R. R. Sgarro
Director - Regulatory Affairs

PPL Bell Bend, LLC
Two North Ninth Street
Allentown, PA18101-1179
Tel. 610.774.7552 Fax 610.774.2618
rrsgarro@pplweb.com

July 20, 2012

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

BELL BEND NUCLEAR POWER PLANT
ENVIRONMENTAL AUDIT NEED FOR INFORMATION RESPONSES:
SEVENTH SUBMITTAL
BNP-2012-175 Docket No. 52-039

The purpose of this letter is to formally document PPL Bell Bend, LLC's (PPL) responses to NRC Need for Information (NFI) requests that were discussed with the NRC at the Bell Bend Supplemental Environmental Audit held the week of May 14, 2012. Additional letters providing the remainder of NFI responses requested by NRC at the audit will be provided in coming weeks.

Responses to the following NFIs are included in this letter as Enclosure 1:

- ACC-10-2
- MET-04
- RHH-03

As discussed at the audit, the information presented in these three NFI responses requires revision of the Bell Bend Nuclear Power Plant (BBNPP) Combined License Application (COLA) Part 3, "Environmental Report," Rev. 3.0 to be consistent with information provided in Enclosure 1. The revised COLA content will be included in a future revision of the BBNPP COLA. The future revision of the COLA is the only new regulatory commitment in this letter.

Should you have questions or need additional information, please contact the undersigned at 610.774.7552.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 20, 2012.

Respectfully,

Rocco R. Sgarro

RRS/kw

Enclosure: Need for Information Responses

D102
NRO

cc: (w/ Enclosure)

Ms. Laura Quinn-Willingham
Project Manager
U.S. Nuclear Regulatory Commission
11545 Rockville Pike Mailstop: T-6 C32
Rockville, MD 20852

(w/o Enclosure)

Mr. William Dean
Regional Administrator
U.S. Nuclear Regulatory Commission
Region I
2100 Renaissance Blvd., Suite 100
King of Prussia, PA 19406-2713

Enclosure 1

Need for Information Responses

ACCIDENTS (ACC)

ACC-10-2: Revise the information on Postulated Accidents at Alternative Sites presented in BBNPP ER Section 9.3 to reflect updated information discussed at the Environmental Audit.

Audit Disposition: During the Environmental Audit, it was noted that the discussion of Postulated Accidents in Environmental Report (ER) 9.3 may require an update based upon increased population density in the vicinity of the Martins Creek Alternative Site. Upon analysis of the factors considered in the screening level analysis of accidents at the Alternative Sites, PPL completed revisions to the information regarding postulated accidents, as presented in ER 9.3. The proposed ER changes and the basis for the changes are presented below.

Response:

Following the audit, PPL considered the potential impact to average individual early fatality within one mile and latent cancer fatality risks within 10 miles considered in the screening level analysis completed for the Martins Creek Alternative Site associated with increased population in the vicinity of the site.

A population increase around a site is expected to result in an increase in total risk to the public from early fatalities, early injuries, latent cancers, and whole body dose generally proportional to the increase in population. Any increase in early fatalities and early injuries are most influenced by population increases near the plant site. The economic impact is also expected to increase, although this is a non-linear relationship with population.

While it was found that the overall population density within a 50-mile radius of the Martins Creek site is substantially higher than that of BBNPP, the impact of this population increase is not expected to affect the potential risks to the public associated with accidents at Martins Creek when considering the margin to the NRC's Safety Goal Policy Statement (51 CFR 30028) Quantitative Health Objectives (QHOs).

This conclusion is supported by the analysis for BBNPP, which determined that under varying population density scenarios (for the years 2050 and 2080, as shown in Table 1), both the average individual risk of early fatalities within one mile of the reactor and the average individual risk of latent cancer fatalities within 10 miles of the reactor are orders-of-magnitude below their respective Safety Goal Policy QHOs, and exhibited no increase with the increase in population from 2050 to 2080.

While the alternative sites may exhibit different characteristics for meteorology, population distribution, and land use, the consequence metrics for the alternative sites are expected to be comparable to the BBNPP site. Because the risk metrics for all of the alternative sites are expected to remain orders-of-magnitude below their respective Safety Goal Policy Statement QHOs, the risk of accidents to the public for all of the Alternative Sites is small.

Table 1: Base Case and Sensitivity Case S1 Results Compared Against the NRC Safety Goal QHOs

Average Individual Risk[1]	Base Case[2]	Sensitivity Case S1[3]	NRC Safety Goal (QHOs)
Early Fatalities within one mile / person-year	1.12E-11	1.12E-11	4E-07
Latent Cancer Fatalities within 10 miles / person-year	9.23E-11	9.23E-11	2E-06

[1]Risks presented in Table 1 are derived from MACCS2 modeling in combination with the release category frequencies from the Level 2 PRA.
[2]The Base Case results are based on expected 2050 population data.
[3]The Sensitivity Case S1 results are based on expected 2080 population data.

Data Sources: Bell Bend Nuclear Power Plant RAI EIS 5.11-7 (Enclosure 3 of BNP-2010-238, ML 102920368)

COLA Impact:

BBNPP COLA ER Section 9.3.2.5.13 will be revised in a future revision of the COLA as shown on the following pages.

The radiological impacts of constructing and operating a nuclear unit at the Martins Creek site would include doses from direct radiation, and liquid and gaseous radioactive effluents. These pathways would result in low doses to people and biota offsite that would be well below regulatory limits. These impacts are expected to be similar to those estimated for the BBNPP site as described in Section 5.4, Radiological Impacts of Normal Operations.

The radiological impacts of the other operating nuclear power plants listed above also include doses from direct radiation and liquid and gaseous radioactive effluents. These pathways result in low doses to people and biota offsite that are well below regulatory limits as demonstrated by the required ongoing REMP conducted around these plants. These pathways are expected to result in low doses to people and biota offsite that would be well below regulatory limits. Doses attributable to direct radiation and radioactive effluents from hospitals and industrial facilities that use radioactive materials would represent an insignificant contribution to the cumulative impact around the Martins Creek site. This conclusion is based on data from REMPs conducted around currently operating nuclear power plants, which consistently demonstrate that radiological levels at offsite locations are well below acceptable limits at all offsite locations, as required by each facility's operating license. It is concluded that the cumulative radiological impacts from constructing and operating a proposed nuclear unit and other existing and planned projects and actions in the geographic area of interest around the Martins Creek site would be SMALL.

9.3.2.5.13 Postulated Accidents

The analysis of postulated accidents includes accidental radiological releases during operation of a nuclear unit at the Martins Creek site. The analysis also considers other past, present, and reasonably foreseeable future actions that impact radiological health from postulated accidents, including other federal and non-federal projects, and those projects listed in Table 9.3-23 within the geographic area of interest. As described in Section 9.3.2.5.1, Land Use, the Martins Creek site is located approximately 0.5 mi (0.81 km) east southeast of PPL's 1,690 MWe Martins Creek Power Plant and approximately 0.75 mi (1.2 km) south of PPL's existing 623 MWe Lower Mount Bethel Energy Plant. There are currently no nuclear facilities on the site. The geographic area of interest considers all existing and proposed nuclear power plants that have the potential to increase the probability-weighted consequences (i.e., risks) from a severe accident at any location within 50 mi (80.5 km) of the Martins Creek site. Existing facilities potentially affecting radiological accident risk within this geographic area of interest include the existing Limerick Generating Station (Units 1 and 2, 47 mi [75.4 km] southwest), SSES (Units 1 and 2, 58 mi [93.3 km] west northwest), Peach Bottom Atomic Power Station (Units 2 and 3, 48 mi [77.2 km] southwest), Three Mile Island Nuclear Generating Station (Unit 1, 96 mi [154.5 km] west southwest), Salem Nuclear Power Plant (Units 1 and 2, 94 mi [151.3 km] south southwest), the Hope Creek Nuclear Generation Station (Unit 1, 94 mi [151.3 km] south southwest), Oyster Creek Generating Station (Unit 1, 83 mi [133.6 km] southeast), and the Indian Creek Nuclear Generating Station (Units 2 and 3, 68 mi [109.4 km] northeast). No other reactors have been proposed within the geographic area of interest or within the region that would affect accident risk in the geographic area of interest.

The environmental consequences of DBAs at the Martins Creek site are expected to be minimal and similar to those that have been predicted for the U.S. EPR that would be built at the BBNPP site as described in Section 7.1, Design Basis Accidents. DBAs have been specifically addressed for the BBNPP site to demonstrate that the reactor design is robust enough to meet all applicable NRC safety criteria. It is also noted that the U.S. EPR design is independent of site conditions ~~and the meteorology of the Martins Creek and BBNPP sites are considered to be generally similar. Because the meteorology, population distribution, and land use for the~~

(Insert period at the end of the sentence)

~~Martins Creek site are all expected to be similar to the proposed BBNPP site, risks from a severe accident for a U.S. EPR reactor located at the Martins Creek site are expected to be similar to those analyzed for the proposed BBNPP site and described in Section 7.2, Severe Accidents.~~

INSERT A

Although there are no new reactors currently planned within the geographic area of interest, any applications for new reactors would need to demonstrate that the risks would be well below NRC's regulatory requirements for safety. Based on this assessment, the cumulative risks of severe accidents at any location within 50 ~~mi~~ (80.5 km) of the Martins Creek site would be SMALL.

miles

9.3.3 Summary and Conclusions

PPL has implemented the site selection process discussed in the above sections to select a *Proposed Site* for the location of a nuclear power generating facility within the identified ROI. The results of that selection process identified the BBNPP, located in Luzerne County, Pennsylvania, as the *Proposed Site*.

The detailed site evaluations are contained in the BBNPP Alternative Site Evaluation (UniStar, 2011). Table 9.3-10 compares the weighted numerical scores of the Candidate Sites derived from the above referenced Alternative Site Evaluation. Table 9.3-7 is a summary comparison of the *Proposed Site* and *Alternative Sites* using the NRC three level standard of significance. As summarized in Table 9.3-7, the evaluation and comparison of the *Alternative Sites* to the *Proposed Site* verified that none of the *Alternative Sites* is "Environmentally Preferred," and thus "Obviously Superior," to the selected *Proposed Site*. Therefore, the BBNPP site is the candidate site submitted to the NRC by the applicant as the proposed location for a new nuclear power generating station.

The advantages of the BBNPP site over the *Alternative Sites* are summarized as follows:

- The postulated consumptive use of water by a new unit at the BBNPP site would be no greater than water use at the *Alternative Sites*.
- The impacts of development of a new unit at the *Proposed Site* on endangered species are no greater than impacts postulated for the *Alternative Sites*.
- No federal, state, or Native American tribal lands are affected by the *Proposed Site*.
- The BBNPP site contains suitable nesting habitat for he endangered Indiana bat. However, use of the site by Indiana bat maternity colonies has not been observed or documented. The *Alternative Sites* also contain forested areas that could provide suitable maternity colony habitat for the Indiana bat. Because all sites may contain suitable nesting habitat for the indiana bat, and because this habitat can be removed while bats are hibernating and not present on the site, the impacts on spawning or nesting areas at the BBNPP site are no greater than impacts at the *Alternative Sites*.
- Locating the BBNPP immediately adjacent to an existing nuclear facility would have lesser land use impacts than locating the site at an alternative greenfield site. Therefore, land use impacts would be no greater than the impacts at the *Alternative Sites*.
- The potential impacts of a new nuclear facility on terrestrial and aquatic ecology at the BBNPP would be no greater than at the *Alternative Sites*.

INSERT A

For the Martins Creek site, although the meteorology, the population distribution, and land use may be different than those parameters of the BBNPP site, PPL anticipates that the consequence metrics for Martins Creek will be comparable to the BBNPP site. Therefore, qualitatively, with the existing margins for the BBNPP site, PPL anticipates that any variability in the average individual risk of early fatalities for individuals within one mile of the reactor and the average individual risk of latent cancer fatalities for individuals within 10 miles of the reactor for Martins Creek are expected to remain far below their respective NRC Safety Goal Quantitative Health Objectives (QHOs) (4×10^{-7}/year, 2×10^{-6}/year).

HYDROLOGY (HY)

HY-02: Provide an SME who can address water related aspects of the radiological dose assessment. Discuss:

B. Use average annual flow rates for calculation of drinking water doses at Danville.

F. (new) Describe assumptions used for drinking water maximum exposed individual (MEI) dose.

Audit Disposition:

Following review of the HY-02 response at the audit, additional clarification of item HY-02 B was requested, and a new question was raised (named HY-02 F). The response to these questions is provided below.

HY-02B: Provides a revision to ER Section 5.4 regarding doses from liquid effluents entering the drinking water pathway to incorporate summer mean flow dilution in lieu of annual mean flow dilution.

HY-02F: Describe the assumption used for drinking water population doses to complement the existing wording in ER Section 5.4.3.1, and add language to Section 5.4.3.1 to explain the assumptions used for the drinking water MEI doses.

Response:

HY-02B: Drinking water doses are calculated for both the Maximum Exposed Individual (MEI) and the collective population surrounding BBNPP. The MEI doses in ER Section 5.4 are already based on the summer low flow dilution. The population doses for the drinking water pathway will be revised in a future revision of ER Section 5.4 to incorporate the summer mean flow dilution.

HY-02F: Text will be added in a future revision of ER Section 5.4.3.1 to explain that for the MEI dose, it was assumed that all land within one-half mile of the Susquehanna River, for 50 miles downstream from BBNPP, would be irrigated.

COLA Impact:

BBNPP COLA ER Section 5.4 will be revised in a future revision of the COLA as shown on the COLA markup pages following the RFI RHH-03 response.

Radiological Human Health (RHH)

RHH-03: Provide an SME to address issues of hydrologic monitoring during construction and operation. Provide:

A. Information about monitoring equipment, data analysis, and schedules of monitoring.

B. Information on monitoring effects of hydrologic alterations such as infiltration beds, and other diversions on groundwater and surface water flows from surface waters and wetlands.

Audit Disposition:

Upon review of the RHH-03 NFI, NRC had questions on the rationale for choosing a 2070 population projection date in ER Section 5.4, since the initial license of 40 years would extend to the year 2060, and an assumed license renewal of 20 additional years would extend to the year 2080. The NRC requested that the ER be revised to incorporate population projections to 2080. A response and associated COLA markup are provided below.

Response:

The population projection to the year 2080 has been incorporated into the dose calculations and the BBBNPP ER will be revised to reflect the results of these calculations.

COLA Impact:

BBNPP COLA ER Section 5.4 will be revised in a future revision of the COLA as shown on the following pages. Note that the changes for NFI HY-02 and RHH-03 are captured in the same COLA markup of ER 5.4.

Mark-ups to COLA ER Section 5.4

5.4 RADIOLOGICAL IMPACTS OF NORMAL OPERATIONS

The radioactive waste management systems, as discussed in Section 3.5, are designed such that the radiological impacts due to the normal operational releases from BBNPP are within guidelines established in Appendix I to 10 CFR 50 (CFR, 2007). This section evaluates the impacts of radioactive effluents on human beings and other biota inhabiting the general vicinity of the BBNPP site resulting from expected routine operations. Primary exposure pathways to man are examined and evaluated according to the mathematical model described in Regulatory Guide 1.109 (NRC, 1977a). The resulting radiological impacts for BBNPP are compared to regulatory limits for a single unit.

In addition, the radiological impact of BBNPP in conjunction with Susquehanna Steam Electric Station (SSES) Units 1 and 2, including direct radiation, is compared to the corresponding regulatory limits under 40 CFR 190 (CFR, 2007b).

The radioactive waste system's cost benefit analysis is provided in ER 3.5. It includes the dose impact to the general population within 50 mi (80 km) radius from routine operations of BBNPP.

Finally, consideration of the dose impact to biota other than man that appear along the exposure pathways or that are on endangered species lists is presented. Other than the endangered species identified, there are no unusual animals, plants, agricultural practices, game harvest or food operations in the vicinity of BBNPP that need to be considered for radiological impacts. ~~Regulatory guidance is for use of the site boundary for gaseous dose calculations. Site design changes resulted in minor changes to the site boundary during the period dose calculations were performed. Rather than adjust gaseous effluents dose calculations with each change of site boundary, gaseous effluent doses were instead conservatively calculated at the Owner Controlled Area boundary which remained constant.~~

5.4.1 Exposure Pathways

Routine radiological effluent releases from BBNPP are a potential source of radiation exposure to both humans and biota other than man. The major pathways are those that could lead to the highest potential radiological dose to humans and biota. These pathways are determined from the amount and isotopic distribution of activity released in liquids and gases, the environmental transport mechanism, and how the BBNPP site environs are utilized (e.g., location of the Owner Controlled Area (OCA) boundary, residences, gardens, milk animals, beaches, etc.) and the consumption or usage factors applied to exposed individuals. The environmental transport mechanism includes the BBNPP site-specific meteorological dispersion of airborne effluents and aquatic dispersion in the Susquehanna River of liquid releases. This information is used to evaluate how the radionuclides will be distributed within the surrounding area. ~~The gaseous and direct radiation doses are conservatively calculated from the OCA instead of the BBNPP Project Boundary.~~

The potential exposure pathways are impacted by both aquatic (liquid) and gaseous effluents. The radioactive liquid effluent exposure pathways include internal exposure due to ingestion of aquatic foods (fish and invertebrates), external exposure due to recreational activities on the shoreline and in the water (swimming and boating), ingestion of irrigated crops, and drinking water.

The radioactive gaseous effluent exposure pathways include external exposure due to immersion in airborne effluent and exposure to a deposited material on the ground plane.

Internal exposures are due to ingestion of food products grown in areas under influence of atmospheric releases and inhalation.

An additional exposure pathway considered is the direct radiation from the facility structures during normal operation of BBNPP.

The description of the exposure pathways and the calculation methods utilized to estimate doses to the maximally exposed individual and to the population surrounding the BBNPP site are based on Regulatory Guide 1.109 (NRC 1977a) and Regulatory Guide 1.111 (NRC 1977b). The source terms used in estimating exposure pathway doses are based on the projected normal effluent values provided in Section 3.5. The source term for both liquids and gases are calculated using the Nuclear Regulatory Commission GALE code for PWRs (NRC, 1985).

10% of

As indicated in Section 3.5, the liquid and gaseous source term for BBNPP was generated with the a total shim bleed flow rate of 2160 gpd (8176 lpd) to reflect total letdown flow for boron control with ~~all~~ the reactor coolant liquid being recycled. This deviates from the GALE application in the U.S. EPR FSAR where it was assumed that 5% of the letdown flow was sent to the liquid waste system for processing. This approach better approximates anticipated operations. The primary impact of this input assumption to the GALE code causes the annual release of Kr-85 to drop from a very conservative estimate of 34,000 Ci (1.26E+06 GBq) to 2,800 Ci (1.04E+05 GBq) in gaseous effluents. In addition, the GALE code has a fixed annual release value for C-14 of 7.3 Ci (270 GBq), (NRC, 1985) regardless of size (power output) of the reactor, and with no determination of the chemical form of the carbon in the waste gas. This fixed C-14 production in GALE does not recognize that its production in nuclear power plants is mainly produced by activation of O-17 content of water in the primary coolant circuit. The quantity released is directly linked to energy provided by the reactor. Since the U.S. EPR is significant larger (approximately 1,600 MWe) than the size of power plants when the GALE code was developed, the annual release of C-14 is increased for analysis purposes to 18.9 Ci (0.7 TBq) which is estimated to be in the chemical form of ~~80% methane and only 20% carbon dioxide~~ 100%

5.4.1.1 Liquid Pathways 008831

BB-10-0190 Treated liquid radwaste effluent is released to the Susquehanna River at a flow rate of 11 gpm (42 lpm) (see Section 3.3.1) via the BBNPP discharge line situated downstream of the Combined Waste Water Retention Pond. The average discharge flow rate from the retention pond for waste water streams other than treated liquid radiological waste, is conservatively assumed to be 8,654 gpm (0.5459 m^3/sec), resulting in a total average flow of 8,665 gpm (0.5466 m^3/sec) for all liquid effluents discharged to the river. Retention basin flow provides dilution flow to discharged treated liquid radiological waste. As shown in Table 5.4-1, a near-field dilution factor of 11.8 (a mixing ratio of 0.085) was utilized for calculating the maximum individual dose to man for exposures associated with fish and invertebrate ingestion and boating pathways. For swimming and shoreline exposure pathways, an environmental dilution factor of 44 (a mixing ratio of 0.023) was applied for the maximum impacted shoreline. This value is based upon the maximally impacted shoreline dilution factor. These dilution factors are based on a submerged, multi-port diffuser (with seventy-two nozzles), a discharge line situated near the shoreline with the nozzles directed out into the Susquehanna River. Table 5.4-2 provides far-field dilution factors. The physical description of the cooling water discharge system is provided in Section 3.4. Dilution effects for both near-field and far-field mixing are described in Section 5.3.

A dose assessment for a hypothetical maximum individual, where all applicable receptors were located at the ~~OCA boundary~~ was also calculated to account for the possibility for future patterns not commonly practiced.

maximum offsite location

5.4.3 Impacts to Members of the Public

Appendix I to 10 CFR Part 50 (CFR, 2007a) provides design objectives on the levels of exposure to the general public from routine effluent releases that may be considered to be "as low as reasonably achievable" (ALARA). The estimated doses to individuals in the general public in the site vicinity, for the pathways described in Section 5.4.2.1 and Section 5.4.2.2, demonstrate that the proposed plant design is capable of keeping radiation exposures consistent with the ALARA objectives. In addition to the ALARA dose objectives for individuals, 10 CFR 50 Appendix I also requires that an evaluation of alternate radwaste system designs be made to determine the most cost-benefit effective system to keep total radiation exposures to the public as low as reasonably achievable. This cost-benefit evaluation, comparing costs of alternate radwaste systems against their ability to reduce the population doses from plant effluents, is discussed in Section 3.5.2.3 for liquid waste systems process options, and Section 3.5.3.3 for the gaseous waste system alternative design. The cost-benefit ratios for the alternative radwaste augments investigated indicate that no alternate system to the present plant design can be justified on a cost effective basis.

For gaseous effluent ingestion pathways of exposure, the production of milk, meat and vegetables grown within 50 mi (80 km) has been included in the estimation of dose along with plume, ground plane exposures and inhalation. For liquid pathways, the population that can be supported by the recorded harvest of fish and shellfish (invertebrates) within 50 mi (80 km), along with estimated recreational uses of beaches and boating activities, are factored into the aquatic pathway population dose impact assessment.

The population dose assessments which were used in the cost-benefit analysis are based on the models and dose factors given in Regulatory Guide 1.109 (NRC, 1977a). The population which is projected to be contained within 50 mi (80 km) of the site for in the year ~~2060~~ has been used for calculating annual population doses for the gaseous releases.

2080

In addition to the BBNPP dose impacts assessed for the maximum exposed individual and general population, the combined historical dose impacts of SSES Units 1 and 2 and a future projection of the dose impacts of the SSES ISFSI are added to the BBNPP projected impacts to compare to the uranium fuel cycle dose standard of 40 CFR 190 (CFR, 2007b). Since there are no other fuel cycle facilities within 5 mi (8.0 km) of the BBNPP/SSES site, the combined impacts for three units can be used to determine the total impact from liquid and gaseous effluents along with direct radiation from fixed radiation sources onsite to determine compliance with the dose limits of the standard 25 mrem/yr (0.25 mSv/yr) whole body, 75 mrem/yr (0.75 mSv/yr) thyroid, and 25 mrem/yr (0.25 mSv/yr) for any other organ). Table 5.4-23 illustrates the impact from SSES Units 1 and 2 over a recent eight year historical period. Using the highest observed annual dose impact from SSES Units 1 and 2, Table 5.4-24 shows the combined impact along with the projected contributions from BBNPP.

5.4.3.1 Impacts From Liquid Pathways

Release of radioactive materials in liquid effluents to the discharge flow, from where they mix with the Susquehanna River, results in minimal radiological exposure to individuals and the general public. The use of the Susquehanna River for agricultural irrigation is minimal accounting for approximately 1 % of all agriculture in the 50 mi (80 km) radius surrounding BBNPP. As such, water irrigation of farm fields is not assumed for the population pathway

assessments around the BBNPP site. Since it is a possible pathway for a given individual, it was retained for the assessment of the maximally exposed individual.

With respect to drinking water, the Pennsylvania Division of Drinking Water Management has identified a total of three municipal water supplies using the Susquehanna River as a source of water within the 50 mi (80 km) radius, downstream of the BBNPP liquid discharge. Two of the three are in Danville of Montour County, approximately 30 mi (48 km) down river. The third supply is in Sunbury of Northumberland County, approximately 40 mi (64 km) down stream. The annual average dilution for these locations is estimated to be 500 to 1 and the transit time to the nearest public water supply is estimated to be about 63 hours. The combined pumping capacity is recorded as 11.5 million gpd (43.5 million lpd), and is a water supply for a total of 15,940 people.

The BBNPP annual radiation exposures to the maximum exposed individual via the pathways of aquatic foods and shoreline deposits are provided in Table 5.4-16 for total body dose to four age groups (Adult, Teen, Child, Infant) from each dose pathway of exposure, and Table 5.4-17 for the limiting organ dose for each pathway and age group. Table 5.4-18 summarizes the liquid effluent dose to a hypothetical MEI. Population dose impacts within a 50 mi (80 km) radius of the BBNPP site are listed in Table 5.4-19.

~~For the cost-benefit assessment of liquid radiological waste equipment options, the annual release source terms produced with and without demineralizer processing of evaporator and centrifuge treated liquid waste streams are listed in Section 3.5.2.3. The cost-benefit population dose assessment evaluated the "unadjusted" releases from the two waste processing options in order to assess the relative difference between the two cases of processing with and without a waste demineralizer. However, total expected annual radioactivity release used to determine the expected liquid population dose in Table 5.4-19 includes an adjustment to account for the potential anticipated operational occurrences that add to the expected treated discharge stream. This adjustment factor adds 0.16 curies per year to the normal effluent. The liquid effluent population doses provided in Section 3.5.2.3 uses the unadjusted releases so as not to be dominated by the adjustment factor which is not impacted by any treatment option.~~

As can be seen from Table 5.4-18, the maximum exposed individual annual doses from the discharge of radioactive materials in liquid effluents projected from BBNPP meets the design objectives of Appendix I to 10 CFR Part 50. In addition, Section 3.5 shows that the effluent concentration being discharged to the Susquehanna River also meets the effluent release standards of 10 CFR Part 20, (Appendix B, Table 2, Column 2). The maximally exposed individual dose calculated from liquids was also included in the BBNPP site assessment of 40 CFR 190 criteria as shown in Table 5.4-24.

Based on this, the release of radioactive materials in liquid effluents results in minimal radiological exposure to individuals and the general public. As such, the impacts would be SMALL and do not warrant mitigation.

5.4.3.2 Impacts From Gaseous Pathways

The release of radioactive materials in gaseous effluents from BBNPP to the environment results in minimal radiological impacts. Annual radiation exposures to the maximum exposed individual near the BBNPP site via the pathways of submersion, ground contamination, inhalation and ingestion are provided in Table 5.4-20 for the four age groups of interest. Table 5.4-21 provides a summary of the dose to the MEI compared to the dose limits of 10 CFR

40 4.0 offsite 6.0 60

50, Appendix I. Table 5.4-21 indicates that the critical organ dose to the current real MEI is ~~2.7~~ mrem/yr (~~27~~ µSv/yr) to a child's bone via the identified exposure pathways in the BBNPP site vicinity. All projected dose impacts are well within the design objects of Appendix I. If a hypothetical individual is postulated to be exposed to all potential pathways (ground plane, inhalation, vegetable gardens, goat's milk and meat) at the same limiting ~~BBNPP OCA boundary~~ location, the maximum critical organ (child bone) dose increases to ~~4.7~~ mrem/yr (~~47~~ µSv/yr) which is still below the dose objective of 10 CFR 50, Appendix I, Section II.C (CFR, 2007a).

Population dose impacts within a 50 mi (80 km) radius of the BBNPP site from atmospheric releases from BBNPP are listed in Table 5.4-15. Annual production rates of milk, meat, and vegetables for the 50 mi (80 km) radius are provided in Table 5.4-9 through Table 5.4-12. ~~For the cost-benefit assessment of gaseous radiological waste equipment options, the annual release source terms produced by processing the waste purge gas through the base configuration of three charcoal delay beds, as well as the effect of adding a fourth delay bed in series, are provided in Section 3.5.3.3. The estimated holdup times for decay before release are also provided along with the estimated reduction in the population dose afforded by the treatment option.~~

2080

The estimated population distribution in the year ~~2060~~ within a 50 mi (80 km) radius of the BBNPP site is given in Section 2.5.1. The total effective dose equivalent to individuals living in the U.S. from all sources of natural background radiation averages about 300 mrem/yr (3 mSv/yr) (NCRP, 1987). Therefore, the 50 mi (80 km) population (~~2,456,110~~) in year ~~2060~~ projected in the BBNPP site area will receive a collective population dose of approximately ~~7.4E+05~~ person-rem/yr (~~7,400~~ person-Sv/yr) from natural background radiation.

7900 2,640,368 7.9

The concentrations of radionuclides released as gaseous effluents at BBNPP conform to the limits as specified in Column 1 of Table 2 of 10 CFR Part 20 Appendix B (CFR, 2008). Table 5.4-22 shows that the cumulative air concentrations of all radionuclides released is approximately 2% of the levels permissible under 10 CFR 20 Appendix B.

In addition, the maximally exposed individual dose calculated was also compared to 40 CFR 190 criteria (CFR, 2007b) as shown in Table 5.4-24.

Based on this, the release of radioactive materials in gaseous effluents from BBNPP to the environment results in SMALL radiological impacts and do not warrant mitigation.

5.4.3.3 Direct Radiation Doses

Direct radiation doses are discussed in Section 5.4.1.3. Table 5.4-24 includes a projected direct dose (assuming full time occupancy) to the nearest OCA boundary, from BBNPP as part of the total site dose assessment for compliance with the uranium fuel cycle dose standards of 40 CFR 190.

Based on these projections, direct radiation doses from BBNPP to the environment results in SMALL radiological impacts and do not warrant mitigation.

5.4.4 Impacts to Biota other than Members of the Public

Environmental exposure pathways in which biota other than humans could be impacted by plant radiological effluents were examined to determine if doses to biota could be significantly greater than those predicted for humans. This assessment was based on the use of surrogate species that provide representative information on the various dose pathways

NRC, 1987. GASPAR II - Technical Reference and User Guide, NUREG/CR-4653, Nuclear Regulatory Commission (by Pacific Northwest Laboratory), March 1987.

NRC, 1999. Standard Review Plans for Environmental Reviews for Nuclear Power Plants, NUREG-1555, Nuclear Regulatory Commission, October 1999.

ORNL, 1983. Radiological Assessments, A Textbook on Environmental Dose Analysis, NUREG/CR-3332 (ORNL-5968), Nuclear Regulatory Commission, September 1983.

Insert
5.4.4.5-1

Insert 5.4.4.5-1

SSES, 2010. "Susquehanna Steam Electric Station, 2010 Land Use Census," Susquehanna Steam Electric Station, November, 2010.

Table 5.4-13— Distance to Nearest Gaseous Dose Receptors

Sector	OCA[1] Boundary (mi/m)	Residence (mi/km)	Vegetable Garden (mi/km)	Meat Animal[2] (mi/km)	Milk Animal (mi/km)
N	0.26/418	0.78/1.3	0.52/0.83	0.50/0.80	---
NNE	0.26/426	0.79/1.3	0.87/1.4	0.51/0.82	---
NE	0.32/507	1.0/1.7	1.4/2.3	0.62/0.99	---
ENE	0.32/519	1.8/2.9	1.7/2.8	1.4/2.2	---
E	0.30/478	1.4/2.2	1.4/2.3	1.3/2.2	---
ESE	0.20/323	1.4/2.3	1.1/1.8	1.1/1.8	---
SE	0.17/270	0.79/1.3	0.91/1.5	0.58/0.94	---
SSE	0.16/263	1.0/1.6	1.0/1.6	0.51/0.82	---
S	0.16/263	1.1/1.7	0.50/0.81	0.50/0.80	3.0/4.9
SSW	0.17/268	1.0/1.7	0.25/0.41	0.57/0.92	0.74/1.2
SW	0.17/268	0.47/0.76	0.28/0.45	0.39/0.63	~~4.0/6.5[3]~~
WSW	0.16/251	0.63/1.0	0.37/0.60	0.33/0.54	~~4.0/6.4[3]~~
W	0.15/239	0.37/0.60	0.51/0.82	0.33/0.53	4.0/6.5
WNW	0.15/239	0.53/0.85	0.89/1.4	0.34/0.55	4.0/6.5
NW	0.15/244	0.46/0.75	0.45/0.73	0.41/0.66	~~4.2/6.8[3]~~
NNW	0.22/359	0.80/1.3	0.83/1.3	0.50/0.81	4.0/6.4

Distances measured from the plant vent stack.

Notes:

1. "OCA" is the acronym for "Owner Controlled Area."
2. Hypothetical location at nearest Property Boundary in the sector.
~~3. Hypothetical milk animal location.~~

Table 5.4-14— Receptor Locations for Gaseous Effluent Maximum Dose Evaluations

Insert 5.4-14-1

Location (Distance, Sector)	Dose Pathways Evaluated	Undecayed X/Q (sec/m^3)	Depleted X/Q (sec/m^3)	D/Q ($1/m^2$)
Nearest[1] OCA[2] Boundary 0.16 mi (0.25 km), WSW	Plume	6.781E-06	6.529E-06	9.765E-09
Nearest[1] Residence 1.0 mi (1.7 km), NE	Ground	8.178E-07	7.743E-07	5.401E-09
Nearest[1] Residence 0.53 mi (0.85 km), WNW	Inhalation	3.234E-06	3.216E-06	1.914E-09
Nearest[1] Garden 0.51 mi (0.82 km), W	Vegetable	5.722E-06	5.695E-06	1.587E-09
Nearest[1] Milk Animal 0.74 mi (1.2 km), SSW	Milk	3.564E-07	3.260E-07	2.686E-09
Nearest[1] Meat Animal 0.51 mi (0.82 km), NNE	Meat	3.075E-06	3.020E-06	7.604E-09

Note:

1. For a given dose pathway (i.e., plume, ground, inhalation, vegetable, milk, or meat), "nearest" refers to the fact that the location in this table was determined to be the maximum dose location for all of the "nearest" receptor locations (i.e., the nearest site boundary, residence, garden, milk animal, or meat animal within each of the 16 meteorological sectors) for that pathway.
2. "OCA" is the acronym for "Owner Controlled Area."

Insert 5.4-14-1

Table 5.4-14— Receptor Locations for Gaseous Effluent Maximum Dose Evaluations

Location (Distance, Sector)	Dose Pathways Evaluated	Undecayed χ/Q (sec/m^3)	Depleted χ/Q (sec/m^3)	D/Q ($1/m^2$)
Nearest(1) OCA(2) Boundary (0.16 mi WSW)	Plume	6.781E-06	6.529E-06	9.765E-09
Nearest(1) Residence (1.04 mi NE)	Ground	8.178E-07	7.743E-07	5.401E-09
Nearest(1) Residence (0.79 mi NNE)	Inhalation	1.417E-06	1.382E-06	3.741E-09
Nearest(1) Garden (0.25 mi SSW)	Vegetables	1.472E-06	1.394E-06	9.504E-09
Nearest(1) Milk Animal (0.74 mi SSW)	Milk	3.564E-07	3.260E-07	2.686E-09
Nearest(1) Meat Animal (0.33 mi WSW)	Meat	1.755E-06	1.639E-06	3.476E-09

Notes:

1. For a given dose pathway (i.e., plume, ground, inhalation, vegetable, milk or meat), "nearest" refers to the fact that the location in this table was determined to be the maximum dose location for all of the "nearest" receptor locations (i.e., the nearest OCA boundary, residence, garden, milk animal, or meat animal within each of the 16 meteorological sectors) for that pathway.
2. "OCA" is the acronym for "Owner Controlled Area"

Table 5.4-15— 50 Mi (80 km) Population Doses from Gaseous Effluents

Insert 5.4-15-1

Pathway	Total Body Person-Rem (Person-Sieverts)	Skin Person-Rem (Person-Sieverts)	Thyroid Person-Rem (Person-Sieverts)	Critical Organ Bone Person-Rem (Person-Sieverts)
Plume	4.37E+00 (4.37E-02)	1.68E+01 (1.68E-01)	4.37E+00 (4.37E-02)	4.37E+00 (4.37E-02)
Ground Plane	8.49E-03 (8.49E-05)	9.96E-03 (9.96E-05)	8.49E-03 (8.49E-05)	8.49E-03 (8.49E-05)
Inhalation	1.32E-01 (1.32E-03)	1.32E-01 (1.32E-03)	3.02E-01 (3.02E-03)	1.99E-03 (1.99E-05)
Vegetable Ingestion	6.02E-01 (6.02E-03)	6.00E-01 (6.00E-03)	6.06E-01 (6.06E-03)	2.36E+00 (2.36E-02)
Milk Ingestion	1.73E-01 (1.73E-03)	1.73E-01 (1.73E-03)	3.35E-01 (3.35E-03)	7.04E-01 (7.04E-03)
Meat Ingestion	2.37E-01 (2.37E-03)	2.37E-01 (2.37E-03)	2.47E-01 (2.47E-03)	1.05E+00 (1.05E-02)
Total	5.52E+00 (5.52E-02)	1.80E+01 (1.80E-01)	5.87E+00 (5.87E-02)	8.50E+00 (8.50E-02)

Notes:
Based on projected 50 mi (80 km) population for the year 2070 (decade after the 40 year operating license period of BBNPP). Food production within the 50 mi (80 km) radius is presented in Table 5.4-9 through Table 5.4-12.

Insert 5.4-15-1

Table 5.4-15— 50 Mi (80 km) Population Doses from Gaseous Effluents

Pathway	Total Body Person-Rem (Person-Sieverts)	Skin Person-Rem (Person-Sieverts)	Thyroid Person-Rem (Person-Sieverts)	Critical Organ Bone Person-Rem (Person-Sieverts)
Plume	3.74E+00 (3.74E-02)	1.44E+01 (1.44E-01)	3.74E+00 (3.74E-02)	3.74E+00 (3.74E-02)
Ground Plane	5.77E-03 (5.77E-05)	6.77E-03 (6.77E-05)	5.77E-03 (5.77E-05)	5.77E-03 (5.77E-05)
Inhalation	1.13E-01 (1.13E-03)	1.13E-01 (1.13E-03)	2.56E-01 (2.56E-03)	1.64E-03 (1.64E-05)
Vegetable Ingestion	2.51E+00 (2.51E-02)	2.51E+00 (2.51E-02)	2.52E+00 (2.52E-02)	1.19E+01 (1.19E-01)
Milk Ingestion	7.58E-01 (7.58E-03)	7.58E-01 (7.58E-03)	9.22E-01 (9.22E-03)	3.62E+00 (3.62E-02)
Meat Ingestion	1.12E+00 (1.12E-02)	1.12E+00 (1.12E-02)	1.13E+00 (1.13E-02)	5.44E+00 (5.44E-02)
Total	8.25E+00 (8.25E-02)	1.89E+01 (1.89E-01)	8.57E+00 (8.57E-02)	2.47E+01 (2.47E-01)

Notes:

1. Based on projected 50 mile (80 km) population for the year 2080. Food production within the 50 mile (80 km) radius is presented in Table 5.4-9 through Table 5.4-12.

Insert 5.4-16-1

Table 5.4-16— Whole Body Dose from Liquid Effluent to MEI

Dose Pathway	Adult mrem/yr (µSv/yr)	Teen mrem/yr (µSv/yr)	Child mrem/yr (µSv/yr)	Infant mrem/yr (µSv/yr)
Fish	1.28E-01 (1.28E+00)	7.52E-02 (7.52E-01)	3.27E-02 (3.27E-01)	0.00E+00 (0.00E+00)
Invertebrates	1.80E-02 (1.80E-01)	1.14E-02 (1.14E-01)	6.57E-03 (6.57E-02)	0.00E+00 (0.00E+00)
Potable Water	3.59E-01 (3.59E+00)	2.53E-01 (2.53E+00)	4.85E-01 (4.85E+00)	4.76E-01 (4.76E+00)
Irrigation	4.08E-02 (4.08E-01)	3.27E-02 (3.27E-01)	3.92E-02 (3.92E-01)	0.00E+00 (0.00E+00)
Shoreline	3.53E-05 (3.53E-04)	1.97E-04 (1.97E-03)	4.12E-05 (4.12E-04)	3.53E-05 (3.53E-04)
Swimming	3.68E-06 (3.68E-05)	2.06E-05 (2.06E-04)	4.30E-06 (4.30E-05)	3.68E-06 (3.68E-05)
Boating	2.97E-05 (2.97E-04)	2.97E-05 (2.97E-04)	1.66E-05 (1.66E-04)	2.97E-05 (2.97E-04)
Total	5.46E-01 (5.46E+00)	3.73E-01 (3.73E+00)	5.64E-01 (5.64E+00)	4.76E-01 (4.76E+00)

Insert 5.4-16-1

Table 5.4-16— Whole Body Dose from Liquid Effluent to MEI

Dose Pathway	Adult mrem/yr (μSv/yr)	Teen mrem/yr (μSv/yr)	Child mrem/yr (μSv/yr)	Infant mrem/yr (μSv/yr)
Fish	1.20E-01 (1.20E+00)	7.03E-02 (7.03E-01)	3.09E-02 (3.09E-01)	0.00E+00 (0.00E+00)
Invertebrates	1.69E-02 (1.69E-01)	1.07E-02 (1.07E-01)	6.23E-03 (6.23E-02)	0.00E+00 (0.00E+00)
Portable Water	3.59E-01 (3.59E+00)	2.53E-01 (2.53E+00)	4.85E-01 (4.85E+00)	4.76E-01 4.76E+00)
Irrigation	3.92E-02 (3.92E-01)	3.17E-02 (3.17E-01)	3.85E-02 (3.85E-01)	0.00E+00 (0.00E+00)
Shoreline	3.28E-05 (3.28E-04)	1.83E-04 (1.83E-03)	3.83E-05 (3.83E-04)	3.28E-05 (3.28E-05)
Swimming	3.78E-06 (3.78E-05)	2.11E-05 (2.11E-04)	4.41E-06 (4.41E-05)	3.78E-06 (3.78E-05)
Boating	3.05E-05 (3.05E-04)	3.05E-05 (3.05E-04)	1.70E-05 (1.70E-04)	3.05E-05 (3.05E-04)
Total	5.35E-01 (5.35E+00)	3.66E-01 (3.66E+00)	5.61E-01 (5.61E+00)	4.76E-01 (4.76E+00)

Insert 5.4-17-1

Table 5.4-17— Limiting Organ Dose from Liquid Effluent to MEI

Dose Pathway	Adult (Thyroid) mrem/yr (μSv/yr)	Teen (Thyroid) mrem/yr (μSv/yr)	Child (Thyroid) mrem/yr (μSv/yr)	Infant (Thyroid) mrem/yr (μSv/yr)
Fish	1.13E-01 (1.13E+00)	1.04E-01 (1.04E+00)	1.08E-01 (1.08E+00)	0.00E+00 (0.00E+00)
Invertebrates	1.06E-02 (1.06E-01)	9.56E-03 (9.56E-02)	1.01E-02 (1.01E-01)	0.00E+00 (0.00E+00)
Potable Water	6.16E-01 (6.16E+00)	4.76E-01 (4.76E+00)	1.03E+00 (1.03E+01)	1.34E+00 (1.34E+01)
Irrigation	8.40E-01 (8.40E+00)	7.39E-01 (7.39E+00)	1.17E+00 (1.17E+01)	0.00E+00 (0.00E+00)
Shoreline	3.53E-05 (3.53E-04)	1.97E-04 (1.97E-03)	4.12E-05 (4.12E-04)	3.53E-05 (3.53E-04)
Swimming	3.68E-06 (3.68E-05)	2.06E-05 (2.06E-04)	4.30E-06 (4.30E-05)	3.68E-06 (3.68E-05)
Boating	2.97E-05 (2.97E-04)	2.97E-05 (2.97E-04)	1.66E-05 (1.66E-04)	2.97E-05 (2.97E-04)
Total	1.58E+00 (1.58E+01)	1.33E+00 (1.33E+01)	2.32E+00 (2.32E+01)	1.34E+00 (1.34E+01)

Insert 5.4-17-1

Table 5.4-17 – Limiting Organ Dose from Liquid Effluent to MEI

Dose Pathway	Adult (Thyroid) mrem/yr (μSv/yr)	Teen (Thyroid) mrem/yr (μSv/yr)	Child (Thyroid) mrem/yr (μSv/yr)	Infant (Thyroid) mrem/yr (μSv/yr)
Fish	1.18E-01 (1.18E+00)	1.09E-01 (1.09E+00)	1.14E-01 (1.14E+00)	0.00E+00 (0.00E+00)
Invertebrates	1.10E-02 (1.10E-01)	9.97E-03 (9.97E-02)	1.05E-02 (1.05E-01)	0.00E+00 (0.00E+00)
Potable Water	6.32E-01 (6.32E-00)	4.89E-01 (4.89E+00)	1.07E+00 (1.07E+01)	1.39E+00 (1.39E+01)
Irrigated	8.74E-01 (8.74E+00)	7.69E-01 (7.69E+00)	1.22E+00 (1.22E+01)	0.00E+00 (0.00E+00)
Shoreline	3.28E-05 (3.28E-04)	1.83E-04 (1.83E-03)	3.83E-05 (3.83E-04)	3.28E-05 (3.28E-04)
Swimming	3.78E-06 (3.78E-05)	2.11E-05 (2.11E-04)	4.41E-06 (4.41E-05)	3.78E-06 (3.78E-05)
Boating	3.05E-05 (3.05E-04)	3.05E-05 (3.05E-04)	1.70E-05 (1.70E-04)	3.05E-05 (3.05E-04)
Total	1.64E+00 (1.64E+01)	1.38E+00 (1.38E+01)	2.41E+00 (2.41E+01)	1.39E+00 (1.39E+01)

Table 5.4-18— Summary Liquid Effluent Annual Dose to MEI i1309560

Assessment Type	BBNPP Calculated Dose mrem (μSv)	10 CFR 50 Appendix I Limit[1] mrem (μSv)	Fraction of Appendix I Objective
Total Body	~~5.64E-01~~ (~~5.64E+00~~) Child	3 (30)	~~1.88E-01~~
Maximum Organ	~~2.32E+00~~ (~~2.32E+01~~) Thyroid-Child	10 (100)	~~2.32E-01~~

Note:
1. Numerical dose objectives from 10 CFR 50 Appendix I, Section II.A.

1.87E-01

2.41E-01

5.61E-01
(5.61E+00)

2.41E+00
(2.41E+01)

Table 5.4-19— General Population Doses from Liquid Effluents

Total Body Person-Rem (Person-Sieverts)	Person-Thyroid-Rem (Person-Thyroid-Sieverts)
~~1.64E-01 (1.64E-03)~~	~~1.67E-01 (1.67E-03)~~
Includes dose contribution from sport fishing, boating, and consumption of potable water exposures to the 50 mi (80 km) population impacted by water uses of the Susquehanna River 50 mi (80 km) downstream. Based on projected 50 mi (80 km) population for the year ~~2070~~ 2080.	

2.89E-01 (2.89E-03)

3.43E-01 (3.43E-03)

Insert 5.4-20-1

Table 5.4-20— Gaseous Pathway Doses for Maximally Exposed Individuals (MEI)

Location	Pathway	Total Body mrem/yr (μSv/yr)	Max. Organ mrem/yr (μSv/yr)	Skin mrem/yr (μSv/yr)
Nearest[1] OCA[2] Boundary 0.16 mi (0.25 km), WSW	Plume	1.26E+00 -1.26E+01	1.26E+00 -1.26E+01	3.93E+00 -3.93E+01
Nearest[1] Residence 1.0 mi (1.7 km), NE	Ground	7.62E-04 -7.62E-03	7.62E-04 -7.62E-03	8.95E-04 -8.95E-03
Nearest[1] Residence 0.53 mi (0.85 km), WNW	Inhalation			
	Adult	1.33E-02 (1.33E-01)	2.47E-04 (2.47E-03)	1.33E-02 (1.33E-01)
	Teen	1.34E-02 (1.34E-01)	3.01E-04 (3.01E-03)	1.34E-02 (1.34E-01)
	Child	1.19E-02 (1.19E-01)	3.67E-04 (3.67E-03)	1.18E-02 (1.18E-01)
	Infant	6.83E-03 (6.83E-02)	1.91E-04 (1.91E-03)	6.79E-03 (6.79E-02)
Nearest[1] Garden 0.51 mi (0.82 km), W	Vegetable			
	Adult	1.66E-01 (1.66E+00)	5.90E-01 (5.90E+00)	1.66E-01 (1.66E+00)
	Teen	2.53E-01 (2.53E+00)	9.81E-01 (9.81E+00)	2.52E-01 (2.52E+00)
	Child	5.64E-01 (5.64E+00)	2.38E+00 (2.38E+01)	5.64E-01 (5.64E+00)
	Infant	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
Nearest[1] Milk Animal 0.74 mi (1.2 km), SSW	Cow Milk			
	Adult	4.35E-03 (4.35E-02)	1.61E-02 (1.61E-01)	4.23E-03 (4.23E-02)
	Teen	7.37E-03 (7.37E-02)	2.95E-02 (2.95E-01)	7.22E-03 (7.22E-02)
	Child	1.67E-02 (1.67E-01)	7.25E-02 (7.25E-01)	1.65E-02 (1.65E-01)
	Infant	3.36E-02 (3.36E-01)	1.42E-01 (1.42E+00)	3.32E-02 (3.32E-01)
Nearest[1] Meat Animal 0.51 mi (0.82 km), NNE	Meat			
	Adult	2.89E-02 (2.89E-01)	1.25E-01 (1.25E+00)	2.89E-02 (2.89E-01)
	Teen	2.34E-02 (2.34E-01)	1.05E-01 (1.05E+00)	2.34E-02 (2.34E-01)
	Child	4.24E-02 (4.24E-01)	1.98E-01 (1.98E+00)	4.24E-02 (4.24E-01)
	Infant	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)

Note:

1. For a given dose pathway (i.e., plume, ground, inhalation, vegetable, milk, or meat), "nearest" refers to the fact that the location in this table was determined to be the maximum dose location for all of the "nearest" receptor locations (i.e., the nearest site boundary, residence, garden, milk animal, or meat animal within each of the 16 meteorological sectors) for that pathway.
2. "OCA" is the acronym for "Owner Controlled Area."

Insert 5.4-20-1

Table 5.4-20 - Gaseous Pathway Doses for Maximum Exposed Individuals (MEI)[1]

Location	Pathway	Total Body (mrem/yr)	Max. Organ (mrem/yr)	Skin (mrem/yr)
Nearest[1] OCA[2] Boundary 0.16 mi, WSW	Plume	1.26E+00	1.26E+00	3.93E+00
Nearest[1] Residence 0.79 mi, NNE	Ground	5.28E-04	5.28E-04	5.28E-04
Nearest[1] Residence 0.79 mi NNE	Inhalation			
	Adult	5.83E-03	1.06E-04	5.81E-03
	Teen	5.88E-03	1.29E-04	5.86E-03
	Child	5.20E-03	1.58E-04	5.18E-03
	Infant	2.99E-03	8.25E-05	2.98E-03
Nearest[1] Garden 0.25 mi SSW	Vegetable			
	Adult	1.64E-01	7.67E-01	1.63E-01
	Teen	2.66E-01	1.27E+00	2.65E-01
	Child	6.32E-01	3.08E+00	6.31E-01
	Infant	0.00E+00	0.00E+00	0.00E+00
Nearest[1] Milk Animal 0.74 mi SSW	Cow Milk			
	Adult	1.69E-02	7.86E-02	1.67E-02
	Teen	3.04E-02	1.45E-01	3.03E-02
	Child	7.35E-02	3.56E-01	7.32E-02
	Infant	1.52E-01	6.97E-01	1.52E-01
Nearest[3] Meat Animal 0.33 mi WSW	Meat			
	Adult	7.30E-02	3.53E-01	7.29E-02
	Teen	6.11E-02	2.99E-01	6.11E-02
	Child	1.14E-01	5.61E-01	1.14E-01
	Infant	0.00E+00	0.00E+00	0.00E+00

Note:
1. For a given dose pathway (i.e., plume, ground, inhalation, vegetable, milk, or meat), "nearest" refers to the fact that the location in this table was determined to be the maximum dose location for all of the "nearest" receptor locations (i.e., the nearest OCA boundary, residence, garden, milk animal, or meat animal within each of the 16 meteorological sectors) for that pathway.
2. "OCA" is the acronym for "Owner Controlled Area."
3. Nearest meat animal assumed to be at limiting site boundary location since actual location of animals within 5 miles is not available (SSES, 2010).

Table 5.4-21— BBNPP Gaseous Effluent MEI Dose Summary

10 CFR 50 Appendix I Section	Dose Assessment	Calculated Dose	10 CFR 50 Appendix I Limit
II.B.1	Beta Air Dose mrad/yr (μGy/yr)	4.5 (45.0)	20 (200)
	Gamma Air Dose mrad/yr (μGy/yr)	2.0 (20.0)	10 (100)
II.B.2	External Total Body Dose mrem/yr (μSv/yr)	1.3 (13.0)	5 (50)
	External Skin Dose mrem/yr (μSv/yr)	3.9 (39.0)	15 (150)
II.C	Organ Dose (Child, Bone) mrem/yr (μSv/yr)	~~2.7 (27.0)~~ 4.0 (40.0)	15 (150)

Insert 5.4-23-1

Table 5.4-23— Annual Historical Dose Compliance with 40 CFR 190 for SSES Units 1 & 2

Year	Whole Body[1] mrem (μSv)	Thyroid mrem (μSv)	Maximum Organ[2] mrem (μSv)
2000	1.68E-01 (1.68E+00)	1.73E-01 (1.73E+00)	1.73E-01 (1.73E+00)
2001	2.15E-01 (2.15E+00)	2.18E-01 (2.18E+00)	2.23E-01 (2.23E+00)
2002	1.30E+00 (1.30E+01)	1.29E+00 (1.29E+01)	1.31E+00 (1.31E+01)
2003	1.20E+00 (1.20E+01)	1.21E+00 (1.21E+01)	1.21E+00 (1.21E+01)
2004	1.22E+00 (1.22E+01)	1.22E+00 (1.22E+01)	1.22E+00 (1.22E+01)
2005	8.34E-01 (8.34E+00)	8.38E-01 (8.38E+00)	8.34E-01 (8.34E+00)
2006	5.27E-01 (5.27E+00)	5.32E-01 (5.32E+00)	5.32E-01 (5.32E+00)
2007	8.25E-01 (8.25E+00)	8.24E-01 (8.24E+00)	8.28E-01 (8.28E+00)
Maximum Value any Year	1.30E+00 (1.30E+01)	1.29E+00 (1.29E+01)	1.32E+00 (1.32E+01)
SSES ISFSI Projection	4.7E+00 (4.7E+01)	4.7E+00 (4.7E+01)	4.7E+00 (4.7E+01)
Total SSES Dose Contribution	6.01E+00 (6.01E+01)	5.99E+00 (5.99E+01)	6.02E+00 (6.02E+01)

Notes:
1. This is the sum of direct radiation, gaseous and liquid effluents
2. The maximum organ dose from liquids was summed with the thyroid dose from gases and the direct radiation

Insert 5.4-23-1

Table 5.4-23— Annual Historical Dose Compliance with 40 CFR 190 for SSES Units 1 & 2

Year	Whole Body[1] mrem (μSv)	Thyroid[2] mrem (μSv)	Maximum Organ[1] mrem (μSv)
2000	1.68E-01 (1.68E+00)	1.73E-01 (1.73E+00)	1.73E-01 (1.73E+00)
2001	2.15E-01 (2.15E+00)	2.18E-01 (2.18E+00)	2.23E-01 (2.23E+00)
2002	1.30E+00 (1.30E+01)	1.29E+00 (1.29E+01)	1.31E+00 (1.31E+01)
2003	1.20E+00 (1.20E+01)	1.21E+00 (1.21E+01)	1.21E+00 (1.21E+01)
2004	1.22E+00 (1.22E+01)	1.22E+00 (1.22E+01)	1.22E+00 (1.22E+01)
2005	8.34E-01 (8.34E+00)	8.38E-01 (8.38E+00)	8.38E-01 (8.38E+00)
2006	5.22E-01 (5.22E+00)	5.27E-01 (5.27E+00)	5.27E-01 (5.27E+00)
2007	8.25E-01 (8.25E+00)	8.24E-01 (8.24E+00)	8.28E-01 (8.28E+00)
2008	5.49E-01 (5.49E+00)	5.49E-01 (5.49E+00)	5.50E-01 (5.50E+00)
2009	1.03E+00 (1.03E+01)	1.03E+00 (1.03E+01)	1.03E+00 (1.03E+01)
2010	2.29E+00 (2.29E+01)	2.31E+00 (2.31E+01)	7.47E+00 (7.47E+01)
2011	1.19E+00 (1.19E+01)	1.19E+00 (1.19E+01)	1.46E+00 (1.46E+01)
Maximum Value any Year	2.29E+00 (2.29E+01)	2.31E+00 (2.31E+01)	7.47E+00 (7.47E+01)
SSES ISFSI Projection	4.7E+00 (4.7E+01)	4.7E+00 (4.7E+01)	4.7E+00 (4.7E+01)
Total SSES Dose Contributions	6.99E+00 (6.99E+01)	7.01E+00 (7.01E+01)	1.22E+01 (1.22E+02)

Notes:

1. This is the sum of direct radiation, gaseous and liquid effluents
2. The maximum organ dose from liquids was summed with the thyroid dose from gases and the direct radiation

Insert 5.4-24-1

Table 5.4-24— 40 CFR 190 Annual Site Dose Compliance

Facility	Pathway	Whole Body mrem (μSv)	Thyroid mrem (μSv)	Maximum Organ[1] mrem (μSv)
BBNPP	Plume	1.26E+00 (1.26E+01)	1.26E+00 (1.26E+01)	1.26E+00 (1.26E+01)
	Ground	3.20E-03 (3.20E-02)	3.20E-03 (3.20E-02)	3.20E-03 (3.20E-02)
	Inhalation	1.19E-02 (1.19E-01)	3.90E-02 (3.90E-01)	3.67E-04 (3.67E-03)
	Vegetable	5.64E-01 (5.64E+00)	6.18E-01 (6.18E+00)	2.38E+00 (2.38E+01)
	Meat	4.24E-021 (4.24E-01)	4.58E-02 (4.58E-01)	1.98E-01 (1.98E+00)
	Milk	2.59E-02 (2.59E-01)	1.10E-01 (1.10E+00)	1.12E-01 (1.12E+00)
	Fish	3.27E-02 (3.27E-01)	1.08E-01 (1.08E+00)	1.21E-01 (1.21E+00)
	Invertebrate	6.57E-03 (6.57E-02)	1.01E-02 (1.01E-01)	1.71E-02 (1.71E-01)
	Drinking water	4.85E-01 (4.85E+00)	1.03E+00 (1.03E+01)	8.23E-03 (8.23E-02)
	Irrigation	3.92E-02 (3.92E-01)	1.17E+00 (1.17E+01)	6.29E-02 (6.29E-01)
	Shoreline	4.12E-05 (4.12E-04)	4.12E-05 (4.12E-04)	4.12E-05 (4.12E-04)
	Swimming	4.30E-06 (4.30E-05)	4.30E-06 (4.30E-05)	4.30E-06 (4.30E-05)
	Boating	1.66E-05 (1.66E-04)	1.66E-05 (1.66E-04)	1.66E-05 (1.66E-04)
	Fixed Direct	1.87E+00 (1.87E+01)	1.87E+00 (1.87E+01)	1.87E+00 (1.87E+01)
	Total	4.34E+00 (4.34E+01)	6.26E+00 (6.26E+01)	6.03E+00 (6.03E+01)
SSES 1 & 2	Total	6.01E+00 (6.01E+01)	5.99E+00 (5.99E+01)	6.02E+00 (6.02E+01)
All Units	Total	1.04E+01 (1.04E+02)	1.23E+01 (1.23E+02)	1.21E+01 (1.21E+02)

Notes:
1. The critical organ for all pathways was the child bone.

Insert 5.4-24-1

Table 5.4-24— 40 CFR 190 Annual Site Dose Compliance

Facility	Pathway	Whole Body mrem (μSv)	Thyroid mrem (μSv)	Maximum Organ [1] mrem (μSv)
BBNPP	Plume	1.26E+00 (1.26E+01)	1.26E+00 (1.26E+01)	1.26E+00 (1.26E+01)
	Ground	5.28E-04 (5.28E-03)	5.28E-04 (5.28E-03)	5.28E-04 (5.28E-03)
	Inhalation	5.20E-03 (5.20E-02)	1.70E-02 (1.70E-01)	1.58E-04 (1.58E-03)
	Vegetable	6.32E-01 (6.32E+00)	9.52E-01 (9.52E+00)	3.08E+00 (3.08E+01)
	Meat	1.14E-01 (1.14E+00)	1.15E-01 (1.15E+00)	5.61E-01 (5.61E+00)
	Milk	7.35E-02 (7.35E-01)	1.69E-01 (1.69E+00)	3.56E-01 (3.56E+00)
	Fish	3.09E-02 (3.09E-01)	1.14E-01 (1.14E+00)	1.12E-01 (1.12E+00)
	Invertebrates	6.23E-03 (6.23E-02)	1.05E-02 (1.05E-01)	1.59E-02 (1.59E-01)
	Potable Water	4.85E-01 (4.85E+00)	1.07E+00 (1.07E+01)	7.88E-03 (7.88E-02)
	Irrigation	3.85E-02 (3.85E-01)	1.22E+00 (1.22E+01)	5.87E-02 (5.87E-01)
	Shoreline	3.83E-05 (3.83E-04)	3.83E-05 (3.83E-04)	3.83E-05 (3.83E-04)
	Swimming	4.41E-06 (4.41E-05)	4.41E-06 (4.41E-05)	4.41E-06 (4.41E-05)
	Boating	1.70E-05 (1.70E-04)	1.70E-05 (1.70E-04)	1.70E-05 (1.70E-04)
	Fixed Direct	1.87E+00 (1.87E+01)	1.87E+00 (1.87E+01)	1.87E+00 (1.87E+01)
	Total	4.52E+00 (4.52E+01)	6.80E+00 (6.80E+01)	7.32E+00 (7.32E+01)
SSES 1 & 2	Total	6.99E+00 (6.99E+01)	7.01E+00 (7.01E+01)	1.22E+00 (1.22E+01)
All Units	Total	1.15E+01 (1.15E+02)	1.38E+01 (1.38E+02)	1.95E+01 (1.95E+02)

Insert 5.4-29-1

Table 5.4-29— Dose to Biota from all Sources

Biota	Effluents Liquid		Gaseous Effluents		Fixed Sources	Total
	Internal Dose[1] mrad/yr (μGy/yr)	External Dose[1] mrad/yr (μGy/yr)	Internal Dose mrem/yr (μSv/yr)	External Dose mrem/yr (μSv/yr)	External Dose mrem/yr (μSv/yr)	All Pathways Dose[1] mrad/yr (μGy/yr)
Fish	1.14E-01 (1.14E+00)	8.42E-02 (8.42E-01)	NA	NA	NA	1.98E-01 (1.98E+00)
Invertebrate	5.36E-01 (5.36E+00)	1.67E-01 (1.67E+00)	NA	NA	NA	7.03E-01 (7.03E+00)
Algae	2.29E+00 (2.29E+01)	1.72E-03 (1.72E-02)	NA	NA	NA	2.29E+00 (2.29E+01)
Muskrat	5.86E-01 (5.86E+00)	5.56E-02 (5.56E-01)	2.79E-02 (2.79E-01)	1.27E+00 (1.27E+01)	1.87E+00 (1.87E+01)	3.81E+00 (3.81E+01)
Raccoon	1.32E-01 (1.32E+00)	3.30E-02 (3.30E-01)	2.79E-02 (2.79E-01)	1.27E+00 (1.27E+01)	1.87E+00 (1.87E+01)	3.33E+00 (3.33E+01)
Heron	1.72E+00 (1.72E+01)	4.42E-02 (4.42E-01)	2.79E-02 (2.79E-01)	1.27E+00 (1.27E+01)	1.87E+00 (1.87E+01)	4.93E+00 (4.93E+01)
Duck	5.39E-01 (5.39E+00)	8.30E-02 (8.30E-01)	2.79E-02 (2.79E-01)	1.27E+00 (1.27E+01)	1.87E+00 (1.87E+01)	3.79E+00 (3.79E+01)

Note:

1. For approximations of total doses, assume that 1 μGy = 1 μSv (1 mrad = 1 mrem).

Insert 5.4-29-1

Table 5.4-29— Dose to Biota from all Sources

Biota	Effluents Liquid		Gaseous Effluents		Fixed Sources	Total
	Internal Dose[1] mrad/yr (µGy/yr)	External Dose[1] mrad/yr (µGy/yr)	Internal Dose mrem/yr (µSv/yr)	External Dose mrem/yr (µSv/yr)	External Dose mrem/yr (µSv/yr)	All Pathways Dose[1] mrad/yr (µGy/yr)
Fish	1.09E-01 (1.09E+00)	7.85E-02 (7.85E-01)	NA	NA	NA	1.88E-01 (1.88E+00)
Invertebrate	5.00E-01 (5.00E+00)	1.55E-01 (1.55E+00)	NA	NA	NA	6.55E-01 (6.55E+00)
Algae	2.13E+00 (2.13E+01)	1.77E-03 (1.77E-02)	NA	NA	NA	2.13E+00 (2.13E+01)
Muskrat	5.59E-01 (5.59E+00)	5.18E-02 (5.18E-01)	7.29E-03 (7.29E-02)	1.26E+00 (1.26E+01)	1.87E+00 (1.87E+01)	3.75E+00 (3.75E+01)
Raccoon	1.25E-01 (1.25E+00)	3.07E-02 (3.07E-01)	7.29E-03 (7.29E-02)	1.26E+00 (1.26E+01)	1.87E+00 (1.87E+01)	3.30E+00 (3.30E+01)
Heron	1.61E+00 (1.61E+01)	4.11E-02 (4.11E-01)	7.29E-03 (7.29E-02)	1.26E+00 (1.26E+01)	1.87E+00 (1.87E+01)	4.79E+00 (4.79E+01)
Duck	5.15E-01 (5.15E+00)	7.72E-02 (7.72E-01)	7.29E-03 (7.29E-02)	1.26E+00 (1.26E+01)	1.87E+00 (1.87E+01)	3.73E+00 (3.73E+01)

Note:

1. For approximations of total doses, assume that 1 µGy = 1 µSv (1 mrad = 1 mrem).