Public (maximum)*

Surface Drinking Water	Infant	0.73 mRem to Liver
Ground Drinking Water	Infant	1.13 mRem to Liver
Fish Ingestion	Adult/Teen	1.01 mRem to Liver
Inhalation (Intruder)	Teen	1.27 mRem to Lung

I & M concludes, based on the analysis and evaluations presented in this application, that disposal of the turbine room sump absorption pond sludge in the manner described has negligible impact on the public health and safety.

*Pathways/population group yielding the highest calculated dose.

ATTACHMENT 2

Donald C. Cook Nuclear Plant

Turbine Room Sump Absorption Pond Dredging

Radiological Assessment: On-site Sludge Disposal

I. Basis

This study was performed to evaluate the radiological impact of on-site disposal of the pond sludge removed from the Turbine Room Sump Absorption Pond in late 1981/early 1982. This study consists of a determination of the environmental pathways through which radiological exposure could be expected to occur and an evaluation of the radiological consequences of the disposal of the contaminated pond sludge for each of the pathways considered. The following environmental pathways were considered:

- External Exposure - Occupational
- External Exposure - Inadvertent Intruder
- Internal Exposure due to the release of contaminants to surface water - ingestion of drinking water
- Internal Exposure due to the release of contaminants to surface water - ingestion of fish and other aquatic foodstuffs
- Internal exposure due to the release of contaminants to ground water - ingestion of well water
- Internal exposure due to inhalation of resuspended contaminated soil - occupational
- Internal exposure due to inhalation of resuspended contaminated soil - Inadvertent Intruder

To conservatively account for the trace levels of contamination present in the turbine room sump absorption pond sludge, all of the contamination was used at least five (5) times in determining the potential radiological consequences of the on-site disposal:

- External exposures
- Internal exposure due to the ingestion of surface water
- Internal exposure due to the ingestion of fish and other aquatic foodstuffs
- Internal exposure due to the ingestion of ground water
- Internal exposure due to the inhalation of contaminated dusts

Pathway specific assumptions are discussed below in more detail.

The calculational models used in this assessment are:

A. For external exposures, the contaminated pond sludge was assumed to have been spread uniformly over the area of the disposal site.

   The external exposures were then calculated using an infinite slab model of a finite uniform thickness with credit being taken for the self-shielding of the soil slab itself.

B. For internal exposures due to the ingestion of contaminated waters and/or foodstuffs, those models specified in Regulatory Guide 1.109 were used with generic values used for model parameters.

   For those parameters for which "NO DATA" was listed, a value of 0.00E+00 was assumed, unless otherwise specified.

C. For internal exposures due to the inhalation of resuspended contaminated dusts, a model was developed based on NUREG/CR-3332, Section 5.2.2.6.

D. For those scenarios for which institutional control is assumed to remain in effect, the exposures are calculated for the immediate year following the original sludge transfer (i. e., the exposures are calculated and reported as though this application for on-site disposal was being made in 1981). This is done in keeping with the intent of current NRC practices concerning application for and approval of such disposal mechanisms.

II. Source Terms

Following dredging of the Turbine Room Absorption Pond bottoms in late 1981/early 1982, samples of the dredged material were collected for radiological analysis. Listed below are the activity levels on a pCi/cc basis for the samples which showed detectable activity.

Table 1
Volumetric Concentrations
pCi/cm^3

Sample #	Cs-136	Cs-134	Cs-137	Co-60	I-131
1	0.327	2.010	4.810	1.450	
2		0.705	1.650	0.504	
3		4.740	10.600	0.587	
4		6.410	14.800	0.674	
5		0.429	0.917		
6		0.223	0.528		
7		3.230	7.070	2.800	
8		3.130	7.730	2.550	
9		1.440	5.280		0.281
Average	0.0327	2.480	5.930	0.952	0.281

The total volume of sludge that was dredged from the bottom of the Turbine Room Sump Absorption Pond was 1232 cubic yards ($9.42*10^8$ cm^3). This material was subsequently spread over the upper parking lot, an area of approximately 4.7 acres ($1.90*10^8$ cm^2). Consequently the total activity and the areal concentration (activity per unit area) were found to be:

Table 2

Radionuclide	Total Activity uCi	Areal Concentration uCi/cm^2
Cs-136	34.19	$1.80*10^{-7}$
Cs-134	2339.00	$1.23*10^{-5}$
Cs-137	5586.00	$2.94*10^{-5}$
Co-60	896.70	$4.71*10^{-6}$
I-131	29.39	$1.55*10^{-7}$

III. External Exposures: Occupational and Inadvertent Intruder

A. Assumptions

1. Duration of exposures

For the purpose of calculating the dose to an individual from external radiation exposure, the following occupancy times were assumed:

a. Occupational Exposure: 208 hours per year. This occupancy factor is assumed to cover the case of a worker who parks his personal vehicle in the upper parking lot each day. We assume that it takes twenty (20) minutes for the worker to park his vehicle and exit to the paved parking area. This occurs twice per day once when entering the parking lot to start his shift and once when exiting the plant site at the end of the worker's shift. This occurs five (5) days per week, fifty (50) weeks per year. In addition, we assume that the worker works an additional 25% of his normal work schedule in overtime. This overtime is in the form of additional days of work and not additional hours at the end of his normal work day.

b. Inadvertent Intruder: 192 hours per year. This occupancy factor is assumed to cover the case of an individual entering the upper parking lot and spending the night. It is conservatively assumed that the time spent lasts from the end of the day shift continuously to the start of the next day's day shift (i. e. 16 hours per occurrence). It is further assumed that this occurs once per month.

2. Activity Levels

For purposes of calculating the external exposure to an individual, we assume that each radionuclide is uniformly distributed over the surface area of the upper parking lot to a depth of 4.95 cm, with an areal activity concentration as previously specified in Table 2.

3. Model

The model used in calculating the external exposures is that of an infinite slab of sand with a thickness of 4.95 cm and a density of 1.54 grams per cubic centimeter. The soil/sand was assumed to consist of silicon dioxide (SiO_2). The computer code "MicroShield" was used to calculate the dose rates at various times following the transfer of the pond sludge to the upper parking lot. Credit was taken for the self-shielding of the pond sludge. No credit is taken for decay of the material over the period for which the external dose is calculated.

4. Using the inputs specified above the following external exposures were calculated for the first year after the sludge application:

   a. Occupational: 1.02 mRem
   b. Inadvertent Intruder: 0.94 mRem

IV. Internal Exposure: Releases to Surface Waters - Doses due to Ingestion of Drinking Water and Consumption of Fish

A. Assumptions

1. Quantities consumed

   a. For the purpose of calculating the total dose to an individual from the ingestion of drinking water derived from the discharge plume in surface waters, we assume that the volume of contaminated drinking water corresponds to a one (1) day's supply of the maximally exposed individual's annual water intake. Thus we conservatively assume that the radioactive plume constantly supplies the nearest public water intake for a full day, when, in reality, the plume would be rapidly dissipated. The daily water intake for each of the critical populations is given in the table below (derived from the data in Reg. Guide 1.109 on annual water intake):

Table 3

Critical Population Group	Daily Water Intake liters
Adult	1.999
Teenager	1.396
Child	1.396
Infant	0.9035

   b. For the purpose of calculating the total dose to an individual from the ingestion of fish and other aquatic foodstuffs, we assume the total annual intake of such foodstuffs is derived from the volume into which the radioactive material is released.

Table 4

Critical Population Group	Annual Fish Intake kg
Adult	27.0
Teenager	19.8
Child	8.6
Infant	0.0

2. Activity Levels: For purposes of this calculation, no credit was taken for radioactive decay of the material. This is highly conservative since we would expect that the time that it would

take for the radioactive contaminants to travel to Lake Michigan would be significant.

3. Dilution Volumes
   a. For the purpose of calculating the total dose to an individual from the ingestion of drinking water, we take credit for dilution of the discharge to Lake Michigan. The dilution factor was calculated using the methodology of Regulatory Guide 1.113 for a transient release. For purposes of conservatism, it is assumed that the discharge point and the drinking water intake both lie in the plume centerline. Note that the dilution factor was not recalculated for this submittal; the dilution factor was taken from a previous calculation for the Application for Alternative Disposal - Steam Generator Enclosure Concrete (AEP:NRC:1053), dated February 29,1988. This discussion of the calculation of the dilution factor and model used is taken substantially from that submittal.
   b. For the purpose of calculating the total dose to an individual from the ingestion of fish and other aquatic foodstuffs, we assume that because fish and other aquatic foodstuffs are typically free ranging, the volume of water through which the radioactive contaminants are dispersed is defined by a cylinder with a radius of five (5) miles and a depth of one (1) meter.

B. Drinking Water
   1. Model
   In order to calculate the total activity ingested by an individual via the ingestion of drinking water, it is first necessary to calculate the concentration of the radioactive contaminants in the water. Since the total activity of each radionuclide is known, we must calculate the water volume through which the radioactive contaminants will be dispersed in going to the nearest public water intake. Using the methodology for calculating the dilution volume for a transient release per Regulatory Guide 1.113, we have:

$$Vol = \frac{4\,td(K_x K_y)}{e^{-\frac{(X_o - ut)^2}{4K_x t}} * e^{-\frac{(Y_o - Y_s)^2}{4K_y t}} * e^{-\frac{(Y_o + Y_s)^2}{4K_y t}}}$$

where Vol is the dilution volume due to Lake Michigan

X_o, Y_o are the coordinates of the nearest public water intake

Y_s is the location of the discharge (source) location

u is the current velocity

t is the time required for a parcel of water to travel from the point of discharge to the intake

d is the depth of the nearest drinking water intake

K_x, K_y are water turbulence factors

Simplifying the above equation, the dilution volume is found to be given by the equation:

$$Vol = 2tu^2(B_xB_y)^{1/2}$$

where the terms t and u are as previously defined, and B_x, B_y are water turbulence factors

Solving this equation, our dilution volume was found to be $6.26*10^9$ cm^3. Using this value as our dilution volume and using the total activity calculated for each radionuclide, the following water concentrations were obtained:

Table 5

Radionuclide	Activity uCi	Water Concentration pCi/l	Fractional MPC
Cs-136	34.19	5.457	$9.095*10^{-5}$
Cs-134	2339.00	372.800	$4.143*10^{-2}$
Cs-137	5586.00	891.500	$4.458*10^{-2}$
Co-60	896.70	143.100	$4.770*10^{-3}$
I-131	29.39	4.691	$1.564*10^{-2}$
		Total	$1.065*10^{-1}$

where Fractional MPC in the above table is the Fractional Maximum Permissible Concentration for the radionuclide of concern and is calculated using the equation:

$$Fractional\ MPC_i = \frac{Concentration_i}{MPC_i}$$

where

$Concentration_i$ is the water concentration of the i^{th} radionuclide

MPC_i is the maximum permissible concentration in water for the i^{th} radionuclide. The MPC value used in these calculations is the more conservative value of the insoluble or soluble (smaller of the two values) and is taken from 10CFR20, Appendix B, Table 2, Column II.

To calculate the radiological doses due to the ingestion of contaminated drinking water, we simply take the concentration of each radionuclide in water and multiply by the volume of water ingested in a day. This gives us the total activity of each radionuclide ingested and to calculate the organ doses we simply multiply the total activity of each radionuclide ingested by the corresponding dose factor for the organ and radionuclide of interest and then sum over all radionuclides present. This is expressed mathematically as:

$$Dose^{o_{i,p}} = Concentration_i * Intake^{water_p} * DoseFactor^{ing,o_{i,p}}$$

where $Dose^{o}_{i,p}$ is the dose to the o^{th} organ from the i^{th} radionuclide ingested for the p^{th} critical population group in mRem

$Concentration_i$ is the water concentration of the i^{th} radionuclide in pCi/l

$Intake^{water}_{p}$ is the daily water intake for the p^{th} critical population group for the maximally exposed individual

Dose $Factor^{ing,o}_{i,p}$ is the factor which converts the quantity of the i^{th} radionuclide into a dose for the o^{th} organ of the p^{th} critical population group via the ingestion pathway in units of mRem/pCi ingested. Values of the Dose $Factor^{ing,o}_{i,p}$ are listed in Appendix A of this report.

The total dose to an organ from all radionuclides is simply the sum of each of the individual doses from each radionuclide.

$$Dose^{o_p} = \sum_i Dose^{o_{i,p}}$$

The calculated organ doses via this ingestion pathway are listed in Appendix B of this report. The maximum organ dose for each critical population is summarized below:

Table 6

Critical Population Group	Organ	Dose mRem
Adult	Liver	0.3054
Teenager	Liver	0.2889
Child	Liver	0.5912
Infant	Liver	0.7312

C. Fish and Other Aquatic Foodstuffs Ingestion

1. Model

In order to calculate the total activity ingested by an individual via the ingestion of fish and other aquatic foodstuffs, it is first necessary to calculate the concentration of the radioactive contaminants in the fish and other aquatic foodstuffs. To accomplish this, we need to know the concentration of each of the radioactive contaminants in the surface water and the bioaccumulation factor for each element.

The water concentration of each isotope is calculated by multiplying the curie content (given in the previous section) by the dilution factor. The volume of water assumed earlier is a cylinder with a radius of 5 miles and a depth of one meter, the total volume is 5.09E+10 liters. The dilution factor is merely the reciprocal of the volume, or 1.966E-11 liters^{-1}. The calculated concentrations are shown in the table below.

Table 7

Radionuclide	Water Concentration pCi/l	Bioaccumulation Factor (pCi/kg per pCi/l)	Fish Concentration pCi/kg
Cs-136	$6.723*10^{-4}$	2000	1.3450
Cs-134	$4.594*10^{-2}$	2000	91.8700
Cs-137	$1.098*10^{-1}$	2000	219.7000
Co-60	$1.763*10^{-2}$	50	0.8816
I-131	$5.779*10^{-4}$	15	0.008669

To calculate the radiological doses due to the ingestion of fish and other aquatic foodstuffs taken from contaminated surface water, we simply take the concentration of each radionuclide in the edible portions of the fish and other aquatic foodstuffs and multiply by the total quantity of fish consumed in a year. This gives us the total activity of each radionuclide ingested via this pathway. To calculate the organ doses for each of the critical population groups, we simply multiply the ingested activity of each radionuclide by the appropriate critical population group-organ dose factor and then sum over all radionuclides present. This is expressed mathematically as:

$$Dose^{o_{i,p}} = Conc^{fish_i} * Intake^{fish_i} * DoseFactor^{ing,o_{i,p}}$$

where $Dose^{o}_{i,p}$ is the dose to the o^{th} organ from the i^{th} radionuclide ingested for the p^{th} critical population group in mRem

$Conc^{fish}_{i}$ is the concentration of the i^{th} radionuclide in the edible tissues of fish and other aquatic foodstuffs

$Intake^{fish}_{p}$ is the annual intake of fish and other aquatic foodstuffs for the p^{th} critical population group for the maximally exposed individual

Dose $Factor^{ing,o}_{i,p}$ is the factor which converts the quantity of the i^{th} radionuclide into a dose for the o^{th} organ of the p^{th} critical population group via the ingestion pathway in units of mRem/pCi ingested. Values of the Dose $Factor^{ing,o}_{i,p}$ are listed in Appendix A of this report.

The total dose to an organ from all radionuclides is simply the sum of each of the individual doses from each radionuclide.

$$Dose^{o_p} = \sum_{I} Dose^{o_{I,p}}$$

The calculated organ doses via this ingestion pathway are listed in Appendix C of this calculation. The maximum organ dose for each critical population is summarized below:

Table 8

Critical Population Group	Organ	Dose mRem
Adult	Liver	1.015
Teenager	Liver	1.007
Child	Liver	0.8955
Infant		0.000

V. Internal Exposure: Releases to Ground Water - Doses due to Ingestion of Drinking Water

A. Assumptions

1. Quantities consumed: For the purpose of calculating the total dose to an individual from the ingestion of drinking water derived from ground water, we assume that all drinking water is obtained from the water table underlying the Cook Plant. The annual water intake for the maximally exposed individual in each of the critical population groups is listed in the table below:

Table 9

Critical Population Group	Annual Water Intake (liters)
Adult	730
Teenager	510
Child	510
Infant	330

2. Activity Levels: For purposes of this calculation, no credit was taken for radioactive decay of the material. This is highly conservative since we would expect that the time that it would

take for the radioactive contaminants to percolate through the sandy soil to the underlying water table would be significant.

3. Dilution Volumes: For the purpose of calculating the total dose to an individual from the ingestion of drinking water, credit is taken for the dilution of the activity by the average annual rainfall at the Cook Plant.

B. Drinking Water

1. Model

In order to calculate the total activity ingested by an individual via the ingestion of drinking water, it is first necessary to calculate the concentration of the radioactive contaminants in the water. Since the total activity of each radionuclide is known, we must calculate the water volume through which the radioactive contaminants will be dispersed in the ground water that is being used as a source of drinking water. In order for the radioactive material to become available for ingestion, it must first percolate through the sandy soil to the underlying water table. For purposes of this application, we assumed that the radioactive material will be transported to the water table as a result of the percolation of rainfall to the water table. The dilution volume that is assumed is the volume of water defined by an average year's rainfall within the Cook Plant's exclusion area. No credit is taken for any additional dilution arising from the water table itself or rainfall outside of the Cook Plant exclusion area. This ensures that the estimated dilution volume is conservatively small, thereby resulting in a conservatively high concentration in the water itself.

The annual average rainfall at the Cook Plant was estimated by the average annual rainfall measured in Benton Harbor, Michigan, during the period from 1966 to 1969. Based on information contained in the Cook Plant Updated Final Safety Analysis Report, the annual average rainfall was estimated to be approximately 22.19 inches (56.363 cm). This estimate of the average annual rainfall at the Cook Plant was found to be conservative based on information contained in an in-house evaluation of the hydrogeological conditions at the Cook Plant completed in April 1991 which found that the average rainfall was approximately 36.04 inches. Using the estimated annual average rainfall of 22.19 inches and the Cook Plant exclusion area of 650 acres, the dilution volume was found to be $1.48*10^9$ liters.

Table 10

Radionuclide	Activity	Water Concentration	Fractional MPC
	uCi	pCi/l	
Cs-136	34.19	0.02306	$3.843*10^{-7}$
Cs-134	2339.00	1.576	$1.751*10^{-4}$
Cs-137	5586.00	3.768	$1.884*10^{-4}$
Co-60	896.70	0.6048	$2.016*10^{-5}$
I-131	29.39	0.01982	$6.608*10^{-5}$
		Total	$4.501*10^{-4}$

where Fractional MPC in the above table is the Fractional Maximum Permissible Concentration for the radionuclide of concern and is calculated using the equation:

$$Fractional\ MPC_i = \frac{Concentration_i}{MPC_i}$$

where $Concentration_i$ is the water concentration of the i^{th} radionuclide

MPC_i is the maximum permissible concentration in water for the i^{th} radionuclide. The MPC value used in these calculations is the more conservative value of the insoluble or soluble (smaller of the two values) and is taken from 10CFR20, Appendix B, Table 2, Column II.

To calculate the radiological doses due to the ingestion of contaminated drinking water, we simply take the concentration of each radionuclide in water and multiply by the volume of water ingested in a day. This gives us the total activity of each radionuclide ingested and to calculate the organ doses we simply multiply the total activity of each radionuclide ingested by the corresponding dose factor for the organ and radionuclide of interest and then sum over all radionuclides present. This is expressed mathematically as:

$$Dose^{o_{i,p}} = Concentration_i * Intake^{water_p} * DoseFactor^{ing,o_{i,p}}$$

where $Dose^{o}_{i,p}$ is the dose to the o^{th} organ from the i^{th} radionuclide ingested for the p^{th} critical population group in mRem $concentration_i$ is the water concentration of the it^{th} radionuclide in pCi/l

$Intake^{water}_{p}$ is the daily water intake for the p^{th} critical population group for the maximally exposed individual Dose $Factor^{ing,o}_{i,p}$ is the factor which converts the quantity of the i^{th} radionuclide into a dose for the o^{th} organ of the p^{th} critical

population group via the ingestion pathway in units of mRem/pCi ingested. Dose factors are listed in Appendix A of this report.

The total dose to an organ from all radionuclides is simply the sum of each of the individual doses from each radionuclide.

$$Dose^{o_p} = \sum_I Dose^{o_{I,p}}$$

The calculated organ doses via this ingestion pathway are listed in Appendix D of this calculation. The maximum organ dose for each critical population is summarized below:

Table 11

Critical Population Group	Organ	Dose mRem
Adult	Liver	0.4715
Teenager	Liver	0.4459
Child	Liver	0.9125
Infant	Liver	1.1290

VI. Internal Exposure: Doses Due to Inhalation of Resuspended Contaminated Dusts - Occupational and Inadvertent Intruder

A. Assumptions

1. For purposes of calculating the internal doses arising from the inhalation of contaminated pond sludge material, it is assumed that the sludge has dried and that the concentration has changed proportionally.
2. No credit is taken for decay.
3. No credit is taken for the presence of any overlying material such as gravel, fresh clean soil, or any other such material.
4. Occupancy factors are as assumed for the direct external exposure dose calculations.

B. Models: The concentration of the various radionuclides in the dried pond sludge is calculated using the equation:

$$Conc_i^{dry} = \frac{Act_i^{wet}}{Vol^{wet}} * \frac{Vol^{wet}}{Vol^{dry}}$$

$$Conc_i^{dry} = Conc_i^{wet} * \frac{Vol^{wet}}{Vol^{dry}}$$

where $Conc^{dry}_i$ is the concentration of the i^{th} radionuclide in the dry sludge

Act^{wet}_i is the activity of the i^{th} radionuclide in the wet sludge

$Conc^{wet}_i$ is the concentration of the i^{th} radionuclide in the wet sludge (i. e., the measured concentration)

$Vol^{wet} = Vol^{solids} + Vol^{water}$

$Vol^{dry} = Vol^{solids}$

Analysis performed on the wet sludge indicated that the sludge was approximately 83% solids and 17% water. For purposes of being conservative, we assumed that the sludge was 80% solids and 20% water. The dry concentrations are indicated below in Table 12:

Table 12

Radionuclide	Areal Concentration Wet (uCi/cm^2)	Dry (pCi/m^2)
Cs-136	$1.80*10^{-7}$	$2.250*10^{+3}$
Cs-134	$1.23*10^{-5}$	$1.538*10^{+5}$
Cs-137	$2.94*10^{-4}$	$3.675*10^{+5}$
Co-60	$4.71*10^{-6}$	$5.888*10^{+4}$
I-131	$1.55*10^{-7}$	$1.938*10^{+3}$

Having the dry areal concentrations of each radionuclide, we then use Equation 5.27 of Nureg/CR-3332 to calculate the airborne concentration of each radionuclide:

$$Air_i = R_f * Conc_i^{dry} * F$$

where Air_i is the airborne concentration of the i^{th} radionuclide

R_f is the resuspension factor

$Conc^{dry}_i$ is as defined above

F is the fraction of the activity that is available to go airborne. (For this report, we assumed that all activity was available to go airborne.)

Having the airborne concentration of each radionuclide, we then calculate the dose due to the inhalation of such material using the equation:

$$Dose^{inh,o_{i,p}} = Vol_p^{air} * Air_i * DoseFactor^{inh,o_{i,p}} * T$$

where $Dose^{inh,o}_{i,p}$ is the inhalation dose to the o^{th} organ from the i^{th} radionuclide for the p^{th} critical population group

Vol^{air}_p is the minute air volume for the p^{th} critical population group. The minute air volume is the volume of air inhaled in one minute and is summarized in Table 13 below, Air_i is as defined above

Dose $Factor^{inh,o}_{i,p}$ is the factor which converts the quantity of the i^{th} radionuclide inhaled into a dose for the o^{th} organ of the p^{th} critical population group in mRem/pCi inhaled. Inhalation Dose Factors are given in Appendix E of this report.

T is the time spent in the area in which an inhalation dose may occur

The total dose to a given critical population group - organ is simply the sum of the doses from each of the radionuclides:

$$Dose^{inh,o_p} = \sum_i Dose^{inh,o_{i,p}}$$

Table 13
Minute Air Volumes

Critical Population Group	Volume (1/min)
Adult	$1.521*10^{-2}$
Teenager	$1.521*10^{-2}$
Child	$7.035*10^{-3}$
Infant	$2.662*10^{-3}$

Note that minute air volumes were calculated using the annual air volumes for the maximally exposed individual in each critical population group divided by the number of minutes in a year (assumed to be 365.25 days).

1. Occupational Exposures: Two scenarios are assumed to occur for occupational exposure:
   a. Inhalation during the initial grading of the material following the transfer from the absorption pond to the upper parking lot. Because of the mechanical disturbance of the soil, we assume a fairly large value of 10^{-3} m^{-1} for the resuspension factor. In addition, we assume that it took two full working days to completely grade out the material with no credit being taken for breaks or other work stoppages. Finally, since this activity typically involves heavy machinery, we assumed that only adults would be exposed via

this pathway. Based on these assumptions, the inhalation doses were calculated and are listed in Appendix F of this report. The maximum organ dose for an adult was $7.192*10^{-2}$ mrem for the lung.

b. Inhalation during the time a worker transverses the parking lot going to and returning from work. For assessment of inhalation doses via this route, we assumed a resuspension factor 10^{-4} m^{-1} as was recommended by Nureg/CR-3332 for use in desert areas. Since the parking lot is sparsely vegetated, the use of this value is reasonable. The assumed time a person would spend in this area is 208 hours per year as explained in Section III.A.1.a of this report. Again since only workers would be expected to park in this area, inhalation doses were calculated for adults only. Based on these assumptions, the inhalation doses were calculated and are listed in Appendix G of this report. The maximum organ (lung) dose for an adult was $9.365*10^{-1}$ mrem.

2. Inhalation Doses to an Inadvertent Intruder: For this pathway, a resuspension factor of 10^{-4} m^{-1} was assumed. An occupancy time of 192 hours per year was assumed as explained previously in Section III.A.1.b of this report. All critical population groups were assumed to be conceivably exposed via this pathway and the results of our calculations are listed in Appendix H of this report. The maximum organ dose for each of the critical population groups and the maximally exposed organs are indicated in Table 14 below:

Table 14
Inadvertent Intruder Inhalation Doses

Critical Population Group	Organ	Dose (mrem)
Adult	Lung	0.863
Teenager	Lung	1.271
Child	Lung	1.036
Infant	Liver	0.731

APPENDIX A

From Regulatory Guide 1.109, we have the following ingestion dose factors:

Critical Population	Critical Organ	Dose Factors mRem/pCi				
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Adult	Bone	6.510E-06	6.220E-05	7.970E-05		4.160E-06
R. G. 1.109	Liver	2.570E-05	1.480E-04	1.090E-04	2.140E-06	5.950E-06
Table E-11	Total Body	1.850E-05	1.210E-04	7.140E-05	4.720E-06	3.410E-06
	Thyroid					1.950E-03
	Kidney	1.430E-05	4.790E-05	3.700E-05		1.020E-05
	Lung	1.960E-06	1.590E-05	1.230E-05		
	GI-LLI	2.920E-06	2.590E-06	2.110E-06	4.020E-05	1.570E-06
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Teenager	Bone	8.590E-06	8.370E-05	1.120E-04		5.850E-06
R. G. 1.109	Liver	3.380E-05	1.970E-04	1.490E-04	2.810E-06	8.190E-06
Table E-12	Total Body	2.270E-05	9.140E-05	5.190E-05	6.330E-06	4.400E-06
	Thyroid					2.390E-03
	Kidney	1.840E-05	6.260E-05	5.070E-05		1.410E-05
	Lung	2.900E-06	2.390E-05	1.970E-05		
	GI-LLI	2.720E-06	2.450E-06	2.120E-06	3.660E-05	1.620E-06
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Child	Bone	2.350E-05	2.340E-04	3.270E-04		1.720E-05
R. G. 1.109	Liver	6.460E-05	3.840E-04	3.130E-04	5.290E-06	1.730E-05
Table E-13	Total Body	4.180E-05	8.100E-05	4.620E-05	1.560E-05	9.830E-06
	Thyroid					5.720E-03
	Kidney	3.440E-05	1.190E-04	1.020E-04		2.840E-05
	Lung	5.130E-06	4.270E-05	3.670E-05		
	GI-LLI	2.270E-06	2.070E-06	1.960E-06	2.930E-05	1.540E-06
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Infant	Bone	4.590E-05	3.770E-04	5.220E-04		3.590E-05
R. G. 1.109	Liver	1.350E-04	7.030E-04	6.110E-04	1.080E-05	4.230E-05
Table E-14	Total Body	5.040E-05	7.100E-05	4.330E-05	2.550E-05	1.860E-05
	Thyroid					1.390E-02
	Kidney	5.380E-05	1.810E-04	1.640E-04		4.940E-05
	Lung	1.100E-05	7.420E-05	6.640E-05		
	GI-LLI	2.050E-06	1.910E-06	1.910E-04	2.570E-05	1.510E-06

APPENDIX B

Ingestion Doses - Drinking Water - Surface

mRem

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult	Bone	7.100E-05	4.635E-02	1.420E-01		3.900E-05	1.885E-01
R. G. 1.109	Liver	2.803E-04	1.103E-01	1.942E-01	6.121E-04	5.578E-05	3.054E-01
Table E-11	Total Body	2.018E-04	9.016E-02	1.272E-01	1.350E-03	3.197E-05	2.190E-01
	Thyroid					1.828E-02	1.828E-02
	Kidney	1.560E-04	3.569E-02	6.593E-02		9.562E-05	1.019E-01
	Lung	2.138E-05	1.185E-02	2.192E-02			3.379E-02
	GI-LLI	3.185E-05	1.930E-03	3.760E-03	1.150E-02	1.472E-05	1.723E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Teenager	Bone	6.545E-05	4.357E-02	1.394E-01		3.831E-05	1.831E-01
R. G. 1.109	Liver	2.575E-04	1.026E-01	1.855E-01	5.615E-04	5.364E-05	2.889E-01
Table E-12	Total Body	1.730E-04	4.758E-02	6.461E-02	1.265E-03	2.882E-05	1.137E-01
	Thyroid					1.565E-02	1.565E-02
	Kidney	1.402E-04	3.259E-02	6.311E-02		9.235E-05	9.593E-02
	Lung	2.210E-05	1.244E-02	2.452E-02			3.699E-02
	GI-LLI	2.072E-05	1.275E-03	2.639E-03	7.314E-03	1.061E-05	1.126E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Child	Bone	1.791E-04	1.218E-01	4.071E-01		1.127E-04	5.292E-01
R. G. 1.109	Liver	4.922E-04	1.999E-01	3.896E-01	1.057E-03	1.133E-04	5.912E-01
Table E-13	Total Body	3.185E-04	4.217E-02	5.751E-02	3.117E-03	6.438E-05	1.032E-01
	Thyroid					3.746E-02	3.746E-02
	Kidney	2.621E-04	6.195E-02	1.270E-01		1.860E-04	1.894E-01
	Lung	3.909E-05	2.223E-02	4.569E-02			6.795E-02
	GI-LLI	1.730E-05	1.078E-03	2.440E-03	5.855E-03	1.009E-05	9.400E-03

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Infant	Bone	2.263E-04	1.270E-01	4.205E-01		1.521E-04	5.478E-01
R. G. 1.109	Liver	6.656E-04	2.368E-01	4.922E-01	1.396E-03	1.793E-04	7.312E-01
Table E-14	Total Body	2.485E-04	2.392E-02	3.488E-02	3.297E-03	7.883E-05	6.242E-02
	Thyroid					5.891E-02	5.891E-02
	Kidney	2.652E-04	6.097E-02	1.321E-01		2.094E-04	1.935E-01
	Lung	5.423E-05	2.499E-02	5.348E-02			7.853E-02
	GI-LLI	1.011E-05	6.434E-04	1.538E-01	3.323E-03	6.399E-06	1.578E-01

APPENDIX C

Ingestion Doses - Fish

mRem

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult	Bone	2.363E-04	1.543E-01	4.727E-01	0.000E+00	9.737E-07	6.273E 01
R. G. 1.109	Liver	9.330E-04	3.671E-01	6.465E-01	5.094E-05	1.393E-06	1.015E+00
Table E-11	Total Body	6.716E-04	3.001E-01	4.235E-01	1.124E-04	7.981E-07	7.244E 01
	Thyroid	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.564E-04	4.564E 04
	Kidney	5.192E-04	1.188E-01	2.195E-01	0.000E+00	2.387E-06	3.388E 01
	Lung	7.116E-05	3.944E-02	7.296E-02	0.000E+00	0.000E+00	1.125E 01
	GI-LLI	1.060E-04	6.424E-03	1.252E-02	9.569E-04	3.675E-07	2.000E 02
		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Teenager	Bone	2.287E-04	1.523E-01	4.872E-01	0.000E+00	1.004E-06	6.397E 01
R. G. 1.109	Liver	8.999E-04	3.583E-01	6.481E-01	4.905E-05	1.406E-06	1.007E+00
Table E-12	Total Body	6.044E-04	1.663E-01	2.258E-01	1.105E-04	7.552E-07	3.927E 01
	Thyroid	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.102E-04	4.102E 04
	Kidney	4.899E-04	1.139E-01	2.205E-01	0.000E+00	2.420E-06	3.349E 01
	Lung	7.721E-05	4.347E-02	8.569E-02	0.000E+00	0.000E+00	1.292E 01
	GI-LLI	7.242E-05	4.457E-03	9.222E-03	6.389E-04	2.781E-07	1.439E 02
		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Child	Bone	2.717E-04	1.849E-01	6.178E-01	0.000E+00	1.282E-06	8.030E 01
R. G. 1.109	Liver	7.470E-04	3.034E-01	5.914E-01	4.011E-05	1.290E-06	8.955E 01
Table E-13	Total Body	4.834E-04	6.400E-02	8.729E-02	1.183E-04	7.329E-07	1.519E 01
	Thyroid	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.264E-04	4.264E 04
	Kidney	3.978E-04	9.402E-02	1.927E-01	0.000E+00	2.117E-06	2.871E 01
	Lung	5.932E-05	3.374E-02	6.934E-02	0.000E+00	0.000E+00	1.031E 01
	GI-LLI	2.625E-05	1.635E-03	3.703E-03	2.222E-04	1.148E-07	5.587E 03
		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Infant	Bone	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
R. G. 1.109	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Table E-14	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

APPENDIX D

Ingestion Doses - Drinking Water - Ground

mRem

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult	Bone	1.096E-04	7.154E-02	2.192E-01		6.020E-05	2.909E-01
R. G. 1.109	Liver	4.326E-04	1.702E-01	2.998E-01	9.448E-04	8.610E-05	4.715E-01
Table E-11	Total Body	3.114E-04	1.392E-01	1.964E-01	2.084E-03	4.934E-05	3.380E-01
	Thyroid					2.822E-02	2.822E-02
	Kidney	2.407E-04	5.509E-02	1.018E-01		1.476E-04	1.572E-01
	Lung	3.299E-05	1.829E-02	3.383E-02			5.215E-02
	GI-LLI	4.915E-05	2.979E-03	5.803E-03	1.775E-02	2.272E-05	2.660E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Teenager	Bone	1.010E-04	6.726E-02	2.152E-01		5.914E-05	2.826E-01
R. G. 1.109	Liver	3.975E-04	1.583E-01	2.863E-01	8.667E-04	8.280E-05	4.459E-01
Table E-12	Total Body	2.670E-04	7.344E-02	9.972E-02	1.952E-03	4.448E-05	1.754E-01
	Thyroid					2.416E-02	2.416E-02
	Kidney	2.164E-04	5.030E-02	9.742E-02		1.425E-04	1.481E-01
	Lung	3.411E-05	1.920E-02	3.785E-02			5.709E-02
	GI-LLI	3.199E-05	1.969E-03	4.073E-03	1.129E-02	1.638E-05	1.738E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Child	Bone	2.764E-04	1.880E-01	6.283E-01		1.739E-04	8.168E-01
R. G. 1.109	Liver	7.597E-04	3.086E-01	6.014E-01	1.632E-03	1.749E-04	9.125E-01
Table E-13	Total Body	4.916E-04	6.509E-02	8.877E-02	4.812E-03	9.938E-05	1.593E-01
	Thyroid					5.783E-02	5.783E-02
	Kidney	4.046E-04	9.562E-02	1.960E-01		2.871E-04	2.923E-01
	Lung	6.033E-05	3.431E-02	7.052E-02			1.049E-01
	GI-LLI	2.670E-05	1.663E-03	3.766E-03	9.037E-03	1.557E-05	1.451E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Infant	Bone	3.493E-04	1.960E-01	6.490E-01		2.348E-04	8.456E-01
R. G. 1.109	Liver	1.027E-03	3.655E-01	7.597E-01	2.155E-03	2.767E-04	1.129E+00
Table E-14	Total Body	3.835E-04	3.692E-02	5.383E-02	5.089E-03	1.217E-04	9.634E-02
	Thyroid					9.093E-02	9.093E-02
	Kidney	4.094E-04	9.411E-02	2.039E-01		3.231E-04	2.987E-01
	Lung	8.371E-05	3.858E-02	8.255E-02			1.212E-01
	GI-LLI	1.560E-05	9.931E-04	2.375E-01	5.129E-03	9.878E-06	2.436E-01

Appendix E

Inhalation Dose Factors
mRem/pCi

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131
Adult	Bone	4.880E-06	4.660E-05	5.980E-05		3.150E-06
R. G. 1.109	Liver	1.830E-05	1.060E-04	7.760E-05	1.440E-06	4.470E-06
Table E-7	Total Body	1.380E-05	9.100E-05	5.350E-05	1.850E-06	2.560E-06
	Thyroid					1.490E-03
	Kidney	1.070E-05	3.590E-05	2.780E-05		7.660E-06
	Lung	1.500E-06	1.220E-05	9.400E-06	7.460E-04	
	GI-LLI	1.460E-06	1.300E-06	1.050E-06	3.560E-05	7.850E-07
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Teenager	Bone	6.440E-06	6.280E-05	8.380E-05		4.430E-06
R. G. 1.109	Liver	2.420E-05	1.410E-04	1.060E-04	1.890E-06	6.140E-06
Table E-8	Total Body	1.710E-05	6.860E-05	3.890E-05	2.480E-06	3.300E-06
	Thyroid					1.830E-03
	Kidney	1.380E-05	4.690E-05	3.800E-05		1.050E-05
	Lung	2.220E-06	1.830E-05	1.510E-05	1.090E-03	
	GI-LLI	1.360E-06	1.220E-06	1.060E-06	3.240E-05	8.110E-07
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Child	Bone	1.760E-05	1.760E-04	2.450E-04		1.300E-05
R. G. 1.109	Liver	4.620E-05	2.740E-04	2.230E-04	3.550E-06	1.300E-05
Table E-9	Total Body	3.140E-05	6.070E-05	3.470E-05	6.120E-06	7.370E-06
	Thyroid					4.390E-03
	Kidney	2.580E-05	8.930E-05	7.630E-05		2.130E-05
	Lung	3.930E-06	3.270E-05	2.810E-05	1.910E-03	
	GI-LLI	1.130E-06	1.040E-06	9.780E-07	2.600E-05	7.680E-07
		Cs-136	Cs-134	Cs-137	Co-60	I-131
Infant	Bone	3.450E-05	2.830E-04	3.920E-04		2.710E-05
R. G. 1.109	Liver	9.610E-05	5.020E-04	4.370E-04	5.730E-06	3.170E-05
Table E-10	Total Body	3.780E-05	5.320E-05	3.250E-05	8.410E-06	1.400E-05
	Thyroid					1.060E-02
	Kidney	4.030E-05	1.360E-04	1.230E-04		3.700E-05
	Lung	8.400E-06	5.690E-05	5.090E-05	3.220E-03	
	GI-LLI	1.020E-06	9.530E-07	9.530E-07	2.280E-05	7.560E-07

Appendix F

Occupational Dose - Grading of Parking Lot

mRem/yr

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult R. G. 1.109 Table E-7	Bone	1.603E-05	1.046E-02	3.209E-02		8.912E-06	4.258E-02
	Liver	6.012E-05	2.380E-02	4.164E-02	1.238E-04	1.265E-05	6.564E-02
	Total Body	4.534E-05	2.043E-02	2.871E-02	1.590E-04	7.243E-06	4.935E-02
	Thyroid					4.215E-03	4.215E-03
	Kidney	3.515E-05	8.060E-03	1.492E-02		2.167E-05	2.303E-02
	Lung	4.928E-06	2.739E-03	5.044E-03	6.413E-02		7.192E-02
	GI-LLI	4.797E-06	2.919E-04	5.634E-04	3.060E-03	2.221E-06	3.923E-03
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Teenager R. G. 1.109 Table E-8	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Child R. G. 1.109 Table E-9	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Infant R. G. 1.109 Table E-10	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Appendix G

Occupational Dose - Parking in Parking Lot

mRem/yr

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult	Bone	2.088E-04	1.362E-01	4.178E-01		1.160E-04	5.544E-01
R. G. 1.109	Liver	7.829E-04	3.099E-01	5.422E-01	1.612E-03	1.647E-04	8.546E-01
Table E-7	Total Body	5.903E-04	2.660E-01	3.738E-01	2.071E-03	9.430E-05	6.426E-01
	Thyroid					5.489E-02	5.489E-02
	Kidney	4.577E-04	1.049E-01	1.942E-01		2.822E-04	2.999E-01
	Lung	6.417E-05	3.566E-02	6.568E-02	8.351E-01		9.365E-01
	GI-LLI	6.246E-05	3.800E-03	7.337E-03	3.985E-02	2.892E-05	5.108E-02

		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Teenager	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
R. G. 1.109	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Table E-8	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Child	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
R. G. 1.109	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Table E-9	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Infant	Bone	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
R. G. 1.109	Liver	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Table E-10	Total Body	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	Thyroid					0.000E+00	0.000E+00
	Kidney	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.000E+00
	Lung	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00
	GI-LLI	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Appendix H

Inadvertant Intruder
mRem/yr

Critical Population	Critical Organ	Cs-136	Cs-134	Cs-137	Co-60	I-131	Total
Adult	Bone	1.924E-04	1.255E-01	3.851E-01		1.069E-04	5.109E-01
R. G. 1.109	Liver	7.215E-04	2.856E-01	4.997E-01	1.486E-03	1.518E-04	7.876E-01
Table E-7	Total Body	5.441E-04	2.452E-01	3.445E-01	1.909E-03	8.691E-05	5.922E-01
	Thyroid					5.058E-02	5.058E-02
	Kidney	4.218E-04	9.672E-02	1.790E-01		2.601E-04	2.764E-01
	Lung	5.914E-05	3.287E-02	6.053E-02	7.696E-01		8.630E-01
	GI-LLI	5.756E-05	3.502E-03	6.761E-03	3.673E-02	2.665E-05	4.707E-02
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Teenager	Bone	2.539E-04	1.692E-01	5.396E-01		1.504E-04	7.092E-01
R. G. 1.109	Liver	9.541E-04	3.799E-01	6.826E-01	1.950E-03	2.084E-04	1.066E+00
Table E-8	Total Body	0.000E+00	1.848E-01	2.505E-01	2.558E-03	1.120E-04	4.380E-01
	Thyroid					6.213E-02	6.213E-02
	Kidney	5.441E-04	1.264E-01	2.447E-01		3.565E-04	3.719E-01
	Lung	8.752E-05	4.930E-02	9.724E-02	1.124E+00		1.271E+00
	GI-LLI	5.362E-05	3.287E-03	6.826E-03	3.342E-02	2.753E-05	4.362E-02
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Child	Bone	3.209E-04	2.193E-01	7.297E-01		2.041E-04	9.495E-01
R. G. 1.109	Liver	8.424E-04	3.414E-01	6.641E-01	1.694E-03	2.041E-04	1.008E+00
Table E-9	Total Body	5.726E-04	7.563E-02	1.033E-01	2.920E-03	1.157E-04	1.826E-01
	Thyroid					6.893E-02	6.893E-02
	Kidney	4.704E-04	1.113E-01	2.272E-01		3.344E-04	3.393E-01
	Lung	7.166E-05	4.074E-02	8.369E-02	9.113E-01		1.036E+00
	GI-LLI	2.060E-05	1.296E-03	2.913E-03	1.241E-02	1.206E-05	1.665E-02
		Cs-136	Cs-134	Cs-137	Co-60	I-131	
Infant	Bone	2.380E-04	1.334E-01	4.417E-01		1.610E-04	5.756E-01
R. G. 1.109	Liver	6.630E-04	2.367E-01	4.925E-01	1.034E-03	1.883E-04	7.310E-01
Table E-10	Total Body	2.608E-04	2.508E-02	3.662E-02	1.518E-03	8.318E-05	6.357E-02
	Thyroid					6.298E-02	6.298E-02
	Kidney	2.780E-04	6.412E-02	1.386E-01		2.198E-04	2.032E-01
	Lung	5.795E-05	2.683E-02	5.736E-02	5.813E-01		6.656E-01
	GI-LLI	7.037E-06	4.493E-04	1.074E-03	4.116E-03	4.491E-06	5.651E-03

ATTACHMENT 3

Donald C. Cook Nuclear Plant

Turbine Room Sump Absorption Pond Dredging

On-site Sludge Disposal References

I. US NRC, Regulatory Guide 1.109, Rev. 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10 CFR Part 50, Appendix I,". October, 1977.

II. US NRC, Regulatory Guide 1.113, Rev. 1, "Estimating Awuatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implement Appendix I," April, 1977

III. Till, John and Robert H. Meyer,eds., Radiological Assessment, US NRC Technical Report Nureg/CR-3332, September, 1983

IV. Bureau of Radiological Health, Radiological Health Handbook, Washington, DC, US Government Printing Office, 1970

ATTACHMENT 4

Donald C. Cook Nuclear Plant

Turbine Room Sump Absorption Pond Dredging

Sludge Chemical Analysis

ENVIRONMENTAL RESEARCH GROUP INC.

117 N. FIRST . ANN ARBOR, MICHIGAN 48104
(313) 662-3104

SAMPLES RECVD BY : 01-19-82
CLIENT P.O. : 92733-040-IN
REPORT DATE : 02-22-82
REPORT NO. : 5263

FINAL REPORT ON
ERG PROJECT NO. 8319

RESIDUAL SAMPLES WILL BE HELD TWO WEEKS

FOR :

INDIANA & MICHIGAN ELECTRIC
P.O. BOX 458
BRIDGMAN, MI 49106

APPROVED BY

ATTENTION: TOM KRIESEL

REFER TECHNICAL QUESTIONS TO : JOHN WILSON

CLIENT ID — PARAMETER & MATRIX	DATE COLLECTED	RESULT UNIT	ERG SAMPLE NUMBER
COOK PL. BTMS #73812	01-14-82		70694
E.P. TOXICITY (LEACH) OF SLUDGE (EPA)		1/20/82	
COOK PL. BTMS #73812	01-14-82		
PERCENT SOLIDS IN SLUDGE		83 %	
COOK PL. BTMS #73812	01-14-82		
SOLIDS, VOLATILE IN SLUDGE		0.2 %	
COMMENTS: TVS GIVEN AS % OF DRY SAMPLE.			
COOK PL. BTMS #73812	01-14-82		
OIL AND GREASE IN SLUDGE		880 mg/Kg	
LEACHATE OF #73812	01-14-82		70695
E.P. TOXICITY (METALS ONLY) IN EP-TOX LEACHATE			
ARSENIC		0.005 mg/L	
BARIUM		1.2 mg/L	
CADMIUM		<0.003 mg/L	
CHROMIUM		0.013 mg/L	
LEAD		0.094 mg/L	
MERCURY		<0.0002 mg/L	
SELENIUM		ND (0.001) mg/L	
SILVER		ND (0.003) mg/L	
LEACHATE OF #73812	01-14-82		
BORON IN LEACHATE		0.40 mg/L	

SD = SAMPLE DAMAGED
NA = NOT APPLICABLE TO TEST REQUESTED
ER = SEE FIELD REPORT FOR RESULT
SR = SEE ATTACHED REPORT FOR RESULT
< = POSITIVE RESULT BUT AT AN UNQUANTIFIABLE CONCENTRATION BELOW INDICATED LEVEL
ND = NONDETECTED, DETECTION LIMIT IN ()

ATTACHMENT 5

Donald C. Cook Nuclear Plant

Turbine Room Sump Absorption Pond Dredging

Analysis of Recent Samples

RADIOLOGICAL AREA STATUS SHEET

AREA DESCRIPTION Upper Parking Lot

MAP NO. ___-A

AREA CLASSIFICATION
- ☐ RADIATION
- ☐ HIGH RADIATION
- ☐ EXTREME HIGH RADIATION
- ☐ CONTAMINATION
- ☐ AIRBORNE RADIOACTIVITY

(N/A written diagonally across the classification list)

REMARKS △ = Soil Sample Locations

Approx 4" to 8" of top Gravel removed prior to taking Soil Sample

UNLESS NOTED: ✱ DENOTES CONTACT / 18" RDG.

DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100 CM²

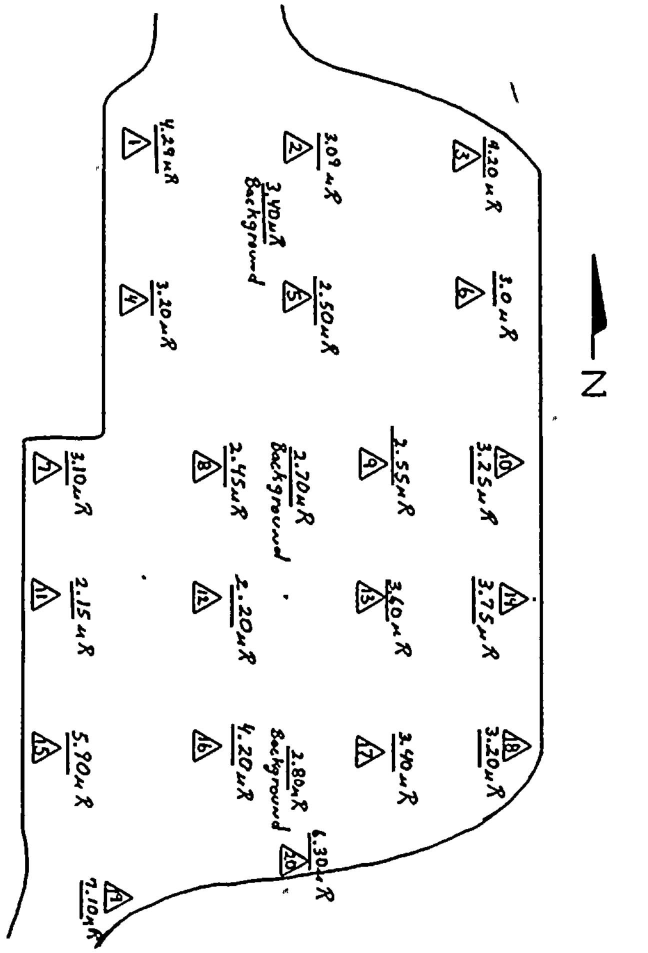
METER TYPE/NO. N/A (initialed 7-7-91) ESP-1 #242

REASON FOR SURVEY
Soil Samples

WP USED: N/A

SURVEYED BY T. Rice, Brown R.L. **TIME** 1800 **DATE** 7-5-91

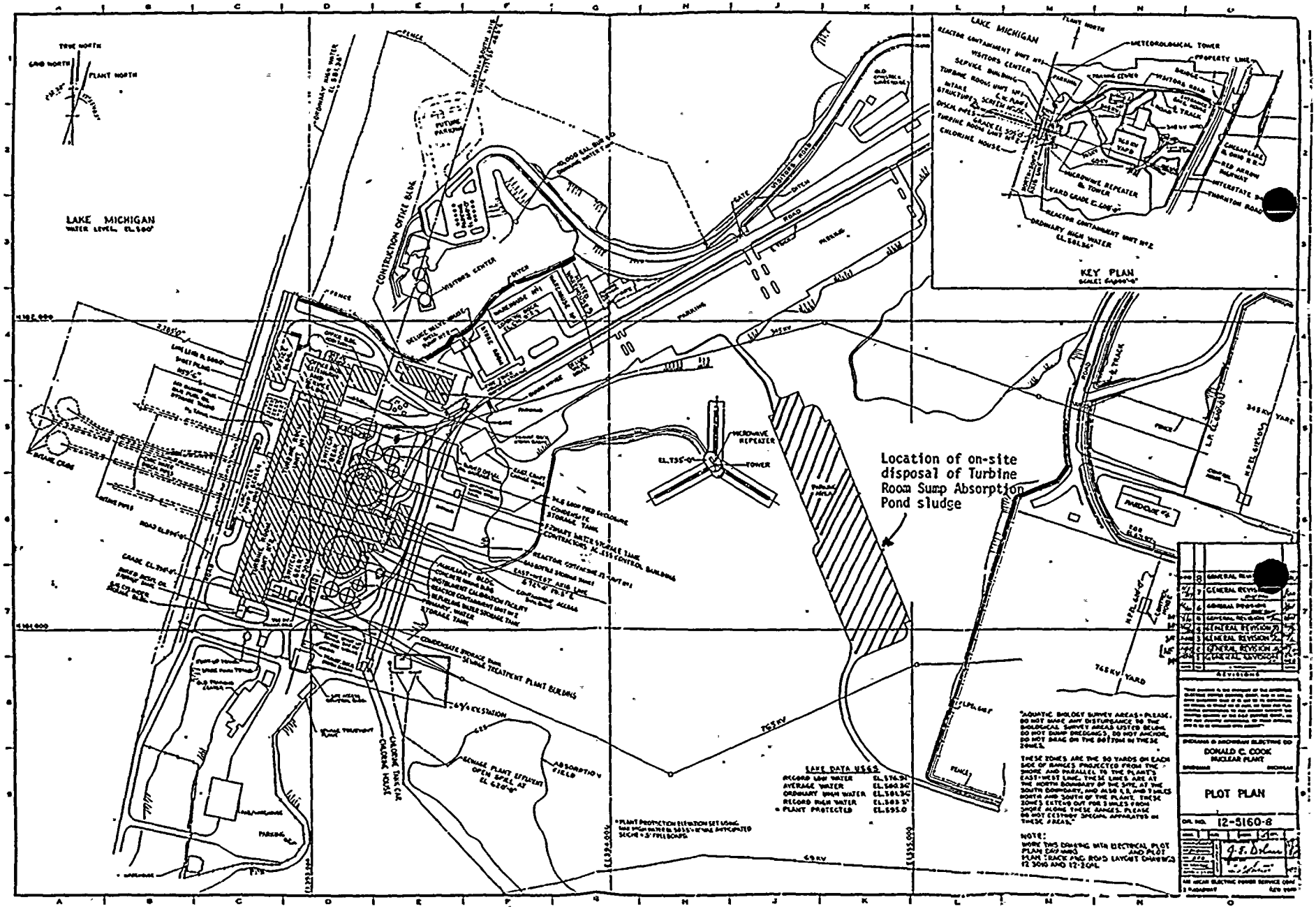
REVIEWED BY [signature] **DATE** 7-5-91



CONTAMINATION/ REMARKS

1	/
2	/
3	/
4	/
5	/
6	/
7	/
8	/
9	/
10	/
11	/
12	/
13	/
14	/
15	/
16	/
17	/
18	/
19	/
20	/
21	/
22	/
23	/
24	/
25	/
26	/
27	/
28	/
29	/
30	/

N/A


LAKE MICHIGAN
WATER LEVEL EL. 580'
Location of on-site disposal of Turbine Room Sump Absorption Pond sludge
KEY PLAN
PLOT PLAN
DONALD C. COOK NUCLEAR PLANT
LAKE DATA USED
RECORD LOW WATER EL. 576.5'
AVERAGE WATER EL. 580.3'
ORDINARY HIGH WATER EL. 581.5'
RECORD HIGH WATER EL. 583.5'
* PLANT PROTECTED EL. 595.0'
"AQUATIC BIOLOGY SURVEY AREAS" PLEASE DO NOT MAKE ANY DISTURBANCE TO THE BIOLOGICAL SURVEY AREAS LISTED BELOW. DO NOT DUMP DREDGING'S. DO NOT ANCHOR. DO NOT DRAG ON THE BOTTOM IN THESE ZONES.
THESE ZONES ARE THE 50 YARDS ON EACH SIDE OF RANGES PROJECTED FROM THE SHORE AND PARALLEL TO THE PLANT'S EAST-WEST LINE. THESE LINES ARE AT THE NORTH BOUNDARY OF THE SITE, AT THE SOUTH BOUNDARY, AND AT 50 L.S. AND 3 MILES NORTH AND SOUTH OF THE PLANT. THESE ZONES EXTEND OUT FOR 3 MILES FROM SHORE ALONG THESE RANGES. PLEASE DO NOT DESTROY SPECIAL APPARATUS ON THESE AREAS."
NOTE:
WORK THIS DRAWING WITH ELECTRICAL PLOT PLAN DRAWINGS AND PLOT PLAN: TRACK AND ROAD LAYOUT DRAWINGS 12-3010 AND 12-2041.
DRAWING NO. 12-5160-8

STATE OF OHIO)
COUNTY OF FRANKLIN)

The applicant and any official executing this application on behalf of the applicant certify that this application and all information contained herein, including any supplements attached is true and correct to the best of our knowledge and belief

E E Fitzpatrick

Subscribed and sworn to before me this 8th

day of October, 1991.

Rita D. Hill
NOTARY PUBLIC

RITA D. HILL
NOTARY PUBLIC, STATE OF OHIO
MY COMMISSION EXPIRES 6-28-94