DUKE ENERGY.

Crystal River Nuclear Plant
15760 W. Power Line Street
Crystal River, FL 34428
Docket 50-302
Docket 72-1035
Operating License No. DPR-72

10 CFR 50.36a(a)(2)
ODCM

April 7, 2020
3F0420-01

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Crystal River Unit 3 – 2019 Annual Radioactive Effluent Release Report

Dear Sir:

Duke Energy Florida, LLC (DEF), hereby provides the 2019 Radioactive Effluent Release Report for Crystal River Unit 3 (CR3) in accordance with 10 CFR 50.36a(a)(2) and the Offsite Dose Calculation Manual (ODCM). The attached report (Attachment 1) includes a summary of the quantities of radioactive liquid and gaseous effluents, and solid waste released from the CR3 site during 2019. The data provided in this report is consistent with the objectives outlined in the ODCM and the Process Control Program (PCP), and is in conformance with 10 CFR 50, Appendix I, Section IV.B.1.

A CR3 administrative procedure requires submittal of licensee initiated changes to the ODCM as part of the Radioactive Effluent Release Report for the period of the report in which any changes were made. The ODCM was revised in 2019; changes are described in this report and a copy of the ODCM is attached (Attachment 2). The PCP was revised in 2019; changes are described in this report.

This letter contains no new regulatory commitments.

If you have any questions regarding this submittal, please contact Mr. Mark Van Sicklen, Licensing Lead, Nuclear Regulatory Affairs, at (352) 501-3045.

Sincerely,

Terry D. Hobbs
General Manager, Decommissioning - SAFSTOR

TDH/mvs

Attachment 1: 2019 Annual Radioactive Effluent Release Report
Attachment 2: CR3 Offsite Dose Calculation Manual

xc: NMSS Project Manager
Regional Administrator, Region I

DUKE ENERGY FLORIDA, LLC

DOCKET NUMBER 50 - 302 / 72-1035
LICENSE NUMBER DPR - 72

ATTACHMENT 1

2019 ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT 2019

DUKE ENERGY FLORIDA, LLC

CRYSTAL RIVER UNIT 3

Facility Operating License No. DPR-72

Docket No. 50-302

CONTENTS

INTRODUCTION

This report is submitted as required by procedure CP-500, section 4.4.1.2 and in accordance with 10 CFR 50.36a. All 40 CFR 190 limits have been met. There were no NEI 07-07 groundwater protection reportable events in 2019.

The scope of this report includes:

- A summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the plant.
- Quarterly and annual dose summaries.
- A list and description of unplanned releases to unrestricted areas (there were none in 2019).
- A description of any changes to the:

  Process Control Program (PCP), and
  Offsite Dose Calculation Manual (ODCM).

- Significant changes to any radioactive waste treatment system.
- A list of new dose calculation location changes identified by the annual land-use census.
- Information relating to effluent monitors or required supporting instrumentation being inoperable for 30 or more days.
- Information required to be included in this report per NEI 07-07 Industry Ground Water Protection Initiative-Final Guidance Document issued in August 2007.

Note for reporting purposes, N/D = Not Detected.

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 1A - Regulatory Guide 1.21

Gaseous Effluents - Summation of All Releases
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Est. Total % Error
A. Fission & Activation Gases						
1. Total Release	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+01
2. Average Release Rate for Period	uCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
B. Iodines						
1. Total Iodine-131	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+01
2. Average Release Rate for Period	uCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
C. Particulates						
1. Particulates with half-lives > 8 days	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+01
2. Average Release Rate for Period	uCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
3. Gross Alpha Radioactivity	Curies	0.00E+00	0.00E+00	0.00E+00	4.24E-10	
D. Tritium						
1. Total Release	Curies	0.00E+00	6.02E-04	2.06E-02	6.86E-03	3.00E+01
2. Average Release Rate for Period	uCi/sec	0.00E+00	7.66E-05	2.59E-03	8.63E-04	

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 1B - Regulatory Guide 1.21

Gaseous Effluents - Elevated Batch Mode
Unit: 3

(This Table Does Not Apply to Crystal River Unit 3)

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Gases					
Total	Curies	N/D	N/D	N/D	N/D
Iodines					
Total	Curies	N/D	N/D	N/D	N/D
Particulates					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	N/D	N/D	N/D	N/D
Gross Alpha	Curies	N/D	N/D	N/D	N/D

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 1B – (Continued) Regulatory Guide 1.21

Gaseous Effluents - Elevated Continuous Mode
Unit: 3

(This Table Does Not Apply to Crystal River Unit 3)

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Gases					
Total	Curies	N/D	N/D	N/D	N/D
Iodines					
Total	Curies	N/D	N/D	N/D	N/D
Particulates					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	N/D	N/D	N/D	N/D
Gross Alpha	Curies	N/D	N/D	N/D	N/D

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 1C - Regulatory Guide 1.21

Gaseous Effluents - Ground Batch Mode
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Gases					
Total	Curies	N/D	N/D	N/D	N/D
Iodines					
Total	Curies	N/D	N/D	N/D	N/D
Particulates					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	N/D	N/D	N/D	N/D
Gross Alpha	Curies	N/D	N/D	N/D	N/D

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 1C – (Continued) Regulatory Guide 1.21

Gaseous Effluents - Ground Continuous Mode
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Gases					
Total	Curies	N/D	N/D	N/D	N/D
Iodines					
Total	Curies	N/D	N/D	N/D	N/D
Particulates					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	N/D	6.02E-04	2.06E-02	6.86E-03
Gross Alpha	Curies	N/D	N/D	N/D	4.24E-10

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 2A - Regulatory Guide 1.21

Liquid Effluents - Summation of All Releases
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Est. Total % Error
A. Fission & Activation Products						
1. Total Release (not including tritium, gases, alpha)	Curies	0.00E+00	1.91E-02	1.15E-05	0.00E+00	2.50E+01
2. Average diluted concentration during period	uCi/ml	0.00E+00	6.12E-10	1.73E-13	0.00E+00	
3. Percent of Applicable Limit	%	0.00E+00	5.09E-03	1.73E-06	0.00E+00	
B. Tritium						
1. Total Release	Curies	1.05E-04	1.32E-01	3.34E-04	0.00E+00	3.00E+01
2. Average diluted concentration during period	uCi/ml	1.32E-12	4.24E-09	5.02E-12	0.00E+00	
3. Percent of Applicable Limit	%	1.32E-08	4.24E-05	5.02E-08	0.00E+00	
C. Dissolved and Entrained Gases						
1. Total Release	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E+01
2. Average diluted concentration during period	uCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
3. Percent of Applicable Limit	%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
D. Gross Alpha Radioactivity						
1. Total Release	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+01
E. Waste Volume Released (Pre-Dilution)	Liters	2.62E+05	7.87E+04	2.49E+05	0.00E+00	1.00E+01
F. Dilution Water Volume During Period	Liters	7.97E+10	3.12E+10	6.64E+10	6.60E+10	1.00E+01

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 2B - Regulatory Guide 1.21

Liquid Effluents - Batch Mode
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Products					
Fe-55	Curies	N/D	2.41E-04	N/D	N/D
Co-60	Curies	N/D	5.04E-04	N/D	N/D
Ni-63	Curies	N/D	2.65E-03	N/D	N/D
Sr-89	Curies	N/D	6.85E-06	N/D	N/D
Sr-90	Curies	N/D	1.05E-05	N/D	N/D
Cs-134	Curies	N/D	3.91E-06	N/D	N/D
Cs-137	Curies	N/D	1.56E-02	1.55E-05	N/D
Total	Curies	N/D	1.91E-02	1.55E-05	N/D
Dissolved and Entrained Gases					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	1.05E-04	1.32E-01	3.34E-04	N/D
Gross Alpha	Curies	N/D	N/D	N/D	N/D

EFFLUENT and WASTE DISPOSAL REPORT-2019

Table 2B - (Continued) Regulatory Guide 1.21

Liquid Effluents - Continuous Mode
Unit: 3

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Fission & Activation Products					
Total	Curies	N/D	N/D	N/D	N/D
Dissolved and Entrained Gases					
Total	Curies	N/D	N/D	N/D	N/D
H-3	Curies	N/D	N/D	N/D	N/D
Gross Alpha	Curies	N/D	N/D	N/D	N/D

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Gaseous Batch Release Summary
Unit: 3

	Jan - Jun	Jul - Dec
Number of Batch Releases	0	0
Total Time Period for Batch Releases	0.00E+00 min	0.00E+00 min
Maximum Time Period for a Batch Release	0.00E+00 min	0.00E+00 min
Average Time Period for a Batch Release	0.00E+00 min	0.00E+00 min
Minimum Time Period for a Batch Release	0.00E+00 min	0.00E+00 min

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Liquid Batch Release Summary
Unit: 3

	Jan - Jun	Jul - Dec
Number of Batch Releases	5	1
Total Time Period for Batch Releases	1.59E+03 min	4.02E+02 min
Maximum Time Period for a Batch Release	5.59E+02 min	4.02E+02 min
Average Time Period for a Batch Release	3.18E+02 min	4.02E+02 min
Minimum Time Period for a Batch Release	6.20E+01 min	4.02E+02 min
Average Stream Flow During Release Periods	6.14E+04 gpm	1.08E+03 gpm

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Gaseous Abnormal Release Summary
Unit: 3

	Jan - Jun	Jul - Dec
Number of Abnormal Releases	0	0
Total Time Period for Abnormal Releases	0.00E+00 min	0.00E+00 min
Maximum Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Average Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Minimum Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Total Activity for Abnormal Releases	0.00E+00 Ci	0.00E+00 Ci

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Liquid Abnormal Release Summary
Unit: 3

	Jan - Jun	Jul - Dec
Number of Abnormal Releases	0	0
Total Time Period for Abnormal Releases	0.00E+00 min	0.00E+00 min
Maximum Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Average Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Minimum Time Period for an Abnormal Release	0.00E+00 min	0.00E+00 min
Total Activity for Abnormal Releases	0.00E+00 Ci	0.00E+00 Ci

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Gaseous NNG Organ Dose
Unit: 3

Receptor Name: Infant Max Ind NW at 1.34 km

	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Calendar Year	
Organ	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**
Bone	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
Liver	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
Total Body	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
Thyroid	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
Kidney	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
Lung	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05
GI-Lli	0.00E+00	0.00E+00	1.45E-07	1.93E-06	4.95E-06	6.60E-05	1.65E-06	2.19E-05	6.74E-06	4.49E-05

Maximum Organ was LIVER.

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Liquid Organ & Whole Body Dose
Unit: 3

Receptor Name: Adult W at 1.34 km

	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Calendar Year	
Organ	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**	**Dose**	**% of ODCM Limit**
Bone	2.24E-12	4.47E-11	9.31E-05	1.86E-03	8.86E-09	1.77E-07	0.00E-00	0.00E-00	9.31E-05	9.31E-04
Liver	2.24E-12	4.47E-11	1.24E-04	2.56E-03	1.21E-08	2.42E-07	0.00E-00	0.00E-00	1.28E-04	1.28E-03
Total Body	2.24E-12	1.49E-10	8.47E-05	5.64E-03	7.94E-09	5.29E-07	0.00E-00	0.00E-00	8.47E-05	2.82E-03
Thyroid	2.24E-12	4.47E-11	2.08E-08	4.16E-07	8.24E-12	1.65E-10	0.00E-00	0.00E-00	2.08E-08	2.08E-07
Kidney	2.24E-12	4.47E-11	4.32E-05	8.65E-04	4.12E-09	8.23E-08	0.00E-00	0.00E-00	4.33E-05	4.33E-04
Lung	2.24E-12	4.47E-11	1.44E-05	2.88E-04	1.37E-09	2.75E-08	0.00E-00	0.00E-00	1.44E-05	1.44E-04
GI-Lli	2.24E-12	4.47E-11	1.28E-05	2.56E-04	2.43E-10	4.85E-09	0.00E-00	0.00E-00	1.28E-05	1.28E-04

Liquid Effluent Dose Limits

Total Body: 1.5 mrem/quarter, 3 mrem/year
Any Organ: 5 mrem/quarter, 10 mrem/year

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

Liquid App I Dose Assessment
Unit: 3

Adult W at 1.34km

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
Maximum Organ Dose	mrem	2.24E-12	1.28E-04	1.28E-08	0.00E+00	1.28E-04
ODCM Limit	mrem	5.00	5.00	5.00	5.00	10.00
% of ODCM Limit	%	4.47E-11	2.56E-03	2.42E-07	0.00E+00	1.28E-04

Maximum Organ was Bone

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
Total Body	mrem	2.24E-12	8.47E-05	7.94E-09	0.00E+00	8.47E-05
ODCM Limit	mrem	1.50	1.50	1.50	1.50	3.00
% of ODCM Limit	%	1.49E-10	5.64E-03	5.29E-07	0.00E+00	2.82E-03

EFFLUENT and WASTE DISPOSAL REPORT-2019

Regulatory Guide 1.21

App I Dose Assessment
Unit: 3

Airborne Noble Gas Doses
Child Site Boundary NW at 1.34 km

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
Beta Air	mRad	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ODCM Limit	mRad	10.00	10.00	10.00	10.00	20.00
% of ODCM Limit	%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Units	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
Gamma Air	mRad	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ODCM Limit	mRad	5.00	5.00	5.00	5.00	10.00
% of ODCM Limit	%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Gaseous Release Dose Summary – There was no measurable noble gases released in 2019 due to the plant shutdown in 2009. All fuel has since been moved to the ISFSI pad.

Gaseous Effluent Dose Limits

Gamma Air Dose: 5 mrad/quarter, 10 mrad/year
Beta Air Dose: 10 mrad/quarter, 20 mrad/year
Any Organ: 7.5 mrem/quarter, 15 mrem/year

TABLE 3

EFFLUENT and WASTE DISPOSAL REPORT-2019

SOLID WASTE AND IRRADIATED FUEL SHIPMENTS

A. SOLID WASTE SHIPPED OFFSITE FOR PROCESSING OR BURIAL (Non-irradiated fuel)

1. Type of waste	Unit	12 month period	Est. Total Error %
a. Spent resins, filter sludge, evaporator bottoms, etc.	m3 Ci	3.63E+1 7.24E-2	25
b. Dry compressible waste, contaminated equipment, etc.	m3 Ci	5.62E+1 2.06E-2	25
c. Irradiated components, control rods, etc.	m3 Ci	0 0	25
d. Other (describe):	m3 Ci	0 0	25

2. Estimate of major nuclide composition (by type of waste in %)*			
a.	Fe-55 3.5 Co-60 33.7 Ni-63 45.3 Cs-137 5.2 C-14 11.8	NA	NA
b.	Cs-137 24.6 Ni-63 57.5 Co-60 10.7 C-14 6.3	NA	NA
c.	NA	NA	NA
d.	NA	NA	NA

* Curie values and principle radionuclides are estimates based on a combination of direct and indirect methods.

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
	(Truck Shipments)	
4	Hittman Transport Services	Energy Solutions – Bear Creek

B. IRRADIATED FUEL SHIPMENTS (Disposition)

Number of Shipments	Mode of Transportation	Destination
0	N/A	N/A

Unplanned Releases

There were no unplanned releases in 2019.

Radioactive Waste Treatment Systems

Major changes in the CR3 radioactive waste treatment systems in 20198 included the retirement of the NUS demineralizers. This system was retired as part of the CR3 transition into SAFSTOR 2 whereby the Aux Building was brought into a “cold and dark” state. All the old NUS resin was sluiced out of the vessels and shipped offsite as radwaste. As a means to release miscellaneous amounts of rainwater and groundwater from building sumps, two poly tanks were installed on the 95’ elevation in the Seawater Room. These tanks are recirculated through filters prior to sampling and releasing in a batch mode. The release is not monitored as both RM-L2 and RM-L7 rad effluent monitors were taken out of service. This radwaste configuration is intended to be used in SAFSTOR and additional radwaste processing features may be added during plant decommissioning.

Annual Land Use Census

The 2019 land-use census did not identify any new dose calculation locations.

Effluent Monitor Instrument Operability

For the year 2019, the main gaseous effluent pathway was the auxiliary building ventilation exhaust system. Radiation monitor RM-A2N is the effluent monitor for this pathway. This monitor was in service for the first half of 2019 before it was taken out of service as part of the CR3 transition into SAFSTOR 2. The new exhaust pathway is via three fans located in the Seawater Room. A continuous air sampler is used to sample to effluent for particulates and tritium. Both the Aux Building and Reactor Building are lined-up through this pathway.

No liquid releases were made in 2019 after the radiation monitors RM-L2 and RM-7 were removed from service.

Assessment of Direct Radiation from ISFSI

The Independent Spent Fuel Storage Installation (ISFSI) pad was loaded with spent fuel beginning in June 2017 and completed in January 2018. Calculation N16-0003, performed prior to fuel movement into dry storage, documents a conservative annual dose estimate at 700 meters from the ISFSI pad of about 0.06 mrem. A distance of 700 meters is well within the site boundary controlled area in all directions. This small dose is not distinguishable from normal background fluctuations of several mrem per year as measured by the REMP TLDs. These TLDs are deployed in the controlled area, at locations adjacent to the site boundary, and at offsite locations. REMP TLD results for 2019 show no detectable changes in dose beyond the expected fluctuations. Based on this, and also including the dose contributions from CR3 effluent releases, the 40 CFR 190 annual dose limit of 25 mrem was not exceeded in 2019.

Meteorology Instrumentation Evaluation

In 2015 the metrology tower was abandoned. It was concluded that an on-site meteorological data collection system was no longer needed at CR3 to support its effluents program because:

- There is no explicit regulatory requirement or license condition to maintain an on-site meteorological program for a decommissioning unit (or facility), and

- From a technical perspective, a reasonably conservative estimate of dose to a member of the public in the unrestricted area can be performed without periodically assessing changes in atmospheric dispersion and deposition based on our low site source term and the conservative nature of the dispersion factors.

See NTM 229460-80 Met Tower Abandonment White Paper for additional details.

Offsite Dose Calculation Manual (ODCM) Changes

The ODCM was revised in 2019 to revision #39 under DRR 2268593 to support various system abandonments as the facility is configured for SAFSTOR. The following changes were incorporated:

Page(s)	ODCM Rev. 39 CHANGE
Throughout	Deleted blank sections and re-numbered remaining sections.
Introduction	• Updated titles of Manager Decommissioning and Manager Radiation Protection and Chemistry • Removed reference to instrument setpoint. Liquid and gas effluent monitors do not have trip setpoints.
1	Removed sampling frequencies no longer used
2	Removed reference to liquid effluent monitoring system, gaseous effluent monitoring systems and ventilation treatment systems. These are no longer being used in SAFSTOR.
4	• Removed specific reference to ECST, LSST and SDT tanks and left as generalized “Batch Waste Release Tanks”. • Removed note referencing BWST tank. • Removed required Sr-89 analysis. Due to the relatively short half-life (50.5 days) versus the time since CR3 was last critical in 2009, there is no longer a significant amount of Sr-89 left.
7	Step 2.4.a – Added Note that due to radioactive decay, any dose from noble gas is now insignificant and no sampling is required. Step 2.5 – Added sentence that any noble gas dose is now insignificant.
8	Removed required Sr-89 analysis. (See above). Added Ni-63 and Fe-55 to quarterly composite particulate sample as they now comprise a significant percent of CR3 residual radioactivity.
12	Step 2.7.1 – Removed redundant sentence. Note: Added for clarity that ISFSI calculation 11182-0502 is based on the CR3 site configuration before Partial Site Release implementation.

Page(s)	ODCM Rev. 39 CHANGE
14	Added note that direct radiation locations C27 and C72 are slightly within the CR3 sight boundary. Also added that Control Location C47 is in Orlando.
19	Added “(if any)” after nearest milk animal. CR3 generally does not have any milk animals identified in the Land Use Census.
21	Step 3.1 – Simplified wording to reference requirements for using the liquid radwaste cleanup system. Step 3.3 – Removed reference to Limiting Condition of Operation since CR3 is not an operating plant. Also removed reference to Appendix I as it is redundant. Step 3.4 – Removed reference to dose rate from noble gas effluents as CR3 no longer has a significant noble gas source term.
22	Step 3.5 - Removed reference to Limiting Condition of Operation since CR3 is not an operating plant. Also removed reference to Appendix I as it is redundant.
23	Step 3.6 – Removed detailed discussion pertaining contribution to Member of Public Dose from other uranium fuel cycle facilities. This does not apply to CR3.
25	• Added exhaust rate from Seawater Room Exhaust Pathway • Added X/Q value that will apply once Partial Site Release becomes effective and the Site Boundary is moved in closer to the plant.
26	• Removed reference to Sr-89 in the calculation as it is no longer present in significant amounts. • Added note to Dilution (D) flow indicating that there could be no dilution flow.
27	Step 2.1 – Added note that due to plant shutdown that dose projections from gaseous effluents is unlikely to be needed.
28	Added reference to Seawater Room exhaust of particulates and tritium
30	Added X/Q and D/Q values that will apply when Partial Site Release is approved and the Site Boundary is moved closer to the plant. Also removed reference to critical receptor X/Q and D/Q values as CR3 does not use these.
31	Added note that dilution flow rate could also include dilution flow from the new Combined Cycle plants.
41	• Removed example calculations for dose due to gaseous releases. CR3 no longer has a significant dose contribution from gaseous releases. • Removed discussion on historical liquid effluent radionuclide concentrations from 2005 to 2013. Added information pertaining to liquid releases from the Seawater Room. • Made changes to the example calculation to reflect a batch release from the Seawater Room poly tanks.
50	Figure 5.4 - Updated map with a more recent view of CR3

Process Control Program (PCP) Changes

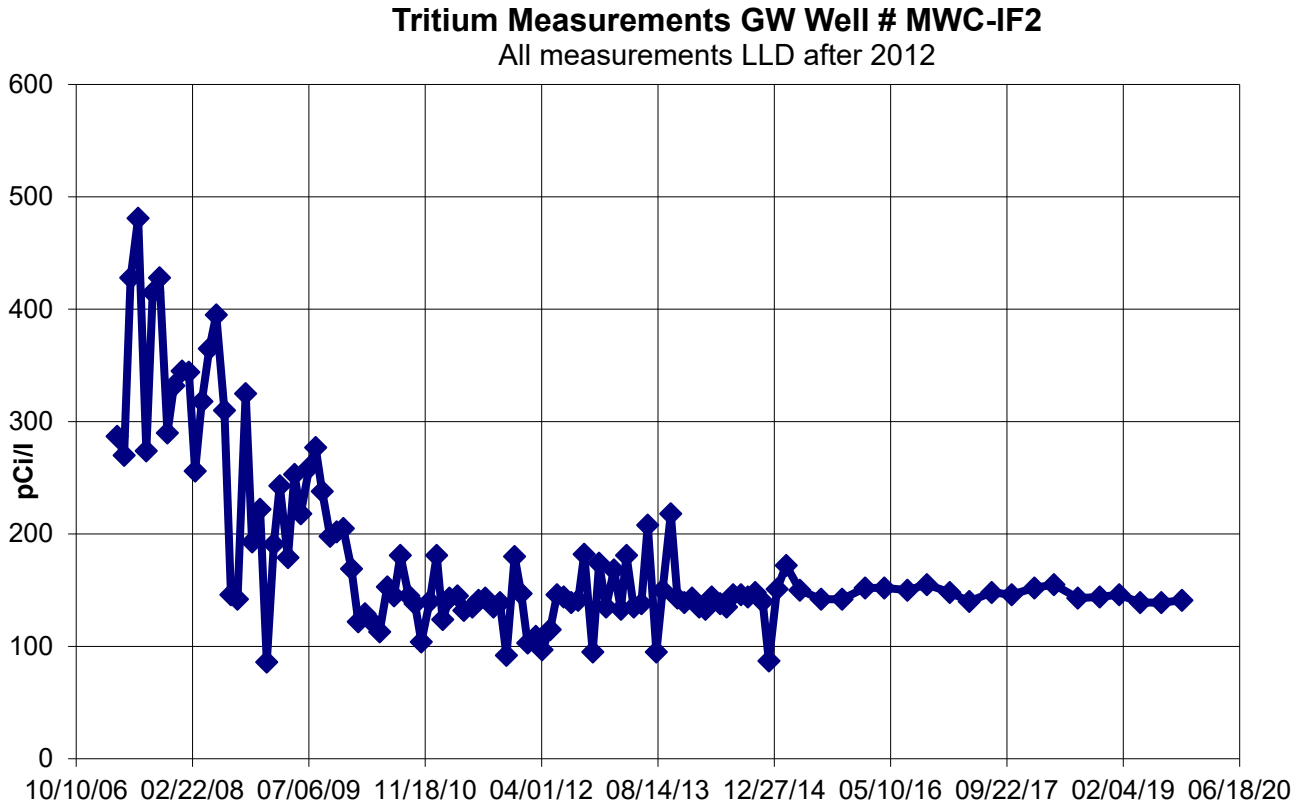
The PCP was revised in 2019 under DRR (2253000) to reflect current SAFSTOR conditions and the removal of installed demineralizers and bulk amounts of waste resin. Going forward into SAFSTOR, CR3 will primarily be generating low amounts of DAW and other solid radwaste.

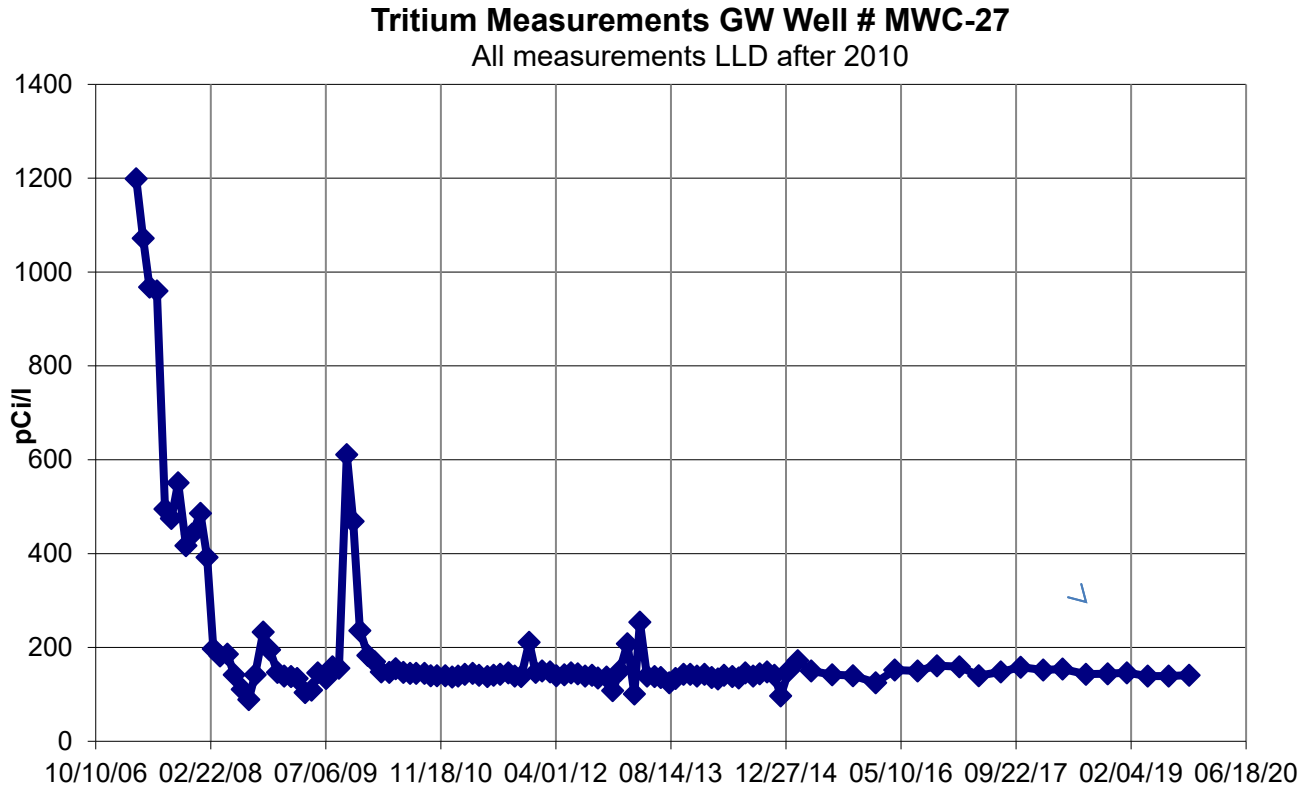
Carbon-14 Evaluation

The plant has not operated since 2009 so there is no source term generation for carbon-14 production. Since the decision to retire the facility has been announced, there will be no C-14 source term generated ever again at CR-3.

Nuclear Electric Institute (NEI) Required Information

The following environmental data is being included in this report per objective 2.4.b.i and 2.4.b.ii of NEI 07-07 Industry Ground Water Protection Initiative, as this groundwater well data is used to assist in evaluation of groundwater at the site, but is not officially included in the Radiological Environmental Monitoring Program (REMP) or the Offsite Dose Calculation Manual (ODCM). These 2 graphs are of tritium measurements in units of pCi/l, taken from groundwater monitoring wells located west of CR-3 on either side (north and south) of the site settling percolation ponds. There are many other groundwater monitoring wells included in the REMP that are used for evaluating the groundwater in the vicinity of the CR-3 site. These two wells are providing supplemental information. The LLD for tritium measurement of these environmental well samples is ~180 pCi/l. Measurements over the past several years have not showed tritium above LLD.


Tritium Measurements GW Well # MWC-IF2
All measurements LLD after 2012
pCi/l
600
500
400
300
200
100
0
10/10/06
02/22/08
07/06/09
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20


Tritium Measurements GW Well # MWC-27
All measurements LLD after 2010
pCi/l
1400
1200
1000
800
600
400
200
0
10/10/06
02/22/08
07/06/09
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20

Additional Information

On February 5, 2013, Duke Energy announced that a decision has been made to permanently retire Crystal River Unit 3. The decision was made due to the high cost of repair and risk associated with repairing the containment building's delaminated concrete wall. The company is working to develop a comprehensive decommissioning plan and intends to begin plant decommissioning mid-2020. place the facility in SAFSTOR for the immediate future and eventual dismantling. The plant staff (called SAFSTOR 2 organization) is working to shut down and abandon as many systems as possible, by removing energy sources, lubrications, greases, electrical, and system fluids to prepare the unit for SAFSTOR and eventual dismantlement. All spent fuel has been relocated from the spent fuel pool to the ISFSI facility as of January 2018.

DUKE ENERGY FLORIDA, LLC

DOCKET NUMBER 50 - 302 / 72-1035
LICENSE NUMBER DPR - 72

ATTACHMENT 2

CR3 OFFSITE DOSE CALCULATION MANUAL

CRYSTAL RIVER UNIT 3

OFF-SITE DOSE CALCULATION MANUAL

DRR 2268593

REVISED BY: Chuck Burtoff on file
Lead Scientist

REVIEWED BY: Larry McDougal on file
Independent Safety Reviewer

APPROVED BY: Bryant Akins on file
Radiation Protection & Chemistry Manager

APPROVED BY: Terry Hobbs signed electronically
GM Decommissioning SAFSTOR

DATE: 7/2/19

REVISION: 39

INTRODUCTION

The Off-Site Dose Calculation Manual (ODCM) is provided to support implementation of the Crystal River Unit 3 radiological effluent controls. The ODCM is divided into two parts.
Part I contains the specifications for liquid and gaseous radiological effluents and the radiological environmental monitoring program which were relocated from the Technical Specifications in accordance with the provisions of Generic Letter 89-01 issued by the NRC in January 1989. Part II of the ODCM contains the calculation methods used in determining the dose to members of the public resulting from routine radioactive effluents released from Crystal River Unit 3.

The ODCM shall become effective after acceptance by the Manager Decommissioning – SAFSTOR and the Manager of Radiation Protection and Chemistry. and in accordance with plant procedures. Changes to the ODCM shall be documented and records of reviews performed shall be retained. This documentation shall contain sufficient information to support the change (including analyses or evaluations), and a determination that the change will maintain the level of radioactive effluent control required by the regulations listed in CP-500 and not adversely impact the accuracy or reliability of effluent or dose calculations.

Changes shall be submitted to the NRC in the form of a complete and legible copy of the entire ODCM as part of, or concurrent with, the Radioactive Effluent Release Report for the period of the report in which any change to the ODCM was made. Each change shall be identified by markings in the margin of the affected pages, clearly indicating the area of the page that was changed, and shall indicate the date (e.g. month/year) the change was implemented.

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PART I

SPECIFICATIONS

1.0 DEFINITIONS

1.1 FREQUENCY

P	Completed prior to each release
M	At least once per 31 days.
Q	At least once per 92 days.
R	At least once per 18 months.

NOTE: Surveillance frequencies are met if the surveillance is performed within 1.25 times the interval specified, as measured from the previous performance or as measured from the time a specified condition of the frequency is met.

1.2 LIQUID RADWASTE TREATMENT SYSTEM

The Liquid Radwaste Treatment System shall be any available equipment (e.g., filters) capable of reducing the quantity of radioactive material, in liquid effluents, prior to discharge.

1.3 MEMBER OF THE PUBLIC

Member of The Public means an individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

1.4 OFFSITE DOSE CALCULATION MANUAL (ODCM)

The ODCM contains the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, and in the conduct of the Radiological Environmental Monitoring Program (REMP). The ODCM also contains information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports.

1.5 SITE BOUNDARY

The Site Boundary shall be that line beyond which the land is not owned, leased, or otherwise controlled by the licensee.

1.6 UNPLANNED RELEASE

An Unplanned Release is an unintended discharge of liquid or airborne radioactivity to the environment. Due to plant shutdown, the chance of having an unplanned release is significantly reduced. Minor equipment failures which cause an increase in plant releases are not unplanned as it is expected that minor failures will occur from time-to-time. Human error which results in a release of radioactivity to the environment is considered unplanned.

EXAMPLES:
1. Releasing the wrong waste tank.
2. Plant leakage which exceeds reporting limits such as those of 10 CFR 50.72 and 10 CFR 50.73.

1.7 UNRESTRICTED AREA

An Unrestricted Area shall be any area at or beyond the site boundary, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the site boundary used for residential quarters or industrial, commercial, institutional, and/or recreational purposes.

2.0 SPECIFICATIONS

2.1 LIQUID RADWASTE TREATMENT SYSTEM

The Liquid Radwaste Treatment System shall be used, as required, to reduce radioactive materials in liquid wastes prior to their discharge, when projected monthly doses due to liquid effluents discharged to Unrestricted Areas would exceed the following values:

a. 0.06 mrem whole body;

b. 0.2 mrem to any organ

APPLICABILITY: At all times.

ACTION:

a. When radioactive liquid waste, in excess of the above limits, is discharged without prior treatment, prepare and submit to the Commission within 30 days, a Special Report which includes the following information:

1. Identification of inoperable equipment and the reasons for inoperability.

2. Actions taken to restore the inoperable equipment to operable status.

3. Actions taken to prevent recurrence.

SURVEILLANCE REQUIREMENTS

2.1.1 Doses due to liquid releases shall be projected at least once per 31 days if a liquid release was made.

2.2 LIQUID EFFLUENTS CONCENTRATION

The concentration of radioactive material released to Unrestricted Areas shall be less than or equal to 10 times the concentrations specified in 10 CFR Part 20, Appendix B, Table II, Column 2 for radionuclides other than dissolved or entrained noble gases.

APPLICABILITY: At all times.

ACTION:

a. With the concentration of radioactive materials released to Unrestricted Areas exceeding the above limits, without delay restore the concentration of radioactive materials being released to Unrestricted Areas to within the above limits.

SURVEILLANCE REQUIREMENTS

2.2.1 Radioactive liquid wastes shall be sampled and analyzed in accordance with the sampling and analysis program of Table 2-1.

2.2.2 The results of the radioactivity analyses shall be used to assure the concentrations of radioactive material released from the site are maintained in accordance with Specification 2.3.

TABLE 2-1

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)[a]
A. Batch Waste Release Tanks [d,e]	P Each Batch	P Each Batch	Principal Gamma Emitters[f]	$5x10^{-7}$
	P Each Batch	M Composite[b,c]	H-3	$1x10^{-5}$
			Gross Alpha	$1x10^{-7}$
	P Each Batch	Q Composite[b,c]	Sr-90	$5x10^{-8}$
			Fe-55, Ni-63	$1x10^{-6}$

TABLE NOTATION

a. The LLD* is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = 4.66 s_b / (2.22x10^6 E V Y e^{-\lambda \Delta t})$$

Where:

LLD is the lower limit of detection as defined above (as microcurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

$2.22x10^6$ is the number of disintegrations per minute per microcurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples).

Typical values of E, V, Y, and Δt shall be used in the calculation.

* The LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

TABLE 2-1 (Continued)

TABLE NOTATION

b. A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

c. Prior to analyses, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.

d. A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed to assure representative sampling.

e. Means shall exist to determine waste volume, waste discharge flow rate, and dilution flow rate for each batch release.

f. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Cs-134, Cs-137, and Ce-144. This list does not mean that only these nuclides are to be detected and reported. Other peaks, which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses shall be reported as "less than" the nuclide's LLD, and shall not be reported as being present at the LLD level for that nuclide. The "less than" values shall not be used in the required dose calculations.

2.3 LIQUID EFFLUENTS - DOSE

The dose or dose commitment to a Member of The Public from radioactive materials in liquid effluents released to Unrestricted Areas shall be limited as follows:

a. During any calendar quarter to less than or equal to 1.5 mrem to the total body and less than or equal to 5 mrem to any organ.

b. During any calendar year to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ.

APPLICABILITY: At all times.

ACTION:

a. With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission, within 30 days, which includes:

1. Identification of the cause for exceeding the limit(s);

2. Corrective action taken to reduce the release of radioactive materials in liquid effluents during the remainder of the current calendar quarter and during the remainder of the current calendar year so that the dose or dose commitment to a Member of The Public from this source is less than or equal to 3 mrem total body and less than or equal to 10 mrem to any organ during the calendar year.

SURVEILLANCE REQUIREMENTS

2.3.1 DOSE CALCULATIONS. Cumulative dose contributions from liquid effluents shall be determined at least once per 31 days if a release has been made.

2.4 **Gaseous Effluents – Dose Rate**

The dose rate at or beyond the Site Boundary, due to radioactive materials released in gaseous effluents, shall be limited as follows:

a. Tritium and radioactive particulates with half-lives of greater than 8 days: less than or equal to 1500 mrem/year to any organ.

APPLICABILITY: At all times

ACTION:

a. With dose rate (s) exceeding the above limits, without delay decrease the dose rate to within the above limit(s). Note: Due to the long period of time that the plant has been in SAFSTOR, any potential dose or dose rate contribution from noble gas is now negligible and does not require sampling.

SURVEILLANCE REQUIREMENTS

2.4.1 The dose rate due to radioactive materials specified above in gaseous effluents shall be determined to be within the above limits by obtaining representative samples and performing analyses in accordance with Table 2-2.

2.5 **Dose - Noble Gases**

Due to the long period of time that the plant has been in SAFSTOR, any potential dose or dose rate contribution from noble gas is now negligible. There is no means to create these fission gases with the only significant quantities of Kr-85 remaining in the spent fuel being located in the ISFSI.

TABLE 2-2

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)[a]
Seawater Room Ventilation [b] Auxiliary Building and Fuel Handling Area Exhaust [b]	Grab Sample	M	Principal Gamma Emitters [d]	$1x10^{-4}$
			H-3	$1x10^{-6}$
	Grab Sample [c]	M Particulate Sample	Principal Gamma Emitters [d] (Others)	$1x10^{-11}$
	Grab Sample c	M Composite Particulate Sample	Gross Alpha	$1x10^{-11}$
	Grab Sample [c]	Q Composite Particulate Sample	Sr-90 Fe-55, Ni-63	$1x10^{-11}$

TABLE 2-2 (Continued)

TABLE NOTATION

a. The LLD* is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = 4.66 s_b / (2.22 \times 10^6 \, EVY \, e^{-\lambda \Delta t})$$

Where:

LLD is the lower limit of detection as defined above (as microcurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

2.22×10^6 is the number of disintegrations per minute per microcurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples).

Typical values of E, V, Y, and Δt shall be used in the calculation.

* The LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

TABLE 2-2 (Continued)

TABLE NOTATION

b. Means shall exist to determine ventilation exhaust flow rate. Samples shall be obtained using calibrated samplers

c. The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with the Specifications 2.7 and 2.9.

d. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Cs-134, Cs-137 and Ce-144 for particulate emissions. This list does not mean that only these nuclides are to be detected and reported. Other peaks, which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses shall be reported as "less than" the nuclide's LLD and shall not be reported as being present at the LLD level for that nuclide. The "less than" values shall not be used in the required dose calculations.

2.6 DOSE – TRITIUM AND RADIOACTIVE PARTICULATES

The dose to a Member of The Public from Tritium and radioactive particulates with half-lives greater than 8 days in gaseous effluents released from the site to areas at or beyond the Site Boundary shall be limited as follows:

a. During any calendar quarter: less than or equal to 7.5 mrem to any organ, and

b. During any calendar year: less than or equal to 15 mrem to any organ.

APPLICABILITY: At all times.

ACTION:

a. With the calculated dose from the release of Tritium and radioactive particulates with greater than 8 day half-lives, in gaseous effluents, exceeding any of the above limits, prepare and submit to the Commission, within 30 days, a report which includes:

1) Identification of the cause for exceeding the limits(s);

2) Corrective action to reduce those releases during the remainder of the current calendar quarter and the remainder of the current calendar year so that the average dose to any organ is less than or equal to 15 mrem.

b. If the projected monthly dose exceeds 0.3 mrem to any organ, then action shall be taken to reduce the quantity of radioactive material in the effluents.

SURVEILLANCE REQUIREMENTS

2.6.1 DOSE CALCULATIONS: Cumulative dose calculations for the current calendar quarter and current calendar year shall be determined at least once per 31 days.

2.6.2 DOSE PROJECTIONS: Dose shall be projected at least once per 31 days

2.7 TOTAL DOSE

The calendar year dose or dose commitment to any Member Of The Public, due to releases of radioactivity and radiation, from uranium fuel cycle sources shall be limited to less than or equal to 25 mrem to the total body or any organ (except the thyroid, which shall be limited to less than or equal to 75 mrem).

APPLICABILITY: At all times.

ACTION:

a. With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Specification 2.6.a or 2.6.b, calculations should be made, which include direct radiation contributions from the reactor, to determine whether the above limits of Specification 2.10 have been exceeded. If such is the case, prepare and submit to the Commission within 30 days, a report that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits. This report, as defined in 10 CFR Part 20.2203, shall include an analysis that estimates the radiation exposure (dose) to a Member Of The Public from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in violation of 40 CFR Part 190 has not already been corrected, the report shall include a request for a variance in accordance with the provisions of 40 CFR Part 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

SURVEILLANCE REQUIREMENTS

2.7.1 DOSE CALCULATIONS -

Total dose must also consider shine from the ISFSI pad and must be less than 25 mrem in a year as per 40 CFR 190.

NOTE: Procedure ISFS-212, section 5.2.1, equates the ISFSI controlled area boundary to CR3's owner controlled area boundary as described in the DSAR. Real individuals beyond the controlled area are where the ISFSI dose limits of 72.104 apply. These are the same dose limits imposed by 40 CFR 190, which is the basis for the limits of ODCM Specification 2.7 above. ISFSI calculation 11182-0502 (CR3 reference calculation N16-0003), which is based on the CR3 site before Partial Site Release, demonstrates that the highest annual dose at the controlled area boundary is ~ 0.1 mrem.

2.8 RADIOLOGICAL ENVIRONMENTAL MONITORING

The radiological environmental monitoring program shall be conducted as specified in Table 2-3.

APPLICABILITY: At all times.

ACTION:

a. With the radiological environmental monitoring program not being conducted as specified in Table 2-3, prepare and submit to the Commission, in the Annual Radiological Environmental Operating Report, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

b. With the level of radioactivity, resulting from plant effluents, in an environmental sampling medium exceeding the reporting levels of Table 2-4 when averaged over any calendar quarter, prepare and submit to the Commission, within 30 days of obtaining analytical results from the affected sampling period, a report, which identifies the cause(s) for exceeding the limit(s) and defines corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a Member Of The Public is less than the calendar year limits of Specifications 2.4, 2.5, and 2.6. When more than one of the radionuclides in Table 2-4 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration (1)}}{\text{limit level (1)}} + \frac{\text{concentration (2)}}{\text{limit level (2)}} + \ldots \geq 1.0$$

When radionuclides other than those in Table 2-4 are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a Member Of The Public is greater than or equal to the calendar year limits of Specifications 2.4, 2.5, and 2.6. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report.

c. With fresh leafy vegetation samples unavailable from one or more of the sample locations required by Table 2-3, identify the cause of the unavailability of samples and identify locations for obtaining replacement samples in the next Annual Radiological Environmental Operating Report. The locations from which samples were unavailable may then be deleted from those required by Table 2-3, provided the locations from which the replacement samples were obtained are added to the environmental monitoring program as replacement locations.

SURVEILLANCE REQUIREMENTS

2.8.1 The radiological environmental monitoring samples shall be collected pursuant to Table 2-3 from the locations given in the table and Figures 5.1, 5.2 and 5.3 and shall be analyzed pursuant to the requirements of Tables 2-3 and 2-5.

TABLE 2-3

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling/ Collection Frequency	Type/Frequency of Analysis
1. AIRBORNE particulates	One sample each: C07, C18, C40, C41, C46 and Control Location C47	Continuous sampler/ Weekly collection	Particulate sampler: a) Gross ß at ≥ 24 hours/ following weekly filter change. b) Composite gamma special analysis (by location)/ quarterly. (Gamma Spectral Analysis shall also be performed on individual samples if gross beta activity of any sample is greater than 1.0 pCi/m^3 and which is also greater than ten times the control sample activity.
2. DIRECT RADIATION	1) Site Boundary: C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C41, C70, C27, C71, C72, C73 2) Five Miles: C18, C03, C04, C74, C75, C76, C08, C77, C09, C14G, C01, C79 3) Control Location: C47 (Orlando)	Continuous placement/Quarterly collection (Note: C27 & C72 are slightly within the Site Boundary)	Gamma exposure rate/quarterly

TABLE 2-3 (Continued)

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling/ Collection Frequency	Type/Frequency of Analysis
3. WATERBORNE Seawater	One sample each: C14H, C14G Control Location C13	Grab sample/Monthly	Gamma spectral analysis/monthly Tritium analysis on each sample or on a quarterly composite of monthly samples
Ground water	One sample: C40 (Control Location)	Grab sample/semiannual	Gamma spectral and Tritium analysis/each sample
Site Ground Water	One sample each: CR3-1S, CR3-1D, CR3-2, CR3-3S, CR3-3D, CR3-4, CR3-5, CR3-6S, CR3-6D, CR3-7 CR3-8, CR3-9, CR3-10	Grab sample/quarterly	Gamma spectral and Tritium analysis/each sample
Drinking water	One sample each: C07, C10, C18 (All Control Locations)	Grab sample/quarterly	Gamma spectral and Tritium analysis/each sample
Shoreline Sediment	One sample each: C14H, C14M, C14G Control Location C09	Semiannual sample	Gamma spectral analysis/each sample
4. INGESTION Fish & Invertebrates	One sample each: C29, Control Location C30	Quarterly: Oysters and carnivorous fish	Gamma spectral analysis on edible portions/each sample
Food Products	One sample each: C48a*, C48b*, Control Location C47	Monthly (when available): Sample comprised of three (3) types of broad leaf vegetation from each location	Gamma spectral analysis/each sample
	One sample: C19	Annual during harvest: Citrus	Gamma spectral analysis/each sample
	One sample: C04	Annual during harvest: Watermelon	Gamma spectral analysis/each sample

TABLE 2-4

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/Kg, wet)	Milk (pCi/l)	Food Products (pCi/Kg, wet)
H-3	20,000[(a)]				
Mn-54	1,000		30,000		
Fe-59	400		10,000		
Co-58	1,000		30,000		
Co-60	300		10,000		
Zn-65	300		20,000		
Zr-Nb-95[(b)]	400				
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140[(b)]	200			300	

(a) For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/l may be used. At the Crystal River site, there is no drinking water pathway due to the direction of groundwater flow being west-southwest towards the Gulf of Mexico and the fact that the groundwater at the site is too saline for human consumption.

(b) An equilibrium mixture of the parent and daughter isotope which contains the reporting value of the parent isotope.

TABLE 2-5

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD) a, d

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/Kg, wet)	Milk (pCi/l)	Food Products (pCi/Kg, wet)	Sediment (pCi/Kg, dry)
gross beta		0.01				
^{3}H	2000[b]					
^{54}Mn	15		130			
^{59}Fe	30		260			
^{58}Co	15		130			
^{60}Co	15		130			
^{65}Zn	30		260			
^{95}Zr-Nb	15[c]					
^{134}Cs	15	0.05[e]	130	15	60	150
^{137}Cs	18	0.06[e]	150	18	80	180
^{140}Ba-La	15[c]			15[c]		

TABLE 2-5 (Continued)

TABLE NOTATION

a. The LLD* is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = 4.66 s_b / (2.22 \; E \; V \; Y \; e^{-\lambda \Delta t})$$

Where:

LLD is the lower limit of detection as defined above (as picocurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

2.22 is the number of disintegrations per minute per picocurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between environmental collection, or end of the sample collection period, and time of counting.

Typical values of E, V, Y, and Δt shall be used in the calculation.

* The LLD is defined as an a priori (before the fact) limit representing the capability of the measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLD's will be achieved under routine conditions. Occasionally, background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLD's unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report.

b. LLD for drinking water. If no drinking water pathway exists, a value of 3000 pCi/l may be used.

c. The specified LLD is for an equilibrium mixture of parent and daughter nuclides which contain 15 pCi/l of the parent nuclide.

d. Other peaks which are measurable and identifiable, together with the radionuclides in Table 2.5, shall be identified and reported.

e. Cs-134, and Cs-137 LLD's apply only to the quarterly composite gamma spectral analysis, not to analyses of single particulate filters.

2.9 LAND USE CENSUS

A land use census shall be conducted and shall identify the location of the nearest milk animal (if any), the nearest residence and the nearest garden* of greater than 500 square feet producing fresh leafy vegetables in each of the land based meteorological sectors within a distance of five miles.

APPLICABILITY: At all times.

ACTION:

a. With a land use census identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated by Specification 2.6, identify the new location in the next Annual Radiological Environmental Operating Report.

b. With a land use census identifying a location(s) which yields a calculated dose or dose commitment (via the same exposure pathway) which is at least 20% greater than at a location from which samples are currently being obtained in accordance with Specification 2.8, this location shall be added to the radiological environmental monitoring program within 30 days. The new sampling location shall replace the present sampling location, which has the lower calculated dose or dose commitment (via the same exposure pathway), after June 30 following this land use census. Identification of the new location and revisions of the appropriate figures shall be submitted with the next Radioactive Effluent Release Report.

* Broad leaf vegetation sampling may be performed at the site boundary in the direction sector with the highest D/Q in lieu of the garden census.

SURVEILLANCE REQUIREMENTS

2.9.1 The land use census shall be conducted at least once per 12 months during the growing season by a door-to-door survey, aerial survey, or by consulting local agriculture authorities, using that information which will provide adequate results.

2.10 INTERLABORATORY COMPARISON PROGRAM

Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program which has been approved by the Commission. A summary of the results obtained from this program shall be included in the Annual Radiological Environmental Operating Report.

APPLICABILITY: At all times.

ACTION:

a. With analyses not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report.

SURVEILLANCE REQUIREMENTS

2.10.1 No surveillance requirements other than those required by the Interlaboratory Comparison Program.

3.0 SPECIFICATION BASES

3.1 LIQUID RADWASTE TREATMENT SYSTEM BASIS

Use of the Liquid Radwaste Treatment System will implement the ALARA requirements of 10 CFR 50, Appendix I and the guidance specified in Chapter 4 of the CR3 DSAR.

3.2 LIQUID EFFLUENTS CONCENTRATION BASIS

This specification is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to Unrestricted Areas will be less than 10 times the effluent concentration limits (ECLs) specified in 10 CFR Part 20. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in Unrestricted Areas will result in exposures within the Section II.A design objectives of Appendix I, 10 CFR 50, to a Member of The Pubic. There are no Noble gases seen in the typical waste water due to lengthy radioactive decay.

3.3 LIQUID EFFLUENTS DOSE BASIS

This specification is provided to implement the requirements of Sections II.A, III-A and IV.A of Appendix I, 10 CFR Part 50. It also implements the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable" (ALARA). The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

3.4 GAS EFFLUENTS DOSE RATE BASIS

These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a member of the public, either within or outside the site boundary, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR 20.

3.5 GASEOUS EFFLUENTS DOSE: TRITIUM AND RADIOACTIVE PARTICULATE BASIS

This specification is provided to implement the requirements of Sections II.C, III.A, and IV.A of Appendix I, 10 CFR Part 50 and assures that the releases of radioactive materials in gaseous effluent will be kept "as low as is reasonably achievable" (ALARA). The methods for calculating the dose due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for Tritium, and radioactive particulates with half-life greater than eight days are dependent on the existing radionuclide pathways to man, in areas at and beyond the site boundary. The pathways which were examined in the development of these calculations were:

1) Individual inhalation of airborne radionuclides,
2) Deposition of radionuclides onto green leaf vegetation with subsequent consumption by man,
3) Deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and
4) Deposition on the ground with subsequent exposure of man.

3.6 TOTAL DOSE BASIS

This specification is provided to meet the dose limitations of 40 CFR Part 190 that have now been incorporated into 10 CFR Part 20 by 46 FR 18525. This specification applies to Members Of The Public beyond the site boundary (i.e. in the unrestricted area). The specification requires the preparation and submittal of a report whenever the calculated doses from plant radioactive effluents exceed twice the design objective doses of Appendix I.

3.7 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM BASIS

The radiological monitoring program required by this specification provides measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures of Member Of The Public resulting from the station operation. This monitoring program thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. Program changes may be initiated based on operational experience.

The LLD's required by Table 2-5 are considered optimum for routine environmental measurements in industrial laboratories. The LLD's for drinking water meet the requirements of 40 CFR 141.

3.8 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM LAND USE CENSUS BASIS

This specification is provided to ensure that changes in the use of areas at or beyond the Site Boundary are identified and that modifications to the monitoring program are made if required by the results of this census. Adequate information gained from door-to-door or aerial surveys or through consultation with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 500 square feet provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumption were used:

1) that 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and
2) a vegetation yield of 2 kg/square meter.

3.9 RADIOLOGICAL ENVIRONMENTAL MONITORING INTERLABORATORY COMPARISON PROGRAM BASIS

The requirement for participation in an Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid.

PART II
METHODOLOGIES

Section 1.0
PRE-RELEASE CALCULATIONS

PRE-RELEASE CALCULATION 1-1
GASEOUS RADWASTE RELEASE

I. INTRODUCTION

Prior to initiating a release of gaseous radwaste, it must be determined that the concentration of radionuclides to be released, and the flow rates at which they are released will not cause the dose rate limitation of 1500 mrem/yr (any organ via the inhalation pathway) to be exceeded from tritium and radioactive particulates with greater than 8 day half-lives at the Site Boundary.

II. INFORMATION REQUIRED

Results of appropriate Nuclide Analysis

III. CALCULATIONS

Tritium, Radioactive Particulates

Dose Rate (T,P) = $\Sigma (X/Q)P_iQ_i$ mrem/yr.

where:

P_i = The dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per µCi/m^3. (See Table 4-2).

Q_i = The release rate of radionuclides, i, in gaseous effluent from individual release sources, in µCi/sec (per unit, unless otherwise specified). Q_i = Effluent stream nuclide concentration x flow rate.

Flow Rates (Variable - based on nominal values listed below.)

1) Auxiliary Building and Fuel Handling Area Exhaust Duct = 156,000 cfm ; or 33,000 cfm from Seawater Room Exhaust

(X/Q) = 2.5×10^{-6} sec/m^3. For all vent releases. The highest calculated annual average relative concentration for any area at or beyond the site boundary. Note: After Partial Site Release is implemented, the X/Q value will be taken as 2.35E-5 sec/m^3 at the new site boundary Reference – CR3 Calculation N18-0003, June 2019.

PRE-RELEASE CALCULATION 1-2
LIQUID RADWASTE RELEASE

I. **INTRODUCTION**

Prior to initiating a release of liquid radwaste, it must be determined that the concentration of radionuclides to be released and the flow rates at which they will be released will not lead to a release concentration greater than the limits of 10 times the effluent concentrations specified by 10 CFR 20 at the point of discharge.

II. **INFORMATION REQUIRED**

Results of appropriate Nuclide Analysis

III. **CALCULATIONS**

$$\text{Discharge Concentration} = 0.1 \left[\sum \frac{C_{\gamma i}}{ECL_{\gamma i}} + \frac{C_{Ni-63}}{ECL_{Ni-63}} + \frac{C_a}{ECL_a} + \frac{C_T}{ECL_T} + \frac{C_s}{ECL_s} + \frac{C_{Fe-55}}{ECL_{Fe-55}}\right] \div \left[\frac{D+E}{E}\right]$$

where:

$C_{\gamma i}$	=	The concentration of isotope i, in the gamma spectrum excluding dissolved or entrained noble gases.
C_T	=	Tritium Concentration from most recent analysis.
C_a	=	Gross alpha concentration from most recent analysis.
C_S	=	Sr-90 concentration from most recent analysis.
C_{Ni}	=	Ni-63 concentration from most recent analysis.
C_{Fe}	=	Fe-55 concentration from most recent analysis.
E	=	Effluent Stream Flow Rate
D	=	Dilution Stream Raw Water Flow Rate (Note: Could be no dilution flow)
ECL	=	10 CFR 20 Appendix B, effluent concentration limit.

If Discharge Concentration is less than or equal to 1, the discharge may be initiated. If Discharge Concentration is greater than 1, then release parameters must be changed to assure that Discharge Concentration is not greater than 1. Changes include reducing tank concentration by decay or dilution, reducing the waste stream release rate, or increasing dilution water flow rate.

SECTION 2.0

RADIOACTIVE EFFLUENTS DOSE PROJECTION CALCULATIONS

2.1 Dose Projection Methodology Gaseous Radwaste

Calculation

Due to plant shutdown and decreased gaseous effluent, dose projection of gaseous radwaste is unlikely to be needed.

$D_p = 31D_c/NDQ$

where:

D_p = Projected Dose (monthly).

D_c = Current quarter cumulative dose, including projection for release under evaluation.

NDQ = Number of days into quarter, where the quarterly periods are:

January 1 through March 31, April 1 through June 30, July 1 through September 30, October 1 through December 31.

2.2 Dose Projection Methodology - Liquid Radwaste

Calculation

Dose projection calculations will be necessary if there is a malfunction of liquid radwaste treatment system equipment and liquid radwaste must be released without prior treatment.

$$D_p = 31D_c/NDQ$$

where:

D_p = Projected Dose (monthly).

D_c = Current quarter cumulative dose, including projection for release under evaluation.

NDQ = Number of days into quarter, where the quarterly periods are:

January 1 through March 31, April 1 through June 30, July 1 through September 30, October 1 through December 31.

SECTION 3.0

RADIOACTIVE EFFLUENTS SAMPLING SPECIFICATIONS

Representative Sampling Method (Liquid)

(Evaporator Condensate Storage Tanks, Laundry & Shower Sump Tanks, Borated Water Storage Tanks, Secondary Drain Tank, Poly Tanks in Seawater Room)

To obtain representative samples from these tanks, the contents of the tank to be sampled will be recirculated through two contained volumes and a grab sample will be collected upon completion. No additions of liquid waste will be made to the tank until completion of the release.

Representative Sampling Method (Particulates and Tritium)

(Auxiliary Building & Fuel Handling Building or Seawater Room)

Representative particulate samples will be taken on a monthly basis at the Seawater Room ventilation exhaust. The volume of air released will also be estimated on a monthly basis, based on the number of fans running, to determine the total release. Sample time and volumes should be established to assure the LLD limits of 1E-11 μCi/ml for principal gamma emitters, gross alpha and Sr-90 are met. Tritium samples should be taken semi-annually and counted to assure an LLD of 1E-5 μCi/ml is met. Note: This sample may be obtained using the old RM-A2 pump skid while it is still in service.

SECTION 4.0

RADIOACTIVE EFFLUENTS
DOSE CALCULATIONAL SPECIFICATIONS

4.1 DOSE CALCULATION (TRITIUM & PARTICULATES)

The dose to an individual at or beyond the Site Boundary due to Tritium and radioactive particulates with half lives of greater than 8 days is calculated as follows:

$$D = 3.17 \times 10^{-8} \sum WR_iQ_i \quad \text{mrem}$$

where:

- D = The radiation dose to an individual at or beyond the Site boundary, in mrem.
- R_i = The dose factor for each identified radionuclide, i, in m^2(mrem/year) per uCi/sec or mrem/year per uCi/m^3.
- W = X/Q for inhalation pathway, 2.5×10^{-6} sec/m^3 at the site boundary. (This value will be taken as 2.25×10^{-6} sec/m^3 at the new site boundary after the Partial Site Release is implemented.)
- W = D/Q for food and ground plane pathway, $1.9 \times 10^{-8} m^{-2}$ at the site boundary. (This value will be taken as 1.61E-7 m^{-2} at the new site boundary after the Partial Site Release is approved.)
- Q_i = Total µCi of isotope i released during the calendar quarter or calendar year, as appropriate
- 3.17×10^{-8} = The number of years in one second

Reference:

NUREG 0133, Section 5.3.1

4.2 DOSE CALCULATION (LIQUID EFFLUENTS)

The dose or dose commitment to a Member Of The Public from radioactive materials in liquid effluents released to Unrestricted Areas is calculated as follows:

$$D = \sum_i \left[A_{i\tau} \sum_k t_k C_{ik} F_k \right]$$

where:

D	=	The cumulative dose commitment to the total body or any organ, T, from the liquid effluents for the total time period Σt_k in mrem.
t_k	=	The length of the kth time period over which C_{ik} is averaged for all liquid releases, in hours.
C_{ik}	=	The average concentration of radionuclide, i, in undiluted liquid effluent during time period t_k from any liquid release, in µCi/ml.
$A_{i\Gamma}$	=	The site related ingestion dose commitment factor to the total body or any organ for each identified principal gamma and beta emitter as shown in Table 4-5 of this manual, in mrem-ml per hour-µCi.
F_K	=	Waste flow rate / (Waste flow rate + Dilution flow rate)* Dilution flow rate is the sum of available Unit 1 &2 circulating water and Raw Water. Flow from the Combined Cycle plants may also be used.

References:

1) NUREG 0133, Section 4.3.

2) *Telecon/Meeting Summary with C. Willis (USNRC) dated 01/16/85 regarding F_k

4.3 **CALCULATION OF INHALATION**

PATHWAY DOSE FACTOR (R_i)

$$R_i = K' \left(BR\right) DFA_i \quad \text{mrem / year per uCi / m}^3$$

where:

K' = A constant unit of conversion - 10^6 pCi/uCi

BR = The Breathing Rate of the represented age group:

1400 m^3/yr - infant

3700 m^3/yr - child

8000 m^3/yr - teen

8000 m^3/yr - adult

DFA_i = The maximum organ inhalation dose factor for the represented age group for the ith radionuclide, in mrem/pCi. From Reference 2 below. This is conservative and consistent with more current radiation protection guidance (e.g. Federal Guidance Report 11 and ICRP-56).

References:

1) NUREG-0133, Section 5.3.1.1

2) Regulatory Guide 1.109, Table E-5, and Tables E-7 through E-10

TABLE 4-1

Inhalation Dose Factors (R_i) - Infant

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	6.47E2	6.47E2	6.47E2	6.47E2	6.47E2	6.47E2	6.47E2
Mn-54	ND	2.53E4	4.98E3	4.98E3	4.98E3	9.95E5	7.06E3
Fe-55	1.97E4	1.17E4	3.33E3	ND	ND	8.69E4	1.09E3
Fe-59	1.36E4	2.35E4	9.48E3	ND	ND	1.02E6	2.48E4
Co-60	ND	8.02E3	1.18E4	ND	ND	4.51E6	3.19E4
Ni-63	3.39E5	2.04E4	1.16E4	ND	ND	2.09E5	2.42E3
Zn-65	1.93E4	6.26E4	3.11E4	ND	3.25E4	6.47E5	5.14E4
Sr-89	3.98E5	ND	1.14E4	ND	ND	2.03E6	6.40E4
Sr-90	4.09E7	ND	2.59E6	ND	ND	1.12E7	1.31E5
Ag-110m	9.98E3	7.22E3	5.00E3	ND	1.09E4	3.67E6	3.30E4
Cs-134	3.96E5	7.03E5	7.45E4	ND	1.90E5	7.97E4	1.33E3
Cs-137	5.49E5	6.12E5	4.55E4	ND	1.72E5	7.13E4	1.33E3
Ce-144	3.19E6	1.21E6	1.76E5	ND	5.38E5	9.84E6	1.48E5

4.4 **Calculation of Ingestion Dose Factor - Grass-Cow-Milk Pathway**

$$R_i^c[D/Q] = K'\left[\frac{Q_F(U_{ap})}{\lambda_i + \lambda_w}\right]F_m(r)(DFL_i)_a\left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)e^{-\lambda_i th}}{Y_s}\right]e^{-\lambda_i tf}$$

where: Unit = m^2·mrem/yr per µCi/sec Reference Table R.G. 1.109

K'	=	A constant of unit conversion, 10^6 pCi/Ci.	
Q_F	=	The cow's consumption rate, 50 kg/day (wet weight)	E-3
U_{ap}	=	The receptor's milk consumption rate for age (a), in liters/yr Infant & Child - 330, Teen - 400, Adult - 310	E-5
Y_p	=	The agricultural productivity by unit area of pasture feed grass 0.7 kg/m^2	E-15
Y_s	=	The agricultural productivity of unit area of stored feed 2.0 kg/m^2	E-15
F_m	=	The stable element transfer coefficients, in days/kg.	E-1
r	=	Fraction of deposited activity retained on cow's feed grass 0.2 particulates	E-15
t_f	=	Transport time from pasture to receptor, in sec. 1.73×10^5 sec (2 days)	E-15
t_h	=	Transport time from crop field to receptor, in sec. 7.78×10^6 sec. (90 days)	E-15
$(DFL_i)_a$	=	The maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group (a), in mrem/pCi	E-11 to E-14
λ_i	=	The decay constant for the ith radionuclide, in sec^{-1}	
λ_w	=	The decay constant for removal of activity on leaf and plant surfaces by weathering 5.73×10^{-7} sec^{-1} (corresponding to a 14 day half-life).	E-15
f_p	=	Fraction of the year that the cow is on pasture (dimensionless) = 1*.	----
f_s	=	Fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless) = 1*.	----

* Milk cattle are considered to be fed from two potential sources, pasture grass and stored feeds.

Note: The above equation does not apply to the concentration of tritium in meat. A separate equation is provided in NUREG 0133, Section 5.3.1.4 to determine Tritium value.

Reference: The equation for R^c_i (D/Q) was taken from NUREG-0133, Section 5.3.1.3

TABLE 4-2

Inhalation Dose Factors (R_i) - Child

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3
Cr-51	ND	ND	1.54E2	8.55E1	2.43E1	1.70E4	1.08E3
Mn-54	ND	4.29E4	9.51E3	ND	1.00E4	1.58E6	2.29E4
Fe-55	4.74E4	2.52E4	7.77E3	ND	ND	1.11E5	2.87E3
Fe-59	2.07E4	3.34E4	1.67E4	ND	ND	1.27E6	7.07E4
Co-60	ND	1.31E4	2.26E4	ND	ND	7.07E6	9.62E4
Ni-63	8.21E5	4.63E4	2.80E4	ND	ND	2.75E5	6.33E3
Zn-65	4.26E4	1.13E5	7.03E4	ND	7.14E4	9.95E5	1.63E4
Sr-89	5.99E5	ND	1.72E4	ND	ND	2.16E6	1.67E5
Sr-90	1.01E8	ND	6.44E6	ND	ND	1.48E7	3.43E5
Ag-110m	1.69E4	1.14E4	9.14E3	ND	2.12E4	5.48E6	1.00E5
Cs-134	6.51E5	1.01E6	2.25E5	ND	3.30E5	1.21E5	3.85E3
Cs-137	9.07E5	8.25E5	1.28E5	ND	2.82E5	1.04E5	3.62E3
Ce-144	6.77E6	2.12E6	3.61E5	ND	1.17E6	1.20E7	3.89E5

TABLE 4-3

Ingestion Dose Factors (R_i^c)

Grass-Cow-Milk Pathway (Infant)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	2.38E3	2.38E3	2.38E3	2.38E3	2.38E3	2.38E3	2.38E3
Mn-54	ND	3.89E7	8.83E6	ND	8.63E6	ND	1.43E7
Fe-55	1.35E8	8.72E7	2.33E7	ND	ND	4.26E7	1.11E7
Fe-59	2.26E8	3.94E8	1.55E8	ND	ND	1.17E8	1.88E8
Co-60	ND	8.81E7	2.08E8	ND	ND	ND	2.10E8
Ni-63	3.49E10	2.16E9	1.21E9	ND	ND	ND	1.07E8
Zn-65	5.55E9	1.90E10	8.78E9	ND	9.24E9	ND	1.61E10
Sr-89	1.26E10	ND	3.61E8	ND	ND	ND	2.59E8
Sr-90	1.22E11	ND	3.10E10	ND	ND	ND	1.52E9
Ag-110m	3.86E8	2.82E8	1.87E8	ND	4.03E8	ND	1.46E10
Cs-134	3.65E10	6.80E10	6.87E9	ND	1.75E10	7.18E9	1.85E8
Cs-137	5.15E10	6.02E10	4.27E9	ND	1.62E10	6.55E9	1.88E8
Ce-144	2.33E6	9.52E5	1.30E5	ND	3.85E5	ND	1.33E8

4.5 Calculation of Dose Factors - in the Ground Plane Pathway (R_i^G [D/Q])

$$R_i^G[D/Q] = K'K''(SF)(DFG_i)\left[\left(1 - e^{-\lambda it}\right) / \lambda_i\right]$$

where: units = m^2 mrem/yr per uCi/sec — Reference Table, R.G. 1.109

K'	=	A constant unit of conversion, 10^6 pCi/μCi.	
K''	=	A constant unit of conversion, 8760 hr/yr	
SF	=	The shielding factor, 0.7(dimensionless)	E-15
λ_i	=	The decay constant for the ith radionuclide, sec^{-1}	
t	=	The exposure period, 4.73 x 10^8 sec (15 years)	
DFGi	=	The ground plane dose conversion factor for the ith radionuclide (mrem/hr per pCi/m^2)	E-6

Reference: The equation deriving R_i^G [D/Q] was taken from NUREG 0133, Section 5.3.1.2.

Table 4-4
Dose Factors Ground Plane Pathway (R_i^G [D/Q])

Nuclide	T. Body	Skin
Mn-54	1.39E9	1.63E9
Fe-55	0	0
Fe-59	2.73E8	3.21E8
Co-60	2.15E10	2.53E10
Ni-63	0	0
Zn-65	7.47E8	8.57E8
Sr-89	2.17E4	2.52E4
Ag-110m	3.44E9	4.02E9
Cs-134	6.85E9	8.00E9
Cs-137	1.03E10	1.20E10
Ce-144	6.95E7	8.05E7

Units are m^2·mrem/yr per µCi/sec

4.6 **CALCULATION OF LIQUID EFFLUENT ADULT INGESTION - DOSE FACTORS**

$$A_{i\tau} = 1.14E5\left(21BF_i + 5BI_i\right)DF_i$$

$A_{i\tau}$ = Composite dose parameter for the total body or critical organ of an adult for nuclide i, for all appropriate pathways, mrem/hr per µCi/ml

1.14E5 = units conversion factor, 10^6pci/µci x 10^3 ml/kg ÷ 8760 hr/yr

BF_i = Bioaccumulation factor for nuclide i, in fish, pCi/kg per pCi/L, from Table A-1 of Regulatory Guide 1.109 (Rev. 1) or Table A-8 of Regulatory Guide 1.109 (original draft).

BI_i = Bioaccumulation factor for nuclide i, in invertebrates, pCi/kg per pCi/L, from Table A-1 of Regulatory Guide 1.109 (Rev. 1) or Table A-8 of Regulatory Guide 1.109 (original draft).

DF_i = Dose conversion factor for nuclide i, for adults in pre-selected organ τ, in mrem/pCi, from Table E-11 or Regulatory Guide 1.109 (Rev. 1) or Table A-3 of Regulatory Guide 1.109 (original draft).

Reference: The equation for Saltwater sites from NUREG 0133, Section 4.3.1, where $U_W/D_W = 0$ since no drinking water pathway exists.

Table 4-5

Liquid Effluent - Adult Ingestion Dose Factors (A_{iT})

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	2.82E-1	2.82E-1	2.82E-1	2.82E-1	2.82E-1	2.82E-1	2.82E-1
Mn-54	ND	7.06E3	1.35E3	ND	2.10E3	ND	2.16E4
Fe-55	5.11E4	3.53E4	8.23E3	ND	ND	1.97E4	2.03E4
Fe-59	8.06E4	1.90E5	7.27E4	ND	ND	5.30E4	6.32E5
Co-60	ND	1.73E3	3.82E3	ND	ND	ND	3.25E4
Ni-63	4.96E4	3.44E3	1.67E3	ND	ND	ND	7.18E2
Zn-65	1.61E5	5.13E5	2.32E5	ND	3.43E5	ND	3.23E5
Sr-89	4.99E3	ND	1.43E2	ND	ND	ND	8.00E2
Sr-90	1.23E5	ND	3.01E4	ND	ND	ND	3.55E3
Ag-110m	1.57E3	1.45E3	1.33E1	ND	2.85E3	ND	5.91E5
Sb-124	2.77E2	5.23E0	1.09E2	6.71E-1	ND	2.15E2	7.83E3
Sb-125	1.77E2	1.97E0	4.20E1	1.80E-1	ND	1.36E2	1.94E3
Cs-134	6.84E3	1.63E4	1.33E4	ND	5.27E3	1.75E3	2.85E2
Cs-137	8.78E3	1.20E4	7.85E3	ND	4.07E3	1.35E3	2.32E2
Ce-144	1.79E2	7.47E1	9.59E0	ND	4.43E1	ND	6.04E4

4.7 SOURCE TERM

Gaseous Releases

CR-3 has been permanently shut down since September 2009 and will remain permanently defueled. All fuel is now on the ISFSI pad. As such, there is no significant releasable noble gas or iodine source term remaining at CR3. With the spent fuel pool drained, there will also be a significantly decreased tritium source term in gaseous releases. The particulate component of any gaseous release should also be minimal. However, because of planned changes in ventilation, particulates, along with tritium, will continue to be sampled and assessed for dose.

Liquids

This section will characterize normal releases and put this characterization in context by deriving a waste concentration or discharge concentration required to challenge the limits of the ODCM – which is 1.5 mrem per quarter total body and 3.0 mrem per year total body.

All releases are made in a batch mode, meaning that waste tanks are first filled, isolated, sampled, and then release permits are prepared specifying the conditions under which the release is to be made. The highest activity releases have been made from WDT-10A and WDT-10B, otherwise known as the evaporator condensate storage tanks (ECSTs). All water, including water that would have gone to the ECST's, will be routed to poly tanks in the Seawater Room and batch released during SAFSTOR 2. It is expected that releases made during SAFSTOR 2 will be less frequent and will contain less radioactivity. This calculation is therefore conservative. These two tanks have a volume of about 1500 gallons each.

A typical release from WDT-10A or WDT-10B had a gamma emitter concentration < 1E-6 µCi/ml (ref. 2017 release data from SP-736L), which is < 4.5E-6 Ci total for the tank.

Example Calculation:

The ODCM limit for total body dose due to liquid releases is 1.5 mrem per quarter.

Assumptions:

Release Volume:	1,500 gallons (maximum for 1 poly tank)
Release Rate:	50 gpm (maximum release rate from poly tank)
Release Duration:	30 minutes (0.5 hours)
Dilution Flow Rate:	60,000 gpm (Approx. equal to 1 CW pump at units 1 & 2)
Isotopic mix:	Cs-137 (due to its relatively high dose factor)

Using ODCM methodology in section 4-2 and solving for the concentration required to reach 1.5 mrem total body:

Concentration in uCi/ml = Dose limit / [Dose Factor)(Duration)(Dilution)]

= 1.5 mrem /(7850 mrem/hr per uCi/ml)(0.5 hours)(50 gpm/60,050 gpm)

= 0.46 uCi/ml (represents a total tank activity of 2.6 Curies of Cs-137)

Note: Without any circ. water dilution flow, the concentration of Cs-137 equates to 3.82E-4 uCi/ml, all other parameters unchanged.

SECTION 5.0

ENVIRONMENTAL MONITORING

Table 5-1

Environmental Radiological Monitoring
Station's Locations

STATION	LOCATION	DIRECTION FROM PLANT	APPROX. DISTANCE FROM PLANT (mi)
C04	State Park Old Dam on River near road intersection	ENE	10.6
C07	Crystal River Public Water Plant	ESE	7.4
C09	Fort Island Gulf Beach	S	3.2
C10	Indian Waters Public Water Supply	ESE	6.0
C13	Mouth of Intake Canal	WSW	3.4
C14H	Head of Discharge Canal	N	0.1
C14M	Midpoint of Discharge Canal	W	1.2
C14G	Discharge Area	W	2.0
C18	Yankeetown City Well	N	5.3
C19	NW Corner State Roads 488 & 495	ENE	9.6
C29	Discharge Area	W	2.0
C30	Intake Area	WSW	3.4
C40	Near E. Site Boundary & well pump - station CR-South #5	E	3.6
C41	Onsite abandoned meteorological tower	SW	0.4
C46	North Pump Station	N	0.4
C47	Office of Radiation Control, Orlando	ESE	78
C48A[1]	Near C46 North Pump Station	N	0.4
C48B[1]	Onsite NNE of CR 4 & 5	NNE	0.9

NOTE: Distances are approximate. More than one type of sample media,(e.g. air and water) are obtained at some stations. For multi-media stations there may be minor difference in distance for each type of sample.

Table 5-2

Environmental Radiological Monitoring
Station's Locations-Groundwater Monitoring Wells

STATION	LOCATION	DIRECTION FROM PLANT	APPROX. DISTANCE FROM PLANT (mi)
*CR3-1S	CR-3 Site Perimeter, Just Outside of Protected Area Fence	ENE	0.2
*CR3-1D	CR-3 Site Perimeter, Just Outside of Protected Area Fence	ENE	0.2
CR3-2	CR-3 Site Perimeter, Just Outside of Protected Area Fence	E	0.1
*CR3-3S	CR-3 Site Perimeter, Just Outside of Protected Area Fence	ESE	0.1
*CR3-3D	CR-3 Site Perimeter, Just Outside of Protected Area Fence	ESE	0.1
CR3-4	CR-3 Site Perimeter, Just Outside of Protected Area Fence	SSE	0.086
CR3-5	CR-3 Site Perimeter, Just Outside of Protected Area Fence	SSW	0.051
CR3-6S	CR-3 Site Perimeter, Just Outside of Protected Area Fence	W	0.038
CR3-6D	CR-3 Site Perimeter, Just Outside of Protected Area Fence	W	0.038
CR3-7	CR-3 Site Perimeter, Just Outside of Protected Area Fence	WNW	0.060
CR3-8	CR-3 Site Perimeter, Just Outside of Protected Area Fence	WNW	0.073
CR3-9	CR-3 Site Perimeter, Just Outside of Protected Area Fence	NW	0.1
CR3-10	CR-3 Site Perimeter, Just Outside of Protected Area Fence	NNE	0.1

The above listed wells have been included in the REMP as a result of information provided in the groundwater flow study completed January 22, 2007 by EnHydro, LLC.

* These wells added to REMP as a result of recommendations made from groundwater flow study completed 11/01/2012 by Gaydos Hydro Services, LLC.

TABLE 5-3

RING TLDs
(INNER RING)

LOCATION	DIRECTION	APPROX. DISTANCE (Mi.)
C27	W	0.4
C60	N	0.9
C61	NNE	0.9
C62	NE	1.2
C63	ENE	0.9
C64	E	0.8
C65	ESE	0.3
C66	SE	0.4
C67	SSE	0.3
C68	S	0.3
C69	SSW	0.3
C41	SW	0.4
C70	WSW	0.7
C71	WNW	0.6
C72	NW	0.3
C73	NNW	0.7

TABLE 5-4

RING TLDs
(5 MILE RING)

LOCATION	DIRECTION	APPROX. DISTANCE (Mi.)
C18	N	5.3
C03	NNE	4.9
C04	NE	6.0
C74	ENE	5.1
C75	E	4.0
C76	ESE	5.6
C08	SE	5.7
C77	SSE	3.4
C09	S	3.2
C14G	W	2.0
C01	NW	4.8
C79	NNW	5.0

FIGURE 5.1
(Environmental Monitoring Sample Station Locations)

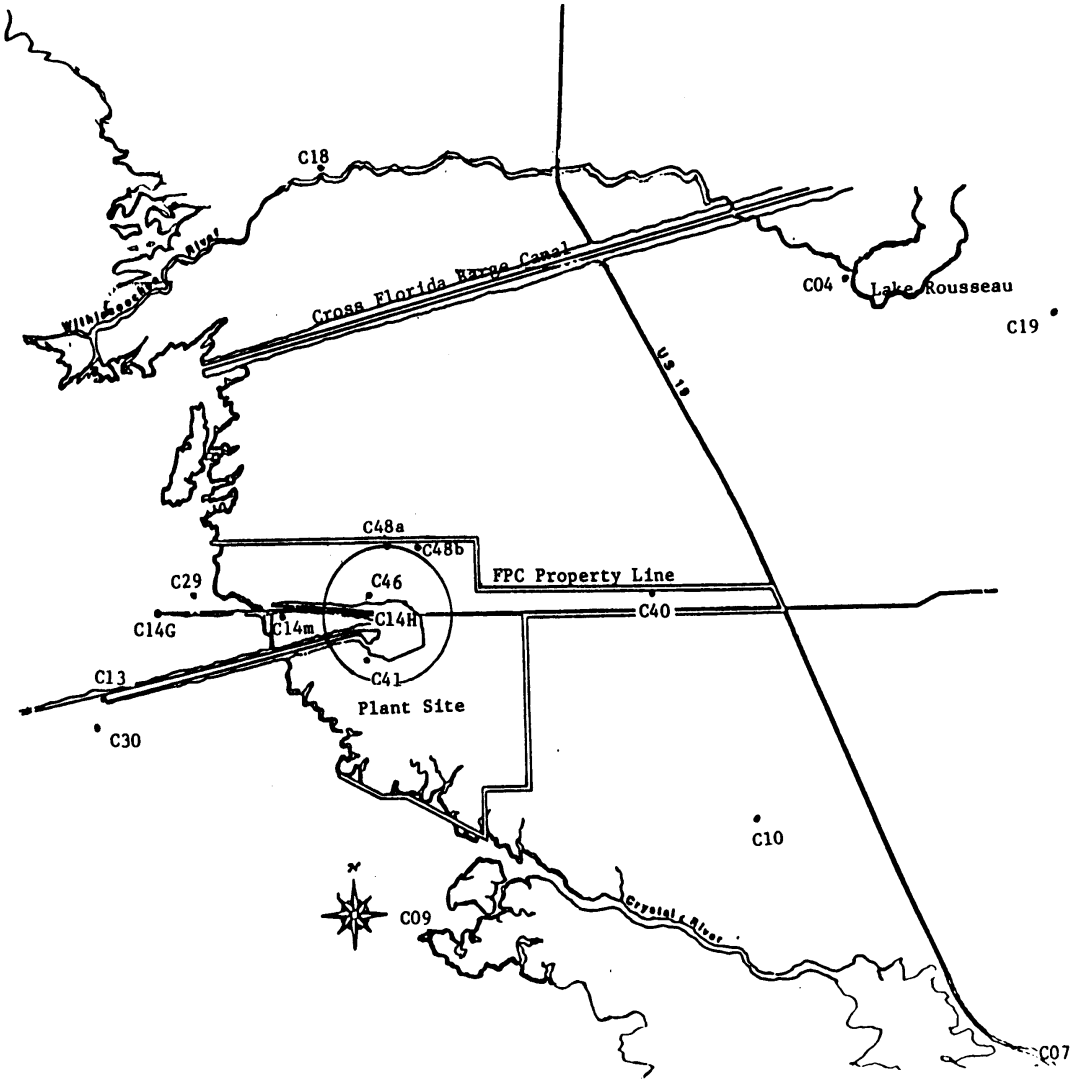


FIGURE 5.2

Environmental Monitoring TLD Locations

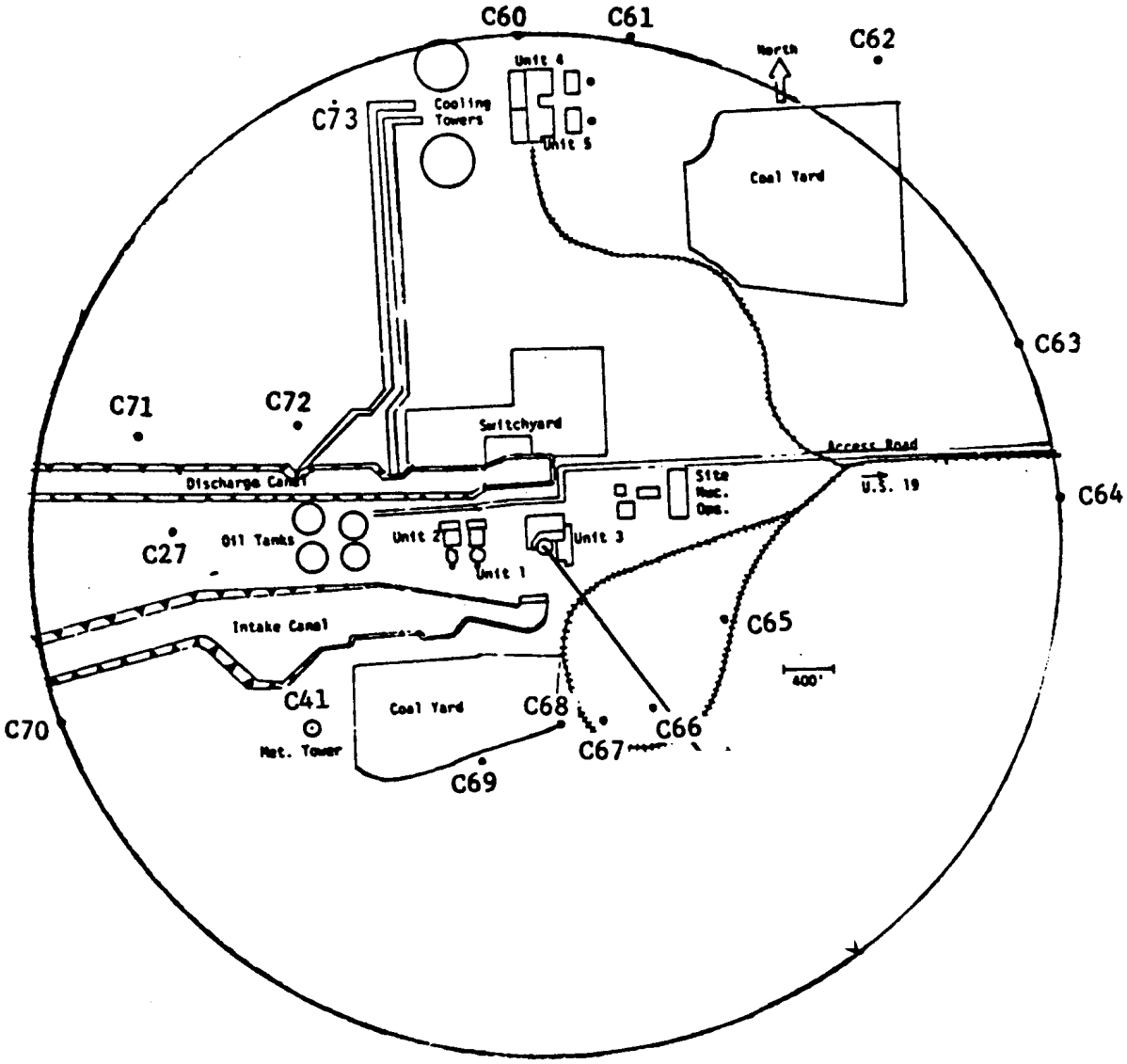


FIGURE 5.3

Environmental Monitoring TLD Locations

(5 mile)

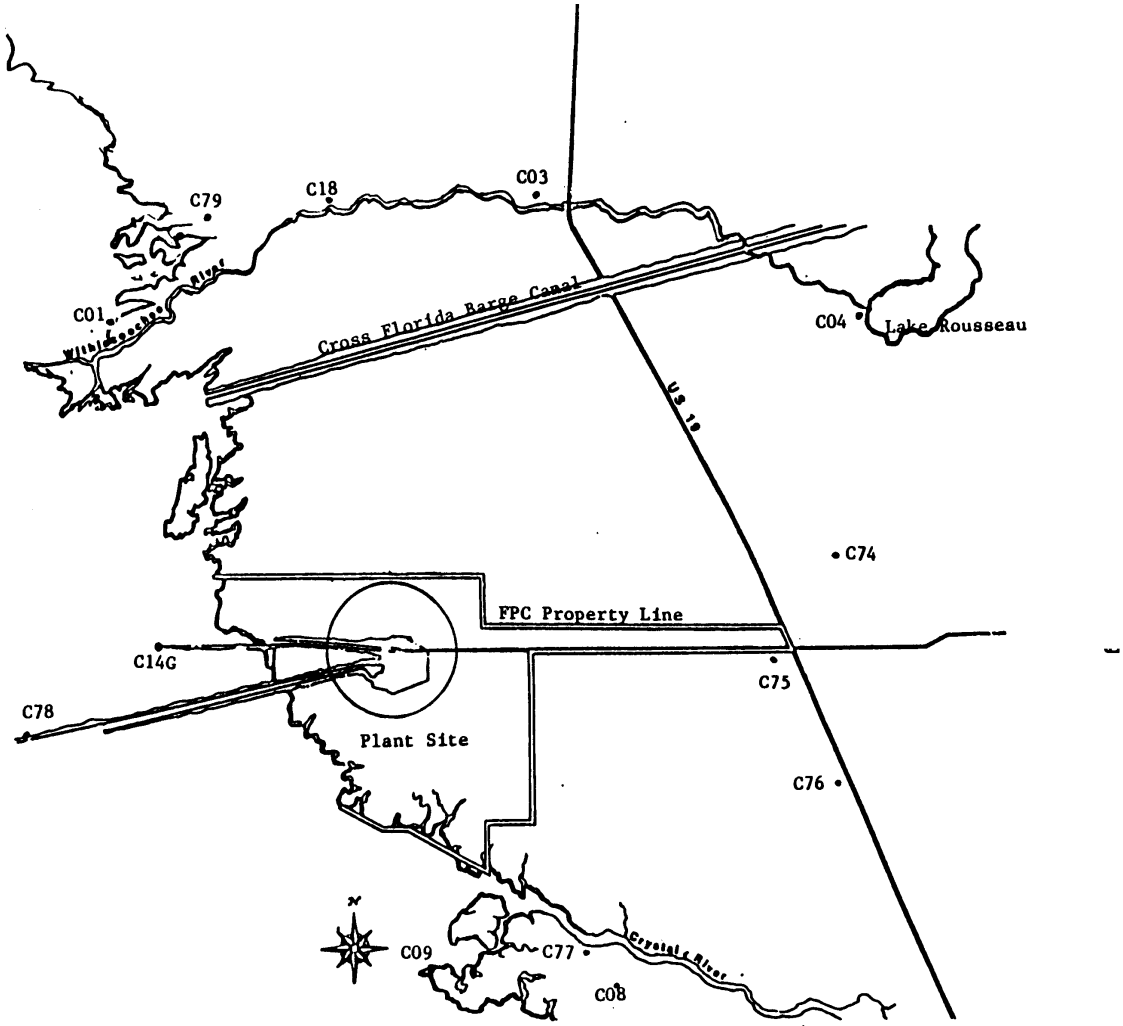
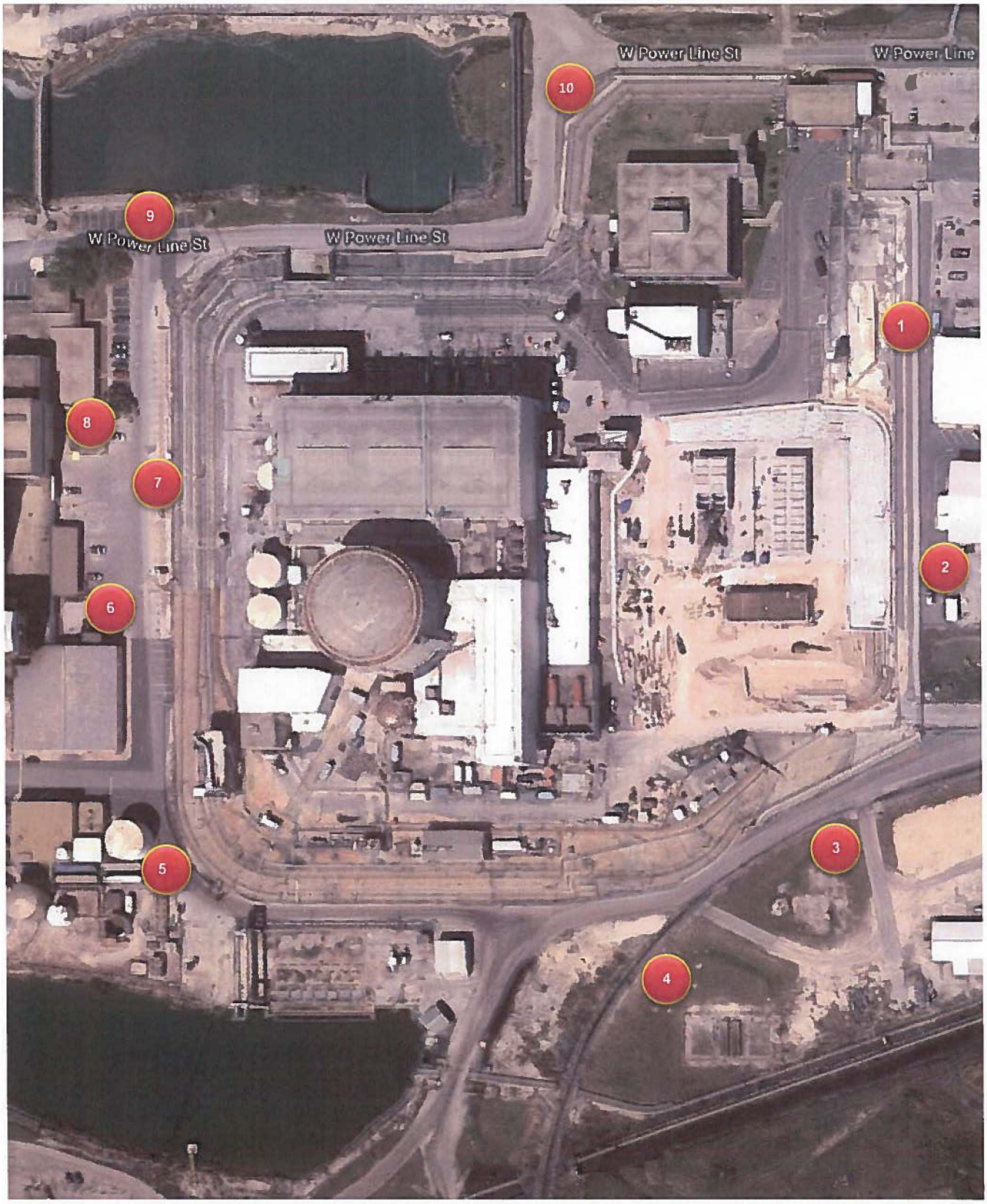


FIGURE 5.4

CR3 Groundwater Monitoring Well Locations

Deep Wells Are Also Installed at #'s 1, 3, 6



Summary of Changes
DRR 2268593

Page(s)	CHANGE
Throughout	Deleted blank sections and re-numbered remaining sections.
Introduction	• Updated titles of Manager Decommissioning and Manager Radiation Protection and Chemistry • Removed reference to instrument setpoint. Liquid and gas effluent monitors do not have trip setpoints.
1	Removed sampling frequencies no longer used
2	Removed reference to liquid effluent monitoring system, gaseous effluent monitoring systems and ventilation treatment systems. These are no longer being used in SAFSTOR.
4	• Removed specific reference to ECST, LSST and SDT tanks and left as generalized “Batch Waste Release Tanks”. • Removed note referencing BWST tank. • Removed required Sr-89 analysis. Due to the relatively short half-life (50.5 days) versus the time since CR3 was last critical in 2009, there is no longer a significant amount of Sr-89 left.
7	Step 2.4.a – Added Note that due to radioactive decay, any dose from noble gas is now insignificant and no sampling is required. Step 2.5 – Added sentence that any noble gas dose is now insignificant.
8	Removed required Sr-89 analysis. (See above). Added Ni-63 and Fe-55 to quarterly composite particulate sample as they now comprise a significant percent of CR3 residual radioactivity.
12	Step 2.7.1 – Removed redundant sentence. Note: Added for clarity that ISFSI calculation 11182-0502 is based on the CR3 site configuration before Partial Site Release implementation.
14	Added note that direct radiation locations C27 and C72 are slightly within the CR3 sight boundary. Also added that Control Location C47 is in Orlando.
19	Added “(if any)” after nearest milk animal. CR3 generally does not have any milk animals identified in the Land Use Census.
21	Step 3.1 – Simplified wording to reference requirements for using the liquid radwaste cleanup system. Step 3.3 – Removed reference to Limiting Condition of Operation since CR3 is not an operating plant. Also removed reference to Appendix I as it is redundant. Step 3.4 – Removed reference to dose rate from noble gas effluents as CR3 no longer has a significant noble gas source term.
22	Step 3.5 - Removed reference to Limiting Condition of Operation since CR3 is not an operating plant. Also removed reference to Appendix I as it is redundant.

Page(s)	CHANGE
23	Step 3.6 – Removed detailed discussion pertaining contribution to Member of Public Dose from other uranium fuel cycle facilities. This does not apply to CR3.
25	• Added exhaust rate from Seawater Room Exhaust Pathway • Added X/Q value that will apply once Partial Site Release becomes effective and the Site Boundary is moved in closer to the plant.
26	• Removed reference to Sr-89 in the calculation as it is no longer present in significant amounts. • Added note to Dilution (D) flow indicating that there could be no dilution flow.
27	Step 2.1 – Added note that due to plant shutdown that dose projections from gaseous effluents is unlikely to be needed.
28	Added reference to Seawater Room exhaust of particulates and tritium
30	Added X/Q and D/Q values that will apply when Partial Site Release is approved and the Site Boundary is moved closer to the plant. Also removed reference to critical receptor X/Q and D/Q values as CR3 does not use these.
31	Added note that dilution flow rate could also include dilution flow from the new Combined Cycle plants.
41	• Removed example calculations for dose due to gaseous releases. CR3 no longer has a significant dose contribution from gaseous releases. • Removed discussion on historical liquid effluent radionuclide concentrations from 2005 to 2013. Added information pertaining to liquid releases from the Seawater Room. • Made changes to the example calculation to reflect a batch release from the Seawater Room poly tanks.
50	Figure 5.4 - Updated map with a more recent view of CR3