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PG&E Letter HBL-20-011

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

Docket No. 50-133, License No. DPR -7
Humboldt Bay Power Plant, Unit 3
Response to NRC Request for Additional Information on the Final Status Survey Report for the Caisson, Survey Units NOL01-09 and NOL01-09-FSR

Reference:

1. PG&E Letter HBL-20-007, Final Status Survey Report for the Humboldt Bay Power Plant Reactor Caisson Survey Units, dated April 1, 2020 (ML20092M643)
2. NRC Letter to PG&E, Humboldt Bay Power Plant, Unit 3 – Request for Additional Information on the Final Status Survey Report for the Caisson, Survey Units NOL01-09 and NOL01-09-FSR, dated June 18, 2020 (ML20162A091)

Dear Commissioners and Staff:

In Reference 1, Pacific Gas and Electric Company (PG&E) submitted the Final Status Survey Report for the Humboldt Bay Power Plant Reactor Caisson Survey Units. In Reference 2, the NRC provided requests for addition information (RAIs), dated June 18, 2020. The Enclosure to this letter provides PG&E responses to the RAIs.

PG&E makes no new or revised regulatory commitments (as defined in NEI 99-04) in this letter.

If you have any questions or require additional information, please contact Mr. Philippe Soenen at (805) 459-3701.

Sincerely,

/Maureen Zawalick for James Welsch

James M. Welsch

Enclosure

cc: Humboldt Distribution
cc/enc: John B. Hickman, NRC Project Manager
Scott A. Morris, NRC Region IV Administrator

PG&E Response to NRC Request for Additional Information Regarding the Humboldt Bay Power Plant Final Status Survey Report for the Caisson, Survey Units NOL01-09 and NOL01-09-FSR

RAI-1:

The licensee should provide final concentration information for residual radioactivity in the groundwater media.

Basis: *In the LTP, the licensee identifies the average member of the critical group as a "resident farmer who lives on the Humboldt Bay site following decommissioning, grows all or a portion of his/her diet onsite, and uses the water from a groundwater source on the site for drinking water and irrigation." Section 2.2.2 of the LTP states that "based on the state of decommissioning, isolation of the Caisson and removal of the source term from plant support structures, there is little potential for ground water to become contaminated during these final stages of decommissioning. Ground water monitoring wells that are identified in this procedure are being phased out as decommissioning progresses." However, as noted in the licensee's submittal, the NE Well was a source of residual radioactivity to the surrounding gravel pack and likely to the groundwater as well. For this reason, staff are requesting additional information with regards to the contaminant levels found or expected to be found in groundwater. This information is needed to determine compliance with 10 CFR 20.1402.*

Path forward: *While the DCGLs were developed considering the groundwater pathway, the assessment provided ignores any potential residual radioactivity in the ground water media. If only negligible levels of residual radioactivity are present, this is acceptable but needs to be shown or discussed. The licensee should provide final concentration information regarding the groundwater media.*

PG&E Response to RAI-1:

Only the caisson excavation was deep enough to breach the groundwater aquifers. However, this was completely within the cutter soil mix (CSM) water cutoff wall such that no groundwater on the site would be impacted by radiologically impacted backfill material. Additionally, the aquifers are supplied through flow from hillsides to the east of the site and are beneath a clay layer, such that waters on the site remain essentially in the perched water zone. All sampling wells into the aquifers are carefully constructed to prevent contamination of the waters in the aquifer. Likewise, demolition of all of the monitoring wells onsite have been in accordance with county requirements for sealing. Depending on the season of the year and rainfall amounts, the aquifers are impacted to more or lesser degree by tidal flows and become saline at varying distances from the bay.

Excavations in the perched zone were backfilled with reuse soil material from the site. Discussion in RAI-4 below indicates the negligible levels of residual radioactivity present in the perched zone even though this water would not be considered usable groundwater.

RAI-2:

The licensee should provide summary information for all Radionuclides of Concern for each of the various media evaluated to assess potential exposure considered in this submittal and/or clarification that the deselected radionuclides in Table 2.7 should be applied to the other elements in the submittal, as needed.

Basis: *Staff noted that, of the Radionuclides of Concern (ROCs) identified in the LTP Table 6-4, the licensee often disregards reporting of many ROCs when summarizing survey data in the submittal. Specifically, in Tables 3.1, 3.3, and 1.1 of the submittal, many ROCs are not tabulated nor discussed. This information is also lacking in the NE Well dose evaluation document (NX-503, Rev 0). Many of the "missing" ROCs (but not all) were selectively disregarded as noted in text and in Table 2.7 of the submittal and were then accounted for as a separate item when assessing survey unit NOL01-09-FSR. NRC staff are now requesting the additional missing information regarding the ROCs. This information is needed to determine compliance with 10 CFR 20.1402.*

Path Forward: *Staff presume that the licensee intended for the radionuclides disregarded in Table 2.7 of the submittal to be similarly considered for the other separately assessed media addressed in this submittal when no data was summarized for those specific radionuclides. While Staff understand the desire to disregard radionuclides which do not exceed the MDC in samples, Staff note in this case that the MDC required of samples analyzed by the licensee was maximally 10% of the DCGL values as per Section 5.4.4.4.6 of the LTP. This means that multiple unreported radionuclides could combine to significantly impact the dose evaluation of the survey unit and should be considered even if results are less than the MDC values which is consistent with MARSSIM. A spreadsheet is attached which highlights the data gaps in Tables 3.1, 3.3, and 1.1 of the submittal as well as in the Results table of NOX-503, Rev O.*

PG&E Response to RAI-2:

Since the deselected doses were developed from sampling in the most highly contaminated site for the hard to detect (HDT) isotopes, the deselected dose can be appropriately applied anywhere on site. Several comments about the deselected dose calculation:

- The gamma emitters were not included since the onsite laboratory can analyze for those isotopes where appropriate.
- Europium isotopes are only appropriate for areas of activated concrete.
- Nb-94 was not calculated because the production method (fission product) and ratio of its half-life to the other fission product of Cs-137 would make the resultant value an insignificant influence of the total dose. (see note 1 below)
- Similar to Nb-94, Np-237 being a transuranic can be analyzed by the ratio to Pu-239 (one of highest of transuranic isotopes due to direct neutron capture in U-238) to demonstrate that the resultant dose would be negligible in the deselection process. (see note 2 below)

All CSM Core Samples were less than minimum detectable activity (MDA) for Co-60, average MDA for Co-60 was less than 6.37E-2 pCi/g. The fractional addition factor for the Co-60 would be 0.017 (less than 0.5 mrem), an insignificant change. Dose for the deselected radionuclides were considered and are included in the dose assigned for the CSM Wall.

The NE Well post-remediation sample (#2018-0370) data showed Eu-154 with results below MDA of less than 6.85E-01 pCi/g, or about 7 percent of a DCGL.

Note 1 – Production of Cs-137 is greater than Nb-94 to start. The ratio of half-lives is provided below:

30 years for Cs-137 divided by 2.1 E+4 years for Nb-94 equals 1.4 E-3 (combined with production difference, less than a significant number for the sum of fractions calculation).

Note 2 – Production of Pu-239 is much greater than that of Np-237 because of direct neutron capture by U-238 vs. multiple decays and capture to produce Np-237. The ratio of half-lives is provided below:

2.4 E+4 years for Pu-239 divided by 2.14 E+6 years for Np-237 = 1E-2 (combined with difference in production, less than a significant number in the sum of fractions calculation).

RAI-3:

The licensee should provide justification for why it disregards anomalies within the survey unit such as the 0.03 uCi "anomaly" it removed from the investigative sample split with ORISE.

Basis: *This information is needed to determine compliance with 10 CFR 20.1402.*

Path Forward: *When analyzing investigative samples, the licensee noted it removed an anomaly of ~0.03 uCi prior to analyzing the sample. The licensee should explain their justification for not analyzing the sample as collected. Also, the licensee should provide its justification for disregarding anomalies such as this in their assessment of potential exposure in a survey unit.*

PG&E Response to RAI-3:

When the investigation sample was taken, it was understood that the sample was to be split with ORISE. Thus, more material than normal was collected. As soon as the sample was split, it was obvious from the dose measurements of the two samples that all the activity was in the HBPP sample. This indicated the presence of a discrete particle that the laboratory personnel were able to locate and remove from the HBPP sample. This was done for two reasons, first it would be important to allow for correlation to the sample results from the split with ORISE and second, a discrete particle does not contribute significantly to uniform dose and must be separately considered against EMC values.

It should be noted that discrete particles were not disregarded during HBPP decommissioning. When discrete particles were identified during surveys, investigations were performed that removed the discrete particles and therefore were no longer of a dose consequence from an ALARA standpoint. Removed particles were assessed against the EMC values to ascertain the potential for missed particles within a survey unit where any investigation identified a discrete particle.

RAI-4:

The licensee should provide data that addresses the bulk of the backfill material for the Caisson excavation and demonstrate that the reuse material, on average, is less than the DCGLs.

Basis: *Staff have noted that the submittal lacks data for the bulk of the reuse/backfill material used to fill the excavation for the Reactor Caisson and which originated from Class 1 areas of the site. The summary for survey unit NOL01-09 contains data for the bottom of the excavation while the summary for survey unit NOL01-09-FSR has data for the top 6" of backfill material. This leaves almost 75' of backfill material within the caisson excavation somewhat unaddressed and the material originated in Class 1 areas. The licensee has discussed the Guardian system and its use as a scanning equivalence for the bulk of the material but has also acknowledged that the system, which is effectively a bulk measurement system, has in the past missed significant spots of elevated residual radioactivity within the trucks of material being assessed. The licensee has also claimed that the material is well mixed due to the process of collection/storage/and placement such that surface samples are representative of all the backfill materials Unfortunately, staff cannot resolve the logic in that case because of the significant quantity of material and the fact the licensee did not perform representative sampling which would have occurred randomly throughout the volume of the backfilled material instead of just the surface of the*

material after placement). This information is needed to determine compliance with 10 CFR 20.1402.

Path Forward: *Data to show the backfill material meets DCGLs could originate from samples of borings into the backfill, from remediation support sampling as the backfill material was being collected, or some other source unknown to Staff but which is applicable to this backfill material in general. The data summary should include average, median, range, and standard deviation. The licensee should provide a description of the survey process and quality controls to determine the average residual radioactivity in the backfill soil and materials. The licensee should seek NRC staff concurrence for the methods or data which it plans to obtain/generate/use to avoid unnecessary work.*

PG&E Response to RAI-4:

Most of the reuse material from the caisson excavation was used as backfill to the caisson. As compared to the remainder of the reuse material used to complete the caisson backfill, the reuse from the caisson was the most radiologically impacted reuse material on site. The plan was to excavate 4 to 5 feet between caisson and CSM wall, then demolish the exposed concrete, and remediate the soil surface before taking out more reuse soil. It worked well until the remediation process at the activated core region failed to adequately remediate before beginning reuse excavation. This led to the bulk of the increased activity levels in reuse soil with a handful of trucks being rejected and that soil being sent as waste.

Although the GARDIAN systems are not intended to provide precise analytical data, a review of the GARDIAN data was performed to provide indication of the approximate radiological concentration of the excavated caisson reuse material. The following are the results of that review:

- Of 1,435 truckloads of material scanned, 138 indicated positive Cs-137 results
- The average Cs-137 indicated concentration for the positive results was 0.66 pCi/g
- The maximum Cs-137 positive result was 2.71 pCi/g
- The average Cs-137 MDA for the 1,297 truckloads that showed no positive results was 0.31 pCi/g
- The average concentration using both positive results and MDAs for Cs-137 was about 0.35 pCi/g
- Although there were about 4 or 5 positive results in the 1,435 truckloads for Co-60, these were in the same range as the MDA values of about 0.25 pCi/g
- The sum of fractions (SOF) for Cs-137 and Co-60 using MDA and positive results for the caisson excavated material indicates about 11 percent of a DCGL

Excavated material from the caisson provided only approximately a third of the backfill material to fill the CSM wall excavation. The remainder of fill material was pulled from the remaining reuse storage area of the discharge canal. This remaining backfill material is the same material that was used to complete the backfill of the trailer city area and final elevation of the discharge canal area.

- From a review of the analytical sampling of this backfill material from these areas, an MDA of approximately 0.1 pCi/g for Cs-137 was estimated. This value would be indicative of the remainder of the reuse material used to complete the backfill of the CSM wall excavation.
- It would also be expected that a majority of the non-positive GARDIAN results would have similar analytical MDA results of less than the 0.31 pCi/g observed through the GARDIAN systems.
- Although MARSSIM and the LTP do not require HTD samples for reuse material, HTD data from the trailer city and discharge areas for samples sent for analysis indicated no positive values above the laboratory's detection limit. Deselection of the HTD isotopes would indicate less than a possible additional 10 percent of a DCGL.

RAI-5:

The basis for the use of the results from Sediment Sample 2018-0370 to calculate the dose from the residual radioactivity in the gravel pack is needed.

Basis: *For the NE Well dose estimate (NX-503, Rev 0), the licensee used the results from Sediment Sample 2018-0370 to calculate the dose from the residual radioactivity in the gravel pack vs Sediment Sample 2018-0373. However, the basis for choosing that sample (i.e., why is this sample thought to be the most representative of the material in the gravel pack) was not provided in writing to the NRC. The use of data from a different sample, Sediment Sample 2018-0373, could result in a higher estimated potential exposure from residual radioactivity in the well. For this reason, the licensee should provide a written basis for why sample 2018-0370 was chosen as the basis for the evaluation instead.*

This information is needed to verify compliance with 10 CFR 20.1402.

Path Forward: *For the NE Well dose estimate (NX-503, Rev 0), the licensee should provide the basis for using the results from Sample 2018-0370 to calculate the dose from the residual radioactivity in the gravel pack vs Sample 2018-0373 (i.e., why is this sample thought to be the most representative of the material in the gravel pack. As part of this basis, the licensee should address the depth at which the samples were taken in the well vs where the gamma measurements were highest, the operational history of the well, and any other factor that was considered when selecting this sample for the dose calculation.*

PG&E Response to RAI-5:

There were 4 dewatering wells installed within the CSM wall used to both pump down entrained water prior to beginning excavation and to control, leakage through the wall, rain water, and process water during demolition activities. Surface water from the rain and misting during concrete demolition was not percolating into the ground as fast as accumulating. This excess was discharged into the dewatering wells (along with concrete and soil fines). Around the time the excavation began of the activated core region, the NE dewatering pump ceased operation. Because this pump was no longer operable and to save the other three pumps, all surface water began to be directed into the NE well.

When the turnover survey was being conducted of the caisson excavation bottom, higher dose levels were identified by the NE well casing. Two samples of sludge material taken inside the casing showed levels significantly above DCGL concentrations. Assessment of the sludge accumulation within the well casing indicated approximately 10 feet above the pump, all of which was assumed to have accumulated since the pump failed.

The decision was made to remediate the material above the pump, pull the pump, and then check for more accumulation after the pump was pulled. The remediated sludge was all collected in a tote and a composite sample taken of this material to provide the best indication of the isotopic mix of the sludge. Once the pump was pulled there was minimal material left inside the casing, a small sample was recovered and analyzed. This sample had higher levels of Cs-137 which, based on solubility of the Cs, would have been consistent with the water flowing into the well during the early stages of caisson excavation and therefore was not considered indicative of the sludge to have been deposited in the gravel pack surrounding the well.

The dose rate inside the well casing, after the pump was removed, was surveyed to provide data to assess the amount of activity in the gravel pack. From the bottom of the casing to the top of the gravel pack, first the dose increased until about less than mid-point and then trended downward. This dose gradient inside the well casing was consistent with the information that the well pump ceased operation at about the time the excavation began at the top of the active core region and the sample taken from the bottom was not representative of gravel pack material.

During past discussions with the NRC Staff, the question of intruder scenario dose was raised. Due to the depth of the well and the sealed nature of the CSM wall (no ground water source), no logical intruder scenario was identified. The only remotely possible scenario was for drilling into the gravel pack. Even in this extremely unlikely case, any material pulled to the surface would be a fraction of the activity in the gravel pack which would also be diluted by drilling materials. Therefore, even

under this unlikely case the dose would be less than that calculated for the buried depth of approximately 100 feet below the surface.

RAI-6:

For the NE Well dose estimate (NX-503, Rev 0), the licensee should provide the basis for assuming that the concentration in the gravel pack is equal to 19% of the amount in the sample.

Basis: *The calculation of the potential dose from residual radioactivity remaining in the NE Well was based on the activity of residual radioactivity in the gravel pack in the well being equal to 19% of the activity in a sample taken from the well. Staff note that this 19% value was generated by comparing the modeled dose rate from the sample to the measured dose rate in the well. It is theoretically possible that the measured dose could be lower than the projected dose due to heterogeneous distributions of the material in the gravel pack and shielding from the gravel. Staff further note that gravel is not normally considered "soil" when collecting environmental samples for final status surveys and the licensee's evaluation did not address uncertainties such as this that may affect their measurements. A written basis for the assumption that the concentration of residual radioactivity in the gravel pack would not exceed 19% was not explicitly provided in the licensee's submittals.*

This information is needed to determine compliance with 10 CFR 20.1402.

Path Forward: *A written basis for the assumption that the concentration in the gravel pack would not exceed 19% of the concentration in the sample should be provided. Information such as the physical process that could result in the concentrations being less in the gravel pack than in the sample from the well would help staff consider the licensee's evaluation. Additionally, provide information on whether or not higher concentrations of material could exist in the gravel pack and the basis for this conclusion (e.g., considering the measurement uncertainties, operating history of the well, the nature of the residual radioactivity, and flow conditions observed in the well, gravel pack, and surrounding area).*

PG&E Response to RAI-6:

Based on the extremely small particle size of the concrete dust suspended in the water discharged to the NE well casing, the probability of a non-homogeneous distribution within the gravel pack was discounted. The pea gravel surrounding the well was designed to prevent soil fines from migrating through the gravel pack to enter the well. In the final situation, the gravel did the opposite and prevented migration of the concrete fines out into the soil as ultimately it plugged and the sludge then began to build up in the well casing itself. Therefore, the assumed density of the pea gravel and interspersed concrete fines provides the best expected condition for the analysis of the remaining activity using the dose gradient within the

casing. The shielding of the gravel was considered as part the MicroShield® modeling used to determine the activity present in the gravel pack through the density factor applied. It is the result of the dose rate measurements in the well casing and the MicroShield® analysis that derived the amount of 19 percent of the sample concentration.

RAI-7:

Given the adjustments previously discussed with respect to the NE Well dose estimate, the licensee should provide a revised dose for the survey unit and a revised version of any calculations done to generate this dose.

Basis: *In the email sent in after the May 1st call, it was stated that there was an error in the value reported for the NE well dose and a new dose was reported. The licensee should submit the revised total survey unit dose, the revised NE Well dose, and any calculations used to generate this dose on the docket. The licensee should provide clarification of the previously stated "31% of the DCGLemc" for the NE Well and how that value was considered in the survey unit dose. Also, the calculation in NX-503 appears to only have a result in terms of the sum of fractions and not a dose result; it would be clearer to have the steps of the dose calculation written out. Several times in the submittal (e.g., Sections 1.3.3 and 1.3.4 of the submittal), the licensee states the wells were "excluded" from survey unit NOL01-09. Please clarify how the well dose was considered in the survey unit.*

This information is needed to determine compliance with 10 CFR 20.1402.

Path Forward: *Provide the revised total survey unit dose, the revised NE Well dose, and any calculations used to generate this dose. Provide clarification of the submittal statement of "31% of the DCGLemc" for the NE Well and how that value was considered in the survey unit dose. Provide details on how the sum of fractions result in the calculation in NX-503 was used to generate the dose result.*

PG&E Response to RAI-7:

Utilizing the previously discussed adjustments and additional conservatism, PG&E has adjusted previously stated dose calculation in the Caisson Survey Report for the NE Well and CSM Wall. Both cases, the Cs-137 dominated (Case 1) and Eu-152 dominated (Case 2) have been provided. The adjustments have increased the calculated dose assignment; however, the area continues to meet the clearance criteria established in 10 CFR 20.1402.

The following is the elevated measurement comparison equation used to document comparison with the release criteria from the LTP and located in Section 8 of MARSSIM:

$$\frac{\delta}{DCGL} + \frac{\bar{C}_{elevated} - \delta}{(Area\ Factor) \times DCGL} < 1$$

Equation 5-14

Where:

δ = average concentration outside the elevated area

$\bar{C}_{elevated}$ = average concentration in the elevated area

A separate term will be used in the equation for each elevated area identified in a survey unit.

In addition, the residual CSM Wall contribution will be added as part of the first term of the formula to document compliance. For conservatism, the NE Well embedded piping dose calculated in accordance with Procedure TBD-403, Derived Concentration Guideline Levels for Embedded and Buried Piping in Support of the Final Status at HBPP, will be added for a final estimation of total dose to compare to Unity EMC Formula Release Criterion of 1.

Radionuclide	Table 5-1 LTP DCGLs pCi/g	Comments
Co-60	3.8E+00	Nuclide ID'd in FSS Sample #3
Cs-137	7.9E+00	Nuclide ID'd in Investigation Samples
Am-241	2.5E+01	Nuclide ID'd in Investigation Samples from ORISE Survey
Eu-152	1.0E+01	Nuclide ID'd in NE Well/Caisson Crushed Concrete Sample
Eu-154	9.4E+00	Nuclide ID'd in NE Well/Caisson Crushed Concrete Sample
C-14	6.3E+00	Nuclide ID'd in NE Well/Caisson Crushed Concrete Sample
Sr-90	1.5E+00	Nuclide ID'd in NE Well/Caisson Crushed Concrete Sample
Nb-94	7.1E+00	RAI 2
Np-237	1.1E+00	RAI 2

Several tables will be used to present the total doses estimated for the Northeast Well from the two modeled cases as follows below. The first two tables show the calculation of the survey unit unity:

Summary Table-FSS Averaged Residual Statistical Results for Caisson Survey Unit NOL01-09									
	Results pCi/g								
Radionuclide	Co-60	Cs-137	Am-241	Eu-152	Eu-154	C-14	Sr-90	Nb-94(1)	Np-237(2)
Average Concentration	7.72E-03	1.26E-03	-3.54E-02	-2.90E-02	-1.90E-02	4.22E-02	1.58E-01	4.94E-02	4.93E-03
$DCGL_W$	3.8E+00	7.9E+00	2.5E+01	1.0E+01	9.4E+00	6.3E+00	1.5E+00	7.1E+00	1.1E+00
Average Nuclide Sum of Fractions(3)	0.2%	0.0%	-0.1%	-0.3%	-0.2%	0.7%	10.5%	0.7%	0.4%

Note (1) Averaged <MDAs were used from all 15 statistical samples
Note (2) Averaged actual reported values <MDA as acceptable by MARRSIM were used from all 15 statistical samples since using <MDA average yielded an unrealistic dose by over 10%
Note (3) The average nuclide sum of fractions are combined for the first term of equation 5-14 to create the survey unit dose in the following table

Table of Statistical Activity Results from Caisson FSS Unit NOL01-09

Sample Location	Co-60 pCi/g	Cs-137 pCi/g	Am-241 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	C-14 pCi/g	Sr-90 pCi/g	Nb-94 pCi/g	Np-237 pCi/g
NOL01-09-001-F	-3.51E-02	1.40E-02	4.74E-02	-1.50E-02	4.43E-02	1.91E-01	1.78E-01	5.30E-02	-2.58E-02
NOL01-09-002-F	2.09E-02	3.13E-02	-1.49E-02	-1.77E-01	2.07E-02	1.51E-01	1.45E-01	5.91E-02	1.75E-02
NOL01-09-003-F	2.76E-01	2.85E-03	8.32E-02	-1.55E-01	-5.12E-02	3.90E-02	1.52E-01	7.12E-02	3.77E-02
NOL01-09-004-F	-9.92E-02	-3.89E-02	-2.25E-01	-8.76E-02	-6.34E-02	-4.15E-03	1.88E-01	5.74E-02	4.41E-02
NOL01-09-005-F	-5.45E-02	3.36E-03	-3.29E-02	1.26E-01	-3.18E-02	-5.72E-02	1.26E-01	5.59E-02	-1.78E-02
NOL01-09-006-F	-1.31E-02	1.98E-02	-1.41E-01	-7.13E-02	1.59E-02	5.64E-02	1.48E-01	4.67E-02	3.18E-02
NOL01-09-007-F	-1.16E-03	-1.02E-02	-7.71E-02	-5.33E-02	4.30E-02	-2.23E-03	6.50E-02	5.63E-02	3.14E-02
NOL01-09-008-F	4.85E-03	7.58E-03	1.66E-02	-1.29E-02	-9.37E-02	-1.21E-02	1.37E-01	3.90E-02	-1.16E-02
NOL01-09-009-F	1.55E-02	-2.17E-02	3.05E-02	1.64E-02	1.90E-03	-1.12E-01	2.06E-01	3.13E-02	-2.33E-02
NOL01-09-010-F	3.87E-03	-1.36E-02	-2.17E-02	-2.18E-02	-3.49E-02	9.58E-02	1.75E-01	4.40E-02	-1.30E-02
NOL01-09-011-F	-2.15E-02	6.35E-04	1.03E-02	6.31E-02	5.15E-03	2.25E-02	1.75E-01	5.60E-02	-3.90E-03
NOL01-09-012-F	7.80E-03	-1.05E-03	-7.39E-02	-6.76E-02	-5.54E-02	1.40E-01	1.96E-01	4.28E-02	-1.76E-02
NOL01-09-013-F	1.16E-02	-4.93E-03	-8.92E-02	7.43E-03	-1.08E-02	8.02E-02	1.39E-01	3.24E-02	-7.41E-03
NOL01-09-014-F	-1.82E-02	2.54E-02	-3.95E-02	6.88E-03	-4.19E-02	-5.34E-03	1.95E-01	4.90E-02	-2.26E-03
NOL01-09-015-F	1.80E-02	4.32E-03	-6.77E-03	6.95E-03	-3.35E-02	5.05E-02	1.42E-01	4.76E-02	3.41E-02
Avg Nuclide Activity	7.72E-03	1.26E-03	-3.56E-02	-2.90E-02	-1.90E-02	4.22E-02	1.58E-01	4.94E-02	4.93E-03
Median Nuclide Activity	3.87E-03	2.85E-03	-2.17E-02	-1.50E-02	-3.18E-02	3.90E-02	1.52E-01	4.90E-02	-3.90E-03
Minimum Nuclide Activity	-9.92E-02	-3.89E-02	-2.25E-01	-1.77E-01	-9.37E-02	-1.12E-01	6.50E-02	3.13E-02	-2.58E-02
Maximum Nuclide Activity	2.76E-01	3.13E-02	8.32E-02	1.26E-01	4.43E-02	1.91E-01	2.06E-01	7.12E-02	4.41E-02
Standard Deviation	8.09E-02	1.81E-02	7.78E-02	7.75E-02	4.04E-02	8.09E-02	3.59E-02	1.06E-02	2.49E-02
Nuclide Residual Dose in %=Nuclide averaged activity/$DCGL_W$	0.2%	0.0%	-0.1%	-0.3%	-0.2%	0.7%	10.5%	0.7%	0.4%
Nuclide Residual Dose in mrem/year= Nuclide averaged activity/$DCGL_W$*25	0.1	0.0	0.0	-0.1	-0.1	0.2	2.6	0.2	0.1
Grand total Caisson NOL01-09 FSS Residual Unit Statistical averaged nuclide doses in mrem/yr									**2.98**

Unity Nuclide Sum of Fractions Dose Calculation from Caisson Survey Unit NOL01-09										
Sample Location	Total Sum of Fraction	Unity from Co-60	Unity from Cs-137	Unity from Am-241	Unity from Eu-152	Unity from Eu-154	Unity from C-14	Unity from Sr-90	Unity from Nb-94	Unity from Np-237
NOL01-09-001	13.1%	-0.9%	0.2%	0.2%	-0.2%	0.5%	3.0%	11.9%	0.7%	-2.3%
NOL01-09-002	13.8%	0.6%	0.4%	-0.1%	-1.8%	0.2%	2.4%	9.7%	0.8%	1.6%
NOL01-09-003	20.7%	7.3%	0.0%	0.3%	-1.6%	-0.5%	0.6%	10.1%	1.0%	3.4%
NOL01-09-004	11.7%	-2.6%	-0.5%	-0.9%	-0.9%	-0.7%	-0.1%	12.5%	0.8%	4.0%
NOL01-09-005	6.1%	-1.4%	0.0%	-0.1%	1.3%	-0.3%	-0.9%	8.4%	0.8%	-1.6%
NOL01-09-006	13.1%	-0.3%	0.3%	-0.6%	-0.7%	0.2%	0.9%	9.9%	0.7%	2.9%
NOL01-09-007	7.4%	0.0%	-0.1%	-0.3%	-0.5%	0.5%	0.0%	4.3%	0.8%	2.9%
NOL01-09-008	7.6%	0.1%	0.1%	0.1%	-0.1%	-1.0%	-0.2%	9.1%	0.5%	-1.1%
NOL01-09-009	10.7%	0.4%	-0.3%	0.1%	0.2%	0.0%	-1.8%	13.7%	0.4%	-2.1%
NOL01-09-010	11.9%	0.1%	-0.2%	-0.1%	-0.2%	-0.4%	1.5%	11.7%	0.6%	-1.2%
NOL01-09-011	12.6%	-0.6%	0.0%	0.1%	0.6%	0.1%	0.4%	11.7%	0.8%	-0.4%
NOL01-09-012	12.9%	0.2%	0.0%	-0.3%	-0.7%	-0.6%	2.2%	13.1%	0.6%	-1.6%
NOL01-09-013	10.2%	0.3%	-0.1%	-0.4%	0.1%	-0.1%	1.3%	9.3%	0.5%	-0.7%
NOL01-09-014	12.7%	-0.5%	0.3%	-0.2%	0.1%	-0.4%	-0.1%	13.0%	0.7%	-0.2%
NOL01-09-015	14.3%	0.5%	0.1%	0.0%	0.1%	-0.4%	0.8%	9.5%	0.7%	3.1%
Avg Total SOF and Nuclide Unity	11.9%	0.2%	0.0%	-0.1%	-0.3%	-0.2%	0.7%	10.5%	0.7%	0.4%
Median SOF	12.6%	0.1%	0.0%	-0.1%	-0.2%	-0.3%	0.6%	10.1%	0.7%	12.6%
Minimum	6.1%	-2.6%	-0.5%	-0.9%	-1.8%	-1.0%	-1.8%	4.3%	0.4%	6.1%
Maximum	20.7%	7.3%	0.4%	0.3%	1.3%	0.5%	3.0%	13.7%	1.0%	20.7%
Standard Deviation	3.5%	2.1%	0.2%	0.3%	0.8%	0.4%	1.3%	2.4%	0.1%	3.5%
Dose %	100.0%	1.7%	0.1%	-1.2%	-2.4%	-1.7%	5.6%	88.3%	5.8%	3.8%
Nuclide Survey dose=Average Nuclide Total Unity*25 mrem/year		0.1	0.0	0.0	-0.1	-0.1	0.2	2.6	0.2	0.1
Total Survey Unit Residual Dose =Average Total SOF*25 mrem/year										**2.98**(1) mrem/year

Note (1) 2.98 mrem/year is the survey unit compliance dose based on the Total Sum of Averaged Nuclide Unity Fractions as shown above. This is the calculation of the first term in LTP Equation 5-14 above.

CSM Characterization Biased Boring Results							
Boring Number	Sample Number	Description	Cs-137 pCi/g	H-3 pCi/g	Sr-90 pCi/g	Co-60 pCi/g-Nuclide MDA USED	Sample Purpose
CSM-RC-01	2015-2055	Soil at 0 to 80 ft.	1.45E+00	N/A	N/A	4.91E-02	FSS
CSM-RC-01S	2015-2056	Soil at 0 to 80 ft.	1.75E+00	N/A	N/A	5.93E-02	FSS
CSM-RC-02	2015-3337	Soil at 0 to 80 ft.	1.20E-02	N/A	N/A	6.09E-02	FSS
CSM-RC-03R	2015-3701	Soil at 0 to 80 ft.	2.35E-02	N/A	N/A	3.26E-02	FSS
CSM-RC-04	2015-1643	Soil at 0 to 80 ft.	1.25E-02	-1.00E-02	-7.90E-02	4.43E-02	FSS
CSM-RC-05	2015-1839	Soil at 0 to 80 ft.	-2.58E-03	-3.00E-02	7.20E-02	6.70E-02	FSS
CSM-RC-05S	2015-1840	Soil at 0 to 80 ft.	5.58E-02	N/A	N/A	5.87E-02	FSS
CSM-RC-06	2015-1441	Soil at 0 to 80 ft.	2.54E-02	5.00E-02	1.47E-01	6.54E-02	FSS
CSM-RC-07	2015-1519	Soil at 0 to 80 ft.	-8.27E-03	3.00E-02	1.56E-01	5.51E-02	FSS
CSM-RC-08	2015-1763	Soil at 0 to 80 ft.	1.58E+00	1.00E-02	-1.24E-01	2.92E-02	FSS
CSM-RC-09	2015-1679	Soil at 0 to 80 ft.	3.00E-02	1.00E-02	8.60E-02	7.36E-02	FSS
$DCGL_W$ in pCi/g			7.0E+00	6.8E+02	1.5E+00	3.8E+00	
Average			4.48E-01	1.00E-02	4.30E-02	5.41E-02	
Standard Deviation			7.39E-01	2.83E-02	1.18E-01	1.40E-02	
Nuclide Dose (mrem/yr) is Nuclide Average pCi/g/$DCGL_W$*25 mrem/year			1.42E+00	Note (1)	Note (1)	3.56E-01	
Total CSM dose Calculated is 1.42 mrem (Cs-137)+0.356 mrem (Co-60)+0.794 mrem (HTD dose from White Paper)							2.57 mrem/yr

Note (1) It is not appropriate to base estimation of dose for H-3 and Sr-90 on incomplete data sets. Therefore, to cover the deselected aspect of HTD radionuclides 0.794 mrem was applied to the CSM Wall estimation in accordance with the HTD Dose Contribution Position paper since no insignificant radionuclides identified and 0.356 mrem from Co-60 MDA Averaged dose was also conservatively added.

Case 1 Sample 2018-0373 Collected 2/1/18 15:15
Sample of sediment bottom collected from 22.5' elevation level (~1' from well casing bottom) after remediation
(Cs-137 Dominant)

	Results pCi/g									
Lab Sample #	Am-241	Co-60	Cs-137	Eu-152	Eu-154	C-14	Sr-90	Nb-94(1)	Np-237(1)	
2018-0373	1.40E+00	1.31E+00	9.34E+01	7.19E-01	2.06E-01	3.18E+00	6.35E-01	2.31E-01	4.88E-01	
Observed Residual Concentration (*0.20(2) per NX-503 Rev 01) Case 1	2.77E-01	2.60E-01	1.85E+01	1.42E-01	4.07E-02	3.18E+00	6.35E-01	4.63E-02	9.77E-02	
$DCGL_W$	2.50E+01	3.80E+00	7.90E+00	1.00E+01	9.40E+00	6.30E+00	1.50E+00	7.10E+00	1.10E+00	LTP Table 5-1
$1m^2$ AF	1.90E+02	1.00E+01	1.40E+01	9.10E+00	9.20E+00	1.80E+04	9.60E+02	9.00E+00	3.50E+02	LTP Table 5-6
$DCGL_{EMC}$	4.75E+03	3.80E+01	1.11E+02	9.10E+01	8.65E+01	1.13E+05	1.44E+03	6.39E+01	3.85E+02	$DCGL_W$*AF
Unity EMC Calculation relative to $DCGL_{EMC}$ (Above Equation 5-14 2nd term) after applying 20% factor and residual adjustment									1.77E-01	
Case 1 NE Well Dose relative to the $DCGL_{EMC}$ dose criteria (0.177*25 mrem/yr) This is the second term of the NE Well dose Equation 5-14									4.42E+00 mrem/yr	

Note (1) <MDA Sample Value used
Note (2) 0.2 factor is 16.08 μR/hr detector response divided by expected response of 81.3 μR/hr to calculate the gravel pack residual source term.

Elevated Measurement Comparison Dose Calculation Evaluation Case 1			
Survey Unit Residual Dose	CSM Dose	NE Well Dose	Total Dose(1)
2.98E+00 mrem/yr	2.57E+00 mrem/yr	4.43E+00 mrem/yr	9.98E+00 mrem/yr
Sum of fractions considering all dose components in EMC Equation 5-14 plus CSM Wall unity and NE Well embedded dose assigned through TBD-403 $$\frac{\delta}{DCGL} + \frac{\bar{C}_{elevated} - \delta}{(Area\ Factor) \times DCGL} < 1$$ **Equation 5-14**			0.40 Passes EMC Test

Note (1) Total Dose is Case 1 Northeast Well dose (which includes the Survey Unit dose and the buried piping dose of 0.01 mrem/yr calculated per TBD-403) plus the CSM Wall dose using an originally calculated dose of 1.42 mrem/yr from Cs-137 and an additional calculated Co-60 dose of 0.356 mrem/yr from average missed dose plus 0.794 mrem/yr applied from HTD Contribution Position White Paper

Discussion

Therefore, this case provides an unrealistic estimate of the Elevated Measurement Concentration dose because of the following reasons:

- The Nuclide Cs to Eu Ratio in this Case was 1.36E+02. The Cs to Eu ratios observed in the original remediation characterization samples ranged from about 8.18E-02 to 1.41E-01. Furthermore, Case 2, with a Cs to Eu Ratio of 5.95E-01, represents a ratio more in line with the actual source profile from the original characterization samples expected in the gravel since it was a composite sample taken from the sediment dewatering box upon source term remediation.
- No other samples collected in the well approached or correlated to the Cs-137 levels Case 1 showed, indicating it was not representative of the source nuclide profile levels residing in the gravel pack.

Case 2 Sample 2018-0370 Collected 2/1/18 15:35
Sample of sediment composited from sediment dewatering box after remediation (Eu-152 Dominant)

	Results pCi/g									
Lab Sample #	Am-241	Co-60	Cs-137	Eu-152	Eu-154	C-14	Sr-90	Nb-94(1)	Np-237(1)	
2018-0370	1.36E+00	1.53E+00	2.06E+01	3.47E+01	1.07E+00	3.18E+00	6.35E-01	2.31E-01	4.88E-01	
Observed Residual Concentration (*0.20(2) per NX-503 Rev 01) Case 2	2.72E-01	3.06E-01	4.13E+00	6.94E+00	2.14E-01	3.18E+00	6.35E-01	4.63E-02	9.77E-02	
$DCGL_W$	2.50E+01	3.80E+00	7.90E+00	1.00E+01	9.40E+00	6.30E+00	1.50E+00	7.10E+00	1.10E+00	LTP Table 5-1
$1m^2$ AF	1.90E+02	1.00E+01	1.40E+01	9.10E+00	9.20E+00	1.80E+04	9.60E+02	9.00E+00	3.50E+02	LTP Table 5-6
$DCGL_{EMC}$	4.75E+03	3.80E+01	1.11E+02	9.10E+01	8.65E+01	1.13E+05	1.44E+03	6.39E+01	3.85E+02	$DCGL_W$ *AF
Unity EMC Calculation relative to $DCGL_{EMC}$ (Above Equation 5-14 2nd term) after applying 20% factor and residual adjustment									1.25E-01	
Case 2 NE Well Dose relative to the $DCGL_{EMC}$ dose criteria (0.125*25 mrem/yr) This is the second term of the NE Well dose Equation 5-14 $\frac{\bar{C}_{elevated} - \delta}{(Area\ Factor) \times DCGL}$									3.13E+00 mrem/yr	

Note (1) <MDA Sample Value used
Note (2) 0.2 factor is 16.08 μR/hr detector response divided by expected response of 80.3 μR/hr to calculate the gravel pack residual source term.

Elevated Measurement Comparison Dose Calculation Evaluation Case 2			
Survey Unit Dose	CSM Dose	NE Well Dose	Total Dose(1)
2.98E+00 mrem/yr	2.57E+00 mrem/yr	3.14E+00 mrem/yr	8.69E+00 mrem/yr
Sum of fractions considering all dose components in EMC Equation 5-14 plus CSM Wall unity and NE Well embedded dose assigned through TBD-403 $$\frac{\delta}{DCGL} + \frac{\bar{C}_{elevated} - \delta}{(Area\ Factor) \times DCGL} < 1$$ **Equation 5-14**			0.35 passes EMC Unity Test

Note (1) Total Dose is Case 2 Northeast Well dose (which includes the Survey Unit dose and the buried piping dose of 0.01 mrem/yr calculated per TBD-403) plus the CSM Wall dose using an originally calculated dose of 1.42 mrem/yr from Cs-137 and an additional calculated Co-60 dose of 0.356 mrem/yr from average missed dose plus 0.794 mrem/yr applied from HTD Contribution Position White Paper

Discussion

Therefore, Eu dominated Case 2 that was used in the FSSR provides a much more realistic estimate of the Elevated Measurement Concentration dose because of the following reasons:

- The Nuclide Cs to Eu Ratio in this Case was 5.95E-01, which is more in line and representative with the Cs to Eu ratios observed in the original remediation characterization samples which ranged from about 8.18E-02 to 1.41E-01. Furthermore, Case one, with a Cs to Eu Ratio of 1.36E+02, represents a ratio not in line with the actual source profile from the original characterization samples that would be expected in the gravel since it was only a grab sample collected of residual material from the bottom of the well casing. Therefore, sample Case 1 represents an inaccurate depiction of the activity levels within the gravel pack as it is was collected as a grab sample instead of a more representative composite sample taken after the well casing sediment source term remediation collected from the sediment dewatering box.

- This is proved in FSSR Section 1.3.4 *Remedial Action Surveys and Activities,* in Table 1.4 which presents the NE Well Characterization Sample Results that give the source term profile considered representative of the material in the well casing that was remediated. Here is an excerpt from Table 1.4 of the FSSR:

Table 1.4 - NE Well Characterization Sample Results

Sample No.	Description	Co-60 pCi/g	Cs-137 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Total EMC Fraction
2018-0044	NE Well Sediment Sample A	3.16E+00	1.12E+01	7.73E+01	2.28E+00	2.36
2018-0045	NE Well Sediment Sample B	5.00E+00	1.15E+01	1.36E+02	4.29E+00	3.95

In the above table, the total unadjusted EMC fraction for the characterization samples was calculated in the following fashion to determine if remediation was needed. Since it was obvious there would need to be remediation, the only part of the EMC term that needed to be calculated was the comparison of the sample results directly to the $DCGL_{EMC}$, which was calculated in the following fashion:

$$\left[\frac{[Co-60]}{[DCGL_{Co-60}*AF_{Co-60}]}+\frac{[Cs-137]}{[DCGL_{Cs-137}*AF_{Cs-137}]}+\frac{[Eu-152]}{[DCGL_{Eu-152}*AF_{Eu-152}]}+\frac{[Eu-154]}{[DCGL_{Eu-154}*AF_{Eu-154}]}\right]*2.22=\text{EMC Unity Fraction}$$

Where AF=1 m^2 Area factor

Therefore, for each sample, the above parameters were input into the EMC evaluations below to see if unity was exceeded to see if remediation was required:

Well sediment A:

$$\left[\frac{[3.16E{+}00\ pCi/g]}{[3.80E{+}01 pCi/g]}+\frac{[1.12E{+}01\ pCi/g]}{[1.11E{+}02\ pCi/g]}+\frac{[7.73E{+}01\ pCi/g]}{[\ 9.10E{+}01\ pCi/g]}+\frac{[2.28E{+}00\ pCi/g]}{[9.65E{+}01\ pCi/g]}\right]*2.22=\text{EMC Fraction}=2.36\ \text{EXCEEDS UNITY}$$

Well sediment B:

$$\left[\frac{[5.00E{+}00\ pCi/g]}{[3.80E{+}01 pCi/g]}+\frac{[1.15E{+}01\ pCi/g]}{[1.11E{+}02\ pCi/g]}+\frac{[1.36E{+}02\ pCi/g]}{[\ 9.10E{+}01\ pCi/g]}+\frac{[4.29E{+}00\ pCi/g]}{[9.65E{+}01\ pCi/g]}\right]*2.22=\text{EMC Fraction}=3.95\ \text{EXCEEDS UNITY}$$

As described in the Submittal, the Total EMC Fraction listed in the above table conservatively estimated the entire source term to exist in a 1 m^2 contamination zone to a depth of 15 cm (from an original source term estimated mass of 5.15E+05 g), for an adjustment factor of 2.22, which is the initial mass (mass of 5.15E+05 g) of source material calculated in well compared to the source activity estimated for the gravel pack after final remediation (to a mass of 1 m^2 to 15 cm^2 or 2.32E+05 g). Since the sample results presented above indicated that remediation was required, the three other active dewatering wells were also excluded from FSS unit NOL01-09.

Clarification of the original submittal statement of "31% of the $DCGL_{EMC}$" for the NE Well and how that value was considered in the survey unit dose was calculated from the NX-503 sample and survey data available at the time using scaled $DCGL_{EMC}$'s to take credit for CSM Wall dose, did not take credit for embedded piping dose, or Cs-137, or Eu-152, as these were not detected in any FSS Samples. The revised Elevated Measurement Comparison Evaluation was used to determine survey unit compliance for the size of the specific elevated area. If the individual area elevated area passes, then the specific area is combined and evaluated under the unity rule. The revised EMC Evaluation is higher than that reported in the Submittal because of the following additions:

1. The single statistical sample that showed a Co-60 value of 2.75E-01 pCi/g was considered representative of the residual source term in the original Engineering calculation, which was evaluated at the time to validate that the remediation was complete. The conservative calculation was summarized and presented in the Submittal.
2. CSM Wall dose was added.
3. Insignificant Buried piping dose was added per TBD-403
4. Insignificant residual contributions adjustments from Cs-137, Eu-152, Eu-154, Am-241, Np-94, and Np-237 were added to the revised evaluation.

5. Separate evaluations were performed at the request of the NRC, based on the two samples presented above that increase the dose calculation, but do not change the release decision. Page 9 of 10 of the NX-503 Engineering Calculation provides all the sample data used for Case 2 and the FSS Average results used at the time to support that the NE Well had been successfully remediated to validate the conclusion that the residual contamination in the gravel pack "Exceeds the $DCGL_W$, but it is 31% of the $DCGL_{EMC}$ and is acceptable to remain in the gravel pack without further remediation effort."