Hickman, John

From: Nick Williams <dewilliams1@energysolutions.com>
Sent: Thursday, May 04, 2017 4:13 PM
To: Hickman, John; Vaaler, Marlayna
Cc: Gerard P. Van Noordennen
Subject: [External_Sender] Zion Ops-DCGL TSD
Attachments: 2017-05-04 TSD 17-004 Rev 0 Operational DCGLs FINAL.pdf

Good Afternoon John and Marlayna,

I've attached the approved Rev 0 of our Ops DCGL TSD for your review. I wanted to call your attention to one section that Eric Darois had suggested relative to implementation. Recognizing that we have waived AF/EMCs which would have allowed measurements above Base Case (25 mrem DCGLs) for small areas, we plan to implement surveys using our lower Operational DCGLs as follows:

"In a Class 1 FSS unit, the SOF (based on the Operational DCGL) for a systematic sample/measurement(s) may exceed one without remediation as long as the survey unit passes the Sign Test and, the SOF for the sample/measurement(s) does not exceed one when using the Base Case DCGLs" (i.e. A Survey Unit must pass the Sign Test based on the lower Operational DCGLs.) Single -measurements (i.e. small areas) in the passing Survey Unit may exceed the lower Ops DCGL, but must be below the Base Case (25 mrem) DCGL. I understand that Gerry is lining up a call for us next week so if possible could you guys give us some feedback on this approach when we talk.

Thanks! Nick

Donald E. Williams Jr. (Nick)
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TSD 17-004

OPERATIONAL DERIVED CONCENTRATION GUIDELINE LEVELS FOR FINAL STATUS SURVEY

Revision 0

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TABLE OF CONTENTS

1. PURPOSE

Derived Concentration Guideline Levels (DCGL) are established to demonstrate compliance with the 25 mrem/yr unrestricted release criterion. DCGLs are calculated by analysis of various pathways (direct radiation, inhalation, ingestion, etc.), media (e.g., concrete, pipe, soils and groundwater) and scenarios through which exposures could occur. Chapter 6 of the Zion License Termination Plan (LTP) (Reference 1) describes in detail the approach, modeling parameters and assumptions used to develop the DCGLs (referred to as Base Case DCGLs) that will be used for the Final Status Survey (FSS) of the Zion Nuclear Power Station (ZNPS). Each Base Case DCGL represents a total dose of 25 mrem/yr. At ZNPS, compliance is demonstrated through the summation of dose from four distinct source terms for the end-state (basements, soils, buried pipe and groundwater). Basements are comprised of the summation of four structural source terms (surfaces, embedded pipe, penetrations and fill). As the summation of dose from each source term must be 25 mrem/yr or less, the Base Case DCGLs are reduced based on an expected, or *a priori*, fraction of total dose from each source term. These reduced DCGLs will be called Operational DCGLs. This Technical Support Document (TSD) details the Operational DCGLs derived for each dose component and the basis for the dose fractions used.

2. DISCUSSION

Each radionuclide-specific DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a Total Effective Dose Equivalent (TEDE) of 25 mrem per year to an Average Member of the Critical Group (AMCG). When applied to backfilled basement surfaces below 588 foot elevation, embedded pipe and penetrations, the DCGLs are expressed in units of activity per unit of area (pCi/m^2). When applied to soil, the DCGLs are expressed in units of activity per unit of mass (pCi/g). For buried piping, DCGLs are calculated and expressed in units of activity per surface area (dpm/100 cm^2).

There will be four distinct source terms for the end-state at Zion: backfilled basements, soil, buried piping and groundwater. Demonstrating compliance with the dose criterion requires the summation of dose from the four source terms as shown in Equation 1 (reproduced from Equation 6-11 from LTP Chapter 6, section 6-17).

The final compliance dose will be calculated using Equation 1 after FSS has been completed in all survey units. The results of the FSS performed for each FSS unit will be reviewed to determine the maximum mean dose from each of the four source terms (e.g., basement, soil, buried pipe and existing groundwater if applicable). The compliance dose must be less than 25 mrem/yr. As the summation of dose from each source term must be 25 mrem/yr or less, the Base Case DCGLs are reduced based on an expected, or *a priori*, fraction of total dose from each media type. The reduced DCGLs are the Operational DCGLs.

Equation 1

Compliance Dose = Max Backfilled Basement + Max Soil + Max Buried Pipe + Max Groundwater

where:

Compliance Dose	=	Dose to Resident Farmer AMCG (mrem/yr),
Max Backfilled Basement	=	Maximum Basement survey unit dose (including surface, embedded pipe, penetrations and fill [if required]),
Max Soil	=	Maximum dose from open land survey units (mrem/yr),
Max Buried Pipe	=	Maximum dose from buried piping (mrem/yr),
Max Groundwater	=	Maximum dose from existing groundwater

The terms for Backfilled Basement, Soil and Buried Pipe use the maximum observed mean dose from FSS. The mean dose fraction is derived by dividing the mean dose by 25 mrem/yr.

The dose fraction for the "Max Groundwater" term will be determined based on the analysis of water samples taken from sample wells established at and around Zion. There has been no groundwater contamination identified by the groundwater monitoring program to date at Zion. It is expected that the potential for future groundwater contamination is also very low. Consequently, the *a priori* dose fraction assumed for groundwater is based on the Minimum Detectable Concentration (MDC) for groundwater analysis, which results in a dose of 1 mrem/yr (or a dose fraction of 0.040).

The dose fraction for the "Max Soil" and "Max Buried Pipe" variables will be determined based on the result of FSS. The Radionuclide-of-Concern (ROC) concentration in each systematic sample/measurement taken in each FSS unit will be divided by its applicable Operational DCGL ($OpDCGL_{SS}$ for surface soil, $OpDCGL_{SB}$ for subsurface soil and $OpDCGL_{BP}$ for buried pipe) to derive a Sum-of-Fraction (SOF) for the ROC. The actual recorded value will be used as the recorded FSS result for measurement and/or sample values that are less than MDC. The SOF for each ROC will be summed to derive a SOF that represents the sample/measurement. The sample/measurement SOF will be used as the weighted sum (W_s) for performing the Sign test. If the number of positive differences is greater than or equal to the critical value for the number of sample/measurements (n) and chosen Type 1 Error (α), then the null hypothesis will be rejected and the FSS data set will pass the Sign test.

The dose fraction for the "Max Backfilled Basement" variable includes the dose contributions from walls and floors (including the steel liner in Containment), defined as structural surfaces, plus the dose contributions from embedded pipe, penetrations and concrete fill (applicable where clean concrete debris is used as fill). Each of these dose

components are surveyed separately during FSS. The summation of the mean dose from each of these dose components provides the total backfilled basement dose for the Basement FSS unit. The backfilled basement with the maximum mean dose will be used for the "Max Backfilled Basement" term in Equation 1.

The dose from concrete fill is predetermined in accordance with LTP Chapter 5, Table 5-16, and is currently based on a maximum allowable MDC of 5,000 dpm/100cm^2, which is a conservative assumption. This is solely a bounding value and not indicative of the actual MDC values experienced when unrestricted release surveys (URS) were performed on the concrete, which were significantly lower. After all URS have been completed on the remainder of the concrete that will be reused as clean fill, the dose from fill in Table 5-16 will be recalculated based on the actual maximum MDC observed during the performance of the URS.

For structural surfaces, embedded pipe and penetrations, the ROC concentration in each systematic sample/measurement taken in each FSS unit will be divided by its applicable Operational DCGL ($OpDCGL_B$ for structural surfaces, $OpDCGL_{EP}$ for embedded pipe and $OpDCGL_{PN}$ for penetrations) to derive a SOF for the ROC. The SOF for each ROC will be summed to derive a SOF that represents the sample/measurement. The sample/measurement SOF will be used as the weighted sum (W_S) for performing the Sign test. If the number of positive differences is greater than or equal to the critical value for the number of sample/measurements (n) and chosen Type 1 Error (α), then the null hypothesis will be rejected and the FSS data set will pass the Sign test.

In all cases (backfilled basements, soil and buried pipe), if the SOF for a systematic sample/measurement (based on the Operational DCGL) exceeds "one", or "0.5" in a Class 3 survey unit, then an investigation will be initiated in accordance with LTP Chapter 5, section 5.6.4.6 (Table 5-20). In Class 3 and Class 2 FSS units, the result of the investigation may prompt the reclassification of the survey unit (or a portion of the survey unit). In a Class 1 FSS unit, the SOF (based on the Operational DCGL) for a systematic sample/measurement(s) may exceed one without remediation as long as the survey unit passes the Sign Test and the SOF for the sample/measurement(s) does not exceed one when using the Base Case DCGLs.

The results of any judgmental sample/measurements will also be compared to the Operational DCGL. As with a systematic sample/measurement, any judgmental sample/measurement that exceeds a SOF of one, or 0.5 in a Class 3 survey unit, will prompt an investigation, reclassification and/or resurvey as applicable. However, remediation will not be required unless the sample/measurement exceeds unity when compared to the applicable Base Case DCGLs.

In Class 1 open land FSS units, any areas of elevated residual radioactivity above the $DCGL_{EMC}$ will be remediated. The $DCGL_{EMC}$ calculation will use Base Case DCGLs ($DCGL_{SS}$ from Table 2 and/or $DCGL_{SB}$ from Table 3). In Class 1 buried pipe, any residual

radioactivity greater than the Base Case DCGL for buried pipe ($DCGL_{BP}$ from Table 4) will be remediated. In all Class 1 structural surfaces, any residual radioactivity greater than the Base Case DCGLs for structures ($DCGL_B$ from Table 1) will be remediated. For all Class 1 embedded pipe and penetrations, any residual radioactivity greater that the Base Case DCGLs for embedded pipe ($DCGL_{EP}$ from Table 5) or penetrations ($DCGL_{PN}$ from Table 6) will be remediated. Any residual radioactivity in Class 1 embedded pipe and penetrations greater than the Base Case DCGLs for the structural surfaces ($DCGL_B$ from Table 1) where the pipe or penetration interface will require further remediation and/or grouting of the pipe.

Once a FSS unit passes the Sign test, the mean concentration for each ROC based on the systematic sample/measurements will be divided by the applicable Base Case DCGL to derive a mean dose SOF for each ROC (with the LTP Chapter 5 Equation 5-9 equation applied as applicable). The mean dose SOF for each ROC is then summed and multiplied by 25 mrem/yr to provide the mean dose for the FSS unit. For Basement FSS units, the mean dose for each dose component (structural surfaces, embedded pipe and penetrations) is summed and added to the applicable fill dose to derive the mean dose for the Basement FSS unit. The mean dose from FSS will also include the dose from judgmental sample/measurements based on an area-weighted average approach using the applicable Base Case DCGL.

3. BASIS FOR DETERMINING OPERATIONAL DCGLS

The Base Case DCGLs from LTP Chapter 5 are reproduced as follows;

Table 1 Base Case Basement DCGLs ($DCGL_B$) – (from LTP Chapter 5, Table 5-3)

Nuclide	Auxiliary Building (pCi/m²)	Containment (pCi/m²)	SFP/Transfer Canal (pCi/m²)	Turbine Building (pCi/m²)	Crib House /Forebay (pCi/m²)	WWTF (pCi/m²)
H-3	5.30E+08	2.38E+08	2.38E+08	1.29E+08	1.93E+08	1.71E+07
Co-60	3.04E+08	1.57E+08	1.57E+08	7.03E+07	5.52E+07	2.83E+07
Ni-63	1.15E+10	4.02E+09	4.02E+09	2.18E+09	3.25E+09	2.89E+08
Sr-90	9.98E+06	1.43E+06	1.43E+06	7.74E+05	1.16E+06	1.03E+05
Cs-134	2.11E+08	3.01E+07	3.01E+07	1.59E+07	2.13E+07	2.31E+06
Cs-137	1.11E+08	3.94E+07	3.94E+07	2.11E+07	2.96E+07	2.93E+06
Eu-152	6.47E+08	3.66E+08	3.66E+08	1.62E+08	1.23E+08	7.55E+07
Eu-154	5.83E+08	3.19E+08	3.19E+08	1.43E+08	1.12E+08	5.74E+07

Note 1: The DCGL for the SFP/Transfer Canal was set equal to the lower of either the Auxiliary Building or Containment DCGLs. The Containment DCGLs were lower for all ROC; therefore, the SFP/Transfer Canal DCGLs were set equal to Containment DCGLs.

Table 2 Base Case DCGLs for Surface Soils ($DCGL_{SS}$) – (from LTP Chapter 5, Table 5-4)

Radionuclide	Surface Soil DCGL (pCi/g)
Co-60	4.26
Cs-134	6.77
Cs-137	14.18
Ni-63	3572.10
Sr-90	12.09

Table 3 Base Case DCGLs for Subsurface Soils ($DCGL_{SB}$) – (from LTP Chapter 5, Table 5-5)

Radionuclide	Subsurface Soil DCGL (pCi/g)
Co-60	3.44
Cs-134	4.44
Cs-137	7.75
Ni-63	763.02
Sr-90	1.66

Table 4 Base Case DCGLs for Buried Pipe ($DCGL_{BP}$) – (from LTP Chapter 5, Table 5-6)

Radionuclide	Buried Piping DCGL (dpm/100 cm^2)
Co-60	2.64E+04
Cs-134	4.54E+04
Cs-137	1.01E+05
Ni-63	4.89E+07
Sr-90	4.50E+04

Table 5 Base Case DCGLs for Embedded Pipe ($DCGL_{EP}$) – (from LTP Chapter 5, Table 5-7)

Radionuclide	Auxiliary Bldg. Basement Embedded Floor Drains (pCi/m²)	Turbine Bldg. Basement Embedded Floor Drains (pCi/m²)	Unit 1 & Unit 2 Containment In-Core Sump Embedded Drain Pipe (pCi/m²)	Unit 1 & Unit 2 Steam Tunnel Embedded Floor Drains (pCi/m²)	Unit 1 & Unit 2 Tendon Tunnel Embedded Floor Drains (pCi/m²)
H-3	N/A	N/A	8.28E+09	N/A	1.61E+10
Co-60	7.33E+09	6.31E+09	5.47E+09	4.07E+10	1.06E+10
Ni-63	2.78E+11	1.96E+11	1.40E+11	1.26E+12	2.72E+11
Sr-90	2.41E+08	6.94E+07	4.98E+07	4.48E+08	9.70E+07
Cs-134	5.10E+09	1.43E+09	1.05E+09	9.22E+09	2.04E+09
Cs-137	2.68E+09	1.89E+09	1.37E+09	1.22E+10	2.67E+09
Eu-152	N/A	N/A	1.28E+10	N/A	2.48E+10
Eu-154	N/A	N/A	1.11E+10	N/A	2.16E+10

Table 6 Base Case DCGLs for Penetrations ($DCGL_{PN}$) – (from LTP Chapter 5, Table 5-8)

Nuclide	Auxiliary Bldg. (pCi/m²)	Containment (pCi/m²)	SFP/ Transfer Canal (pCi/m²)	Turbine Bldg. (pCi/m²)	Crib House/ Forebay (1) (pCi/m²)	WWTF[1] (pCi/m²)
H-3	3.99E+09	3.42E+09	4.84E+16	3.23E+09	N/A	N/A
Co-60	8.82E+07	2.26E+09	4.45E+08	1.76E+09	N/A	N/A
Ni-63	6.79E+10	5.78E+10	1.86E+14	5.48E+10	N/A	N/A
Sr-90	2.41E+07	2.06E+07	9.26E+10	1.94E+07	N/A	N/A
Cs-134	3.28E+08	4.32E+08	7.48E+08	4.00E+08	N/A	N/A
Cs-137	6.17E+08	5.66E+08	1.46E+09	5.29E+08	N/A	N/A
Eu-152	3.29E+08	5.26E+09	9.44E+08	4.06E+09	N/A	N/A
Eu-154	2.33E+08	4.58E+09	8.53E+08	3.58E+09	N/A	N/A

As the Base Case DCGLs represent the dose criterion, a reduction is required to ensure compliance with Equation 1. The reduced DCGLs, or "Operational" DCGLs can be related to the Base Case DCGLs as an expected fraction of dose based on an *a priori* assessment of what the expected dose should be based on the results of site characterization, process knowledge and the extent of planned remediation.

Equation 2

$$f = \frac{D_{exp}}{25}$$

where:

f	=	expected fraction of dose
D_{exp}	=	*a priori* expected dose based on characterization, process knowledge and the extent of planned remediation
25	=	25 mrem/yr dose criteria for unrestricted release

3.1. Operational DCGLs for Basement FSS Units

An *a priori* fraction of dose will be applied to each source term in a basement FSS unit (structural surfaces, embedded pipe and penetrations). The *a priori* fraction of dose for the fill variable is determined by dividing the appropriate assigned dose from fill in LTP Chapter 5, Table 5-16, by 25 mrem/yr.

The sum of the *a priori* fraction of allowable dose for a basement FSS unit ($f_{Basement}$), including the dose assigned from the use of concrete debris as fill (Table 5-16) is;

Equation 3

$$f_{Basement} = f_B + f_{PN} + f_{EP} + f_{CF}$$

where:

f_B	=	*a priori* fraction of dose for surfaces (walls and floors)
f_{PN}	=	*a priori* fraction of dose for penetrations
f_{EP}	=	*a priori* fraction of dose for embedded pipe
f_{CF}	=	*a priori* fraction of dose for concrete fill (LTP Chapter 5, Table 5-16)

Operational DCGLs for Basement FSS units are derived by multiplying the applicable Base Case DCGL ($DCGL_B$ from Table 1, $DCGL_{EP}$ from Table 5 or $DCGL_{PN}$ from Table 6) by the expected fraction of allowable dose for each basement dose component. The Operational DCGL is then used as the DCGL for the FSS design of the survey unit (calculation of surrogate DCGLs, investigations levels, etc.).

As stated previously, the dose from fill is currently based on a maximum allowable MDC of 5,000 dpm/100cm^2. After all URS have been completed on the remainder of the concrete that will be reused as clean fill, the dose from fill in Table 5-16 will be recalculated based on the actual maximum MDC observed during the performance of the URS. At that time, this TSD will be revised to incorporate the revised fraction for fill for the $f_{Basement}$ term using the actual maximum observed MDC.

3.2. Operational DCGLs for Soil and Buried Pipe FSS Units

The same process described above for the determination of operational DCGLs for Basement FSS units will also be applied to the site compliance equation. An *a priori* fraction of dose will be applied to soils and buried pipe such that the sum of the expected fraction of allowable dose for soils, buried pipe and groundwater, when added to the maximum *a priori* dose from basement structures, is less than or equal one.

Equation 4

$$1 \geq f_{Basement} + f_{Soil} + f_{BP} + f_{GW}$$

where:

$f_{Basement}$	=	*a priori* fraction of dose for maximum basement survey unit
f_{soil}	=	*a priori* fraction of dose for maximum soil survey unit
f_{BP}	=	*a priori* fraction of dose for maximum buried pipe survey unit
f_{GW}	=	*a priori* fraction of dose for maximum groundwater

Once the FSS of basements is complete, an actual fraction of allowable dose will be calculated for each Basement FSS unit based on the measured mean SOF for each ROC. The actual fraction of allowable dose from the Basement FSS unit with the highest dose will be used in Equation 4 for the $f_{Basement}$ term. It is anticipated that the actual maximum dose fraction will be significantly less than the *a priori* fraction used to derive the Operational DCGLs, mostly due to conservative assumptions used for remediation effectiveness.

When Basement FSS is completed, the actual fraction of allowable dose from the Basement FSS unit with the highest dose will be subtracted from the *a priori* fraction assigned to basements and the difference will be allocated to the *a priori* fractions for soil (f_{soil}) and/or buried pipe (f_{BP}). This TSD will be revised at that time to reflect the new *a priori* dose fractions and new Operational DCGLs for soil and buried pipe. All FSS performed on soil and buried pipe survey units prior to the completion of FSS of all Basement survey units will comply with the Operational DCGLs documented in this TSD.

4. DETERMINATION OF *A PRIORI* DOSE FRACTIONS

Using the results of characterization data, process knowledge and the extent of expected remediation, the *a priori* dose fractions assigned to each basement dose component are presented in Table 7. The fractions were determined based on the mean concentrations for each ROC measured during characterization and also takes into account anticipated remediation for ALARA purposes. These fractions will be used as the *a priori* fractions for determining operational DCGLs for basements (structural surfaces, embedded pipe and penetrations).

The maximum *a priori* total dose fraction for a basement FSS unit when summing each dose component fraction within each basement is 0.448. This is the value that will be currently applied to the site compliance equation for the expected fraction of dose for the maximum basement survey unit variable ($f_{Basement}$). The remaining dose fraction for the compliance equation, assuming $f_{Basement}$ at 0.448, is 0.552. The expected fraction of dose for the groundwater term (f_{GW}) due to instrument MDC is assumed to be 0.040. The remaining dose fraction of 0.512 is distributed between soil and buried pipe at 0.256 each. FSS surveys of open land and buried pipe survey units performed prior to the completion of the FSS of structures will be performed using these *a priori* fractions and the resulting Operational DCGLs. Once the FSS of structures is complete, the soil and buried pipe Operational DCGLs will be revised by incorporating the difference between the *a priori* fraction of dose for the maximum basement ($f_{Basement}$) and the actual fraction of dose for the maximum basement as measured by FSS results.

For example, if following FSS, the maximum dose attributed to a backfilled basement based on the mean SOF for each ROC equals 10 mrem/yr (summation of mean dose from structures, embedded pipe, penetrations and fill), with a corresponding actual fraction of allowable dose of 0.400.

The *a priori* dose fraction for structures ($f_{Basement}$) was 0.488. The difference between the *a priori* dose fraction (0.488) and the measured dose fraction (0.400) would be 0.088. This difference would then be added to increase the *a priori* dose fraction for soils (f_{soil}), the *a priori* dose fraction for buried pipe (f_{BP}), or a combination of both by 0.088. The establishment of final soil and buried pipe Operational DCGLs will be documented in a revision to this TSD and in subsequent FSS survey design packages and release records. Revision of any completed release records for any FSS performed prior to the establishment of final soil and buried pipe Operational DCGLs will not be necessary as the Operational DCGLs used will be based on a lower *a priori* dose fraction.

Table 7 *a priori* Dose Fractions (f) for Basements

Basement FSS Unit	Surfaces (f_B)		Embedded Pipe (f_{EP})		Penetrations (f_{PN})		Fill (f_{CF})		Total ($f_{Basement}$)
	Dose Component	Fraction of 25 mrem/yr dose limit	Dose Component	Fraction of 25 mrem/yr dose limit	Dose Component	Fraction of 25 mrem/yr dose limit	Dose Component	Fraction of 25 mrem/yr dose limit	
Auxiliary Building Basement	Floors and Walls	0.323	Floor Drains	0.007[1]	Penetrations	0.079	Fill	0.040	0.448
Unit 1 Containment Basement	Floors and Walls (Total)	0.209	In-Core Sump Drain	0.080	Penetrations	0.068	Fill	0.071	0.448
	(Dose Fraction Allocation by Area)								
	Floors and Walls Above 565 ft.	0.125	Tendon Tunnel Drain	0.020					
	Under-Vessel Area	0.084							
Unit 2 Containment Basement	Floors and Walls (Total)	0.209	In-Core Sump Drain	0.080	Penetrations	0.068	Fill	0.071	0.448
	(Dose Fraction Allocation by Area)								
	Floors and Walls Above 565 ft.	0.125	Tendon Tunnel Drain	0.020					
	Under-Vessel Area	0.084							
SFP/Transfer Canal	Floors and Walls[2]	0.209	N/A	N/A	Penetrations[3]	0.233	Fill	0.006	0.448
Turbine Building Basement	Floors and Walls, Circulating Water Intake Pipe, Circulating Water Discharge Pipe (Total)	0.145	560 ft Floor Drains	0.040	Penetrations	0.080	Fill	0.063	0.448
	(Dose Fraction Allocation by Area)		U1 Steam Tunnel Drains	0.040					
	Discharge Tunnel Wall/Floor	0.075	U2 Steam Tunnel Drains	0.040					
	Turbine Walls/Floors, Buttress Pit/Tendon Tunnels, Circulating Water Intake Pipe, Circulating Water Discharge Piping	0.070	U1Tendon Tunnel Drain	0.020					
			U2 Tendon Tunnel Drain	0.020					
Crib House/Forebay	Floors and Walls[2]	0.385	N/A	N/A	N/A	N/A	Fill	0.063	0.448
WWTF	Floors and Walls[2]	0.192	N/A	N/A	N/A	N/A	Fill	0.256	0.448

(1) The FSS of the Auxiliary Building 542 ft. embedded floor drain has been completed. The FSS results produced a mean SOF of 0.1696, equating to a dose of 4.2410 mrem/yr. Following FSS, the Auxiliary Building 542 ft. embedded floor drains were grouted to refusal. The *a priori* dose fraction is based on a conservative estimate of diffusion release through the grout and the FSS dose.

(2) SFP/Transfer Canal Floor/Wall dose set equal to Containment Floor/Wall dose to ensure Operation DCGL is equal to the lesser of Containment or Auxiliary Basement Operational DCGL, consistent with approach used to calculate SFP/Transfer Canal DCGL in LTP Rev 1 section 6.6.8.1 and Footnote (1) to LTP Rev 1 Table 6-26.

(3) Dose fraction by calculation only to add margin allowed to sum basement dose to maximum basement dose of 0.448. Actual dose estimate is less.

5. OPERATIONAL DCGL VALUES

Operational DCGLs are derived by multiplying the Base Case DCGLs (Table 1 through Table 6) by the applicable *a priori* fraction of dose in Table 7. The structural surface dose component for Unit 1 and Unit 2 Containment structural surfaces are further divided into two distinct areas, the surface area above the 565 ft. elevation and the Under-vessel Area below the 565 ft. elevation. The structural surfaces in the Turbine Building are also divided into two distinct areas, the summation of the surface area for the floors and walls, the buttress pits, the tendon tunnels, the Circulating Water Discharge Pipe and the Circulating Water Intake Pipe and the surface area attributed to the Circulating Water Discharge Tunnels. In these cases, the Operational DCGLs were calculated using a weighted average approach using the following equation.

Equation 5

$$DCGL_{OP} = DCGL_{BC} * f_B * \left(\frac{Area_{Total}}{Area_{Surf}}\right)$$

where;

$DCGL_{OP}$ = Operational DCGL

$DCGL_{BC}$ = Base Case DCGL

f_B = *a priori* Dose Fraction for Structural Surface area (from Table 7)

$Area_{Total}$ = Total Area of all Structural Surfaces in Basement FSS unit (from LTP Chapter 5, Table 5-18) in m^2

$Area_{Surf}$ = Surface Area of the specific structural surface area (e.g. In-Core Area = 294 m^2, Discharge Tunnel = 4,868 m^2) or, the Total Area minus the Surface Area of the specific structural surface area (e.g. total Containment Area of 3,482 m^2 minus the In-Core Area of 294 m^2 = 3,188 m^2 or, total Turbine Area of 27,135 m^2 minus the Discharge Tunnel Area of 4,868 m^2 = 22,267 m^2

The operational DCGLs for FSS at Zion are presented in the following tables;

Table 8 Operational Basement DCGLs ($OpDCGL_B$) (pCi/m²)

ROC	Auxiliary Building	Unit 1 Containment (above 565 ft)	Unit 1 Containment Under-vessel	Unit 2 Containment (above 565 ft)	Unit 2 Containment Under-vessel	SFP/Transfer Canal
H-3	1.71E+08	3.25E+07	2.37E+08	3.25E+07	2.37E+08	4.98E+07
Co-60	9.81E+07	2.15E+07	1.56E+08	2.15E+07	1.56E+08	3.28E+07
Ni-63	3.71E+09	5.50E+08	4.00E+09	5.50E+08	4.00E+09	8.41E+08
Sr-90	3.22E+06	1.96E+05	1.42E+06	1.96E+05	1.42E+06	2.99E+05
Cs-134	6.81E+07	4.12E+06	2.99E+07	4.12E+06	2.99E+07	6.30E+06
Cs-137	3.58E+07	5.39E+06	3.92E+07	5.39E+06	3.92E+07	8.24E+06
Eu-152	2.09E+08	5.00E+07	3.64E+08	5.00E+07	3.64E+08	7.66E+07
Eu-154	1.88E+08	4.36E+07	3.17E+08	4.36E+07	3.17E+08	6.67E+07

Table 8 (cont) Operational Basement DCGLs ($OpDCGL_B$) (pCi/m²)

ROC	Turbine Building (Floors & Walls)	Turbine Building (Circ Water Discharge Tunnel)	Crib House/ Forebay	WWTF
H-3	1.10E+07	5.39E+07	7.43E+07	3.28E+06
Co-60	5.98E+06	2.94E+07	2.13E+07	5.43E+06
Ni-63	1.85E+08	9.11E+08	1.25E+09	5.55E+07
Sr-90	6.58E+04	3.24E+05	4.47E+05	1.98E+04
Cs-134	1.35E+06	6.65E+06	8.20E+06	4.44E+05
Cs-137	1.79E+06	8.82E+06	1.14E+07	5.63E+05
Eu-152	1.38E+07	6.77E+07	4.74E+07	1.45E+07
Eu-154	1.22E+07	5.98E+07	4.31E+07	1.10E+07

Table 9 Operational DCGLs for Embedded Pipe ($OpDCGL_{EP}$) (pCi/m²)

Radionuclide	Auxiliary Bldg. Basement Embedded Floor Drains(1)	Turbine Bldg. Basement Embedded Floor Drains	Unit 1 Containment In-Core Sump Embedded Drain Pipe	Unit 2 Containment In-Core Sump Embedded Drain Pipe	Unit 1 & Unit 2 Steam Tunnel Embedded Floor Drains	Unit 1 Tendon Tunnel Embedded Floor Drains	Unit 2 Tendon Tunnel Embedded Floor Drains
H-3	N/A	N/A	6.62E+08	6.62E+08	N/A	3.22E+08	3.22E+08
Co-60	7.33E+09	2.52E+08	4.38E+08	4.38E+08	1.63E+09	2.12E+08	2.12E+08
Ni-63	2.78E+11	7.84E+09	1.12E+10	1.12E+10	5.04E+10	5.44E+09	5.44E+09
Sr-90	2.41E+08	2.78E+06	3.98E+06	3.98E+06	1.79E+07	1.94E+06	1.94E+06
Cs-134	5.10E+09	5.72E+07	8.40E+07	8.40E+07	3.69E+08	4.08E+07	4.08E+07
Cs-137	2.68E+09	7.56E+07	1.10E+08	1.10E+08	4.88E+08	5.34E+07	5.34E+07
Eu-152	N/A	N/A	1.02E+09	1.02E+09	N/A	4.96E+08	4.96E+08
Eu-154	N/A	N/A	8.88E+08	8.88E+08	N/A	4.32E+08	4.32E+08

(1) The FSS of the Auxiliary Building 542 ft. embedded floor drain has been completed. The DCGLs listed are the DCGLAD values used to demonstrate compliance from Table 2 of the Release Record

Table 10 Operational DCGLs for Penetrations ($OpDCGL_{PN}$) (pCi/m²)

Radionuclide	Auxiliary Bldg.	Unit 1 Containment	Unit 2 Containment	SFP/ Transfer Canal	Turbine Bldg.	Crib House/ Forebay	WWTF
H-3	3.14E+08	2.33E+08	2.33E+08	1.13E+16	2.58E+08	N/A	N/A
Co-60	6.95E+06	1.54E+08	1.54E+08	1.04E+08	1.41E+08	N/A	N/A
Ni-63	5.35E+09	3.93E+09	3.93E+09	4.33E+13	4.38E+09	N/A	N/A
Sr-90	1.90E+06	1.40E+06	1.40E+06	2.16E+10	1.55E+06	N/A	N/A
Cs-134	2.58E+07	2.94E+07	2.94E+07	1.74E+08	3.20E+07	N/A	N/A
Cs-137	4.86E+07	3.85E+07	3.85E+07	3.40E+08	4.23E+07	N/A	N/A
Eu-152	2.59E+07	3.58E+08	3.58E+08	2.20E+08	3.25E+08	N/A	N/A
Eu-154	1.84E+07	3.11E+08	3.11E+08	1.99E+08	2.86E+08	N/A	N/A

Table 11 ***a priori*** **DCGLs for Surface Soils ($OpDCGL_{SS}$) (pCi/g)**

Radionuclide	Surface Soil DCGL
Co-60	1.091
Cs-134	1.733
Cs-137	3.630
Ni-63	914.458
Sr-90	3.095

Table 12 ***a priori*** **DCGLs for Subsurface Soils ($OpDCGL_{SB}$) (pCi/g)**

Radionuclide	Subsurface Soil DCGL
Co-60	0.881
Cs-134	1.137
Cs-137	1.984
Ni-63	195.333
Sr-90	0.425

Table 13 ***a priori*** **DCGLs for Buried Pipe ($OpDCGL_{BP}$) (dpm/100cm^2)**

Radionuclide	Buried Piping DCGL
Co-60	6.76E+03
Cs-134	1.16E+04
Cs-137	2.59E+04
Ni-63	1.25E+07
Sr-90	1.15E+04

6. REFERENCES

1. ZSRP License Termination Plan (LTP)