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July 14, 2010

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

BELL BEND NUCLEAR POWER PLANT
PARTIAL RESPONSE FOR RAI No. 93
BNP-2010-100 Docket No. 52-039

References: 1) M. Canova (NRC) to R. Sgarro (PPL Bell Bend, LLC), Bell Bend COLA – Request for Information - Final Letter Nos. 93 and 94 (RAI Nos. 93 and 94) – NSIR-LIB 4443, 4445, e-mail dated April 8, 2010

2) R. R. Sgarro (PPL Bell Bend, LLC) to U.S. Nuclear Regulatory Commission, BNP-2010-159, "Extension Request for RAI Nos. 93 and 94", dated June 16, 2010

The purpose of this letter is to respond to the Request for Additional Information (RAI) No. 93 identified in the NRC correspondence to PPL Bell Bend, LLC (PPL) (Reference 1). This RAI addresses Regional Climatology as discussed in Chapter 2 of the Final Safety Analysis Report (FSAR) and submitted in Part 2 of the Bell Bend Nuclear Power Plant Combined License Application (COLA).

The enclosure provides our response to RAI Questions 02.03.01-1, 02.03.01-3 and 02.03.01-4, which includes revised COLA content. The only new regulatory commitment contained in this letter is to update the BBNPP COLA at a later date.

As identified in Reference 2, RAI 93 Question 02.03.01-2 is dependent on an RAI response for the U.S. EPR FSAR; the response to this question will be submitted by August 13, 2010.

If you have any questions, please contact the undersigned at 570.802.8102.

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

Executed on July 14, 2010

Respectfully,

Rocco R. Sgarro

RRS/kw

Enclosure: As stated

D079
NRO

cc: (w/o Enclosures)

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Enclosure

Response to NRC Request for Additional Information No. 93,
Questions 02.03.01-1, 02.03.01-3 and 02.03.01-4
Bell Bend Nuclear Power Plant

Question 02.03.01-1:

For COL applications, 10 CFR 52.79(a) states that "the application must contain a final safety analysis report that describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components of the facility as a whole. The final safety analysis report shall include the following information, at a level of information sufficient to enable the Commission to reach a final conclusion on all safety matters that must be resolved by the Commission before issuance of a combined license:

(10 CFR 52.79(a)) (iii) The seismic, meteorological, hydrologic, and geologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated."

As stated in RG 1.206, Section C.I.2.3.1.2, applicants "should provide annual (and seasonal, if available) frequencies of severe weather phenomena, including hurricanes, tornadoes and waterspouts, thunderstorms, severe wind events, lightning, hail (including probable maximum size), and high air pollution potential."

In Section 2.3.1.2.2 of the FSAR, the applicant states that data for several severe weather phenomena, including droughts, and dust/sand storms, were obtained from the NCDC "Storm Events" database. For these events, revise the FSAR to remove reference to having searched the database starting in "January 1, 1950." For these events, the NCDC database is not populated with information prior to 1993.

Response:

BBNPP FSAR Sections 2.3.1.2.2.5 and 2.3.1.2.2.8 and Environmental Report Section 2.7.3.5 will be revised to indicate that the starting data period is 1993 rather than 1950.

COLA Impact:

The BBNPP FSAR will be revised as follows:

2.3.1.2.2.5 Droughts

Five drought events were listed in the National Climatic Data Center's Storm Events database for Luzerne County, Pennsylvania, from ~~1950~~ 1993-2008 (see Table 2.3-7).

Eight drought events were listed in the National Climatic Data Center's Storm Events database for Columbia County, Pennsylvania, from ~~1950~~ 1993-2008 (see Table 2.3-8).

2.3.1.2.2.8 Dust/Sand Storms

No dust or sand storms are listed during the period from January ~~1950~~ 1993 to February 2008 in the National Climatic Data Center's Storm Events database for Luzerne or Columbia County, Pennsylvania.

The BBNPP Environmental Report will be revised as follows:

2.7.3.5 Droughts

Eight drought events were listed in the National Climatic Data Center's Storm Events database (NOAA, 2008a) for Columbia County, Pennsylvania, from ~~1950~~ 1993-2008 (Table 2.7-8).

Question 02.03.01-3:

For COL applications, 10 CFR 52.79(a)(iii) states that "the application must contain a final safety analysis report that describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components of the facility as a whole. The final safety analysis report shall include the following information, at a level of information sufficient to enable the Commission to reach a final conclusion on all safety matters that must be resolved by the Commission before issuance of a combined license: (. . .) (iii) The seismic, meteorological, hydrologic, and geologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated."

In accordance with RG 1.206, section C.I.2.3.1.2, "Regional Meteorological Conditions for Design and Operating Bases," the applicant should provide ambient temperature and humidity statistics for use in establishing heat loads for the design of plant heat sink systems and plant heating, ventilation, and air conditioning (HVAC) systems. In FSAR Section 2.3.1.2.2.16, the applicant provided site-specific monthly 0% and 1% exceedance values for dry bulk and wet bulb temperature, stating that the values presented in Table 2.1-1 of the U.S. EPR Final Safety Analysis Report are bounded. However, it is not clear whether the site parameter values presented in Table 2.1-1 of the U.S. EPR Final Safety Analysis Report are monthly, seasonal or annual values. Therefore, the staff requests that the applicant clarify whether site parameter values to which site characteristic values in FSAR Section 2.3.1.2.2.16 are compared are monthly, seasonal or annual values.

Response:

The 0% exceedance temperature values presented in BBNPP Revision 2 FSAR Section 2.3.1.2.2.16 were determined on an annual basis. The U.S. EPR FSAR Table 2.1-1 0% exceedance temperature values were determined on an annual basis.

The 1% exceedance temperature values presented in BBNPP Revision 2 FSAR Section 2.3.1.2.2.16 were determined on a monthly basis. The U.S. EPR FSAR Table 2.1-1 1% exceedance temperature values were determined on a seasonal basis. Since the site-specific 1% exceedance temperature values were not determined on the same basis as those presented in the U.S. EPR FSAR, BBNPP FSAR Section 2.3.1.2.2.16 will be revised to present site-specific 1% exceedance temperature values determined on a seasonal basis as shown below. Additionally, a review of historical maximum and minimum temperature values recorded at various stations within approximately 50 miles of the BBNPP site was conducted to provide a supporting basis for the bounding temperature value conclusions for BBNPP. The BBNPP FSAR will be revised to incorporate the results of this review and to modify tables as shown below.

COLA Impact:

The BBNPP FSAR will be revised as follows:

2.3.1.2.2.16 Temperature and Humidity for Heating, Ventilation and Air Conditioning

~~Table 2.3-21 through Table 2.3-27 present temperature and humidity data for Wilkes-Barre/Scranton, Pennsylvania (ASHRAE, 2005) (NOAA, 2008a). These data are to be used in the design of plant heating, ventilating and air conditioning systems. The National Climatic Data Center identifies both the BBNPP site and the NWS station at Wilkes-Barre/Scranton as being within the same climate division (NCDC, 2002). A climate division represents a region within a state that is climatically homogeneous as possible. As such, it is acceptable to use Wilkes-Barre/Scranton climate statistics to characterize the BBNPP site. Values are expressed in the units provided by ASHRAE.~~

~~The 0% exceedance dry bulb temperature value (100°F or 37.8°C) and the coincident wet bulb temperature value (71.7°F or 21.2°C), and the zero percent exceedance non-coincident wet bulb temperature (78.9°F or 26.1°C) value are presented in Table 2.3-22. The minimum 0% exceedance dry bulb temperature value (-15.1°F or -26.2°C) is presented in Table 2.3-22. These values were determined using 30 years (1971-2000) of hourly meteorological data from the Wilkes-Barre/Scranton NWS site. (NOAA, 2008a)~~

~~The highest 1% monthly design dry bulb and mean coincident wet bulb temperatures presented in Table 2.3-25 (ASHRAE, 2005) are the 1% exceedance dry bulb temperature value (90.5°F or 32.5°C) and the coincident wet bulb temperature value (73.1°F or 22.8°C). the highest 1% monthly design wet bulb temperature presented in Table 2.3-26 (ASHRAE, 2005) is the 1% exceedance non-coincident wet bulb temperature value (76.2°F or 24.6°C). The 1% temperature value listed under coldest month wind speed/mean coincident dry bulb temperature (WS/MCDB) presented in Table 2.3-21 is the minimum 1% exceedance dry bulb temperature value (27.9°F or -2.3°C).~~

~~The site-specific 1% exceedance dry bulb and wet bulb temperature values presented in table 2.3-25 and Table 2.3-26 are bounded by the values presented in table 2.1-1 of the U.S. EPR Final Safety Analysis Report. The site-specific 0% exceedance dry bulb and wet bulb temperature values presented in table 2.3-22 are bounded by the values presented in Table 2.1-1 of the U.S. EPR Final Safety Analysis report.~~

U.S. EPR FSAR Section 2.3.1.1 indicates that the U.S. EPR design is based on the 0% and 1% exceedance dry bulb and coincident wet bulb temperatures listed in U.S. EPR FSAR Table 2.1-1. Site-specific values for these parameters were determined using 45 years (1961-2005) of hourly meteorological data from Wilkes-Barre/Scranton International Airport, Pennsylvania (NOAA, 2008a) (NOAA, 1997) (NOAA, 2002a) (NOAA, 2006a).

The BBNPP site-specific annual-basis 0% exceedance maximum dry bulb and coincident wet bulb temperature values are 100.0°F (37.8°C) and 71.7°F (22.1°C), respectively. The BBNPP site-specific annual-basis 0% exceedance minimum dry bulb temperature value is -17.5°F (-27.5°C). The BBNPP site-specific seasonal-basis 1% exceedance maximum dry bulb and coincident wet bulb temperature values are 89.1°F (31.7°C) and 65.1°F (18.4°C), respectively. The BBNPP site-specific seasonal-basis 1% exceedance minimum dry bulb temperature value is 1.0°F (-17.2°C). The BBNPP site-specific 0% and 1% exceedance temperature values are presented in Table 2.3-22 and Table 2.3-23. The U.S. EPR 0% annual-basis exceedance maximum dry bulb and coincident wet bulb temperature values are 115°F (46°C) and 80°F (27°C), respectively. The U.S. EPR 0% annual-basis exceedance minimum dry bulb temperature value is -40°F (-40°C). The U.S. EPR seasonal-basis 1% exceedance maximum

dry bulb and coincident wet bulb temperature values are 100°F (38°C) and 77°F (25°C), respectively. The U.S. EPR seasonal-basis 1% exceedance minimum dry bulb temperature value is -10°F (-23°C). The U.S. EPR design values bound the 0% and 1% exceedance values for BBNPP.

The calculated 100-year return period values of maximum and minimum dry bulb temperature are 101.5°F (38.6°C) and -21.2°F (-29.6°C), respectively. The 100-year return period value of mean wet bulb temperature coincident with the 100-year return period value of maximum dry bulb temperature is 76.3°F (24.6°C). These values, except for the mean wet bulb temperature coincident with the 100-year return period value of the maximum dry bulb temperature, were determined using the ASHRAE (ASHRAE, 2005) methodology and the maximum two-hour average dry bulb values for each year of the same 45-year meteorological data set used to determine the BBNPP site-specific 0% and 1% exceedance temperature values.

Because the 100-year return period maximum dry bulb temperature is a calculated value, there is no wet bulb temperature measurement that is coincident with it, as there would be if it was a measured value. Therefore, a relationship between dry bulb and wet bulb temperature was determined and this value was also calculated using the ASHRAE (ASHRAE, 2005) methodology and 45 years of hourly meteorological data from Wilkes-Barre/Scranton International Airport, Pennsylvania.

A review was also conducted of historical maximum and minimum temperature values at stations within approximately 50 miles of the BBNPP site and obtained from the National Climatic Data Center (NOAA, 2002b) (NOAA, 2007b). The highest recorded maximum temperature value was 105°F (40.6°C) at Allentown, Pennsylvania, on July 3, 1966 and at Palmerton, Pennsylvania, on August 2, 1975. The lowest recorded minimum temperature value was -28°F (-33.3°C) at Francis E. Walter Dam, Pennsylvania, on February 18, 1979. Therefore, the highest recorded maximum temperature value of 105°F (40.6°C) is the extreme maximum annual site temperature. The lowest recorded minimum temperature value of -28°F (-33.3°C) is the extreme minimum annual site temperature. The U.S. EPR design values bound the site area extreme historic temperature values for BBNPP.

2.3.1.2.3 References

NCDC, 2006c. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Local Climatological Data, 2006 Annual Summary with Comparative Data, Williamsport, Pennsylvania (KIPT).

NOAA, 1997. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, U.S. Hourly Weather Observations 1990-1995.

NOAA, 1999. Air Resources Laboratory, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, "Air Stagnation Climatology for the United States (1948-1998)", April 1999.

NOAA, 2002a. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Integrated Surface Hourly Data 1995-1999.

NOAA, 2002b. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Cooperative Summary of the Day (data through 2001).

NOAA, 2005. National Oceanic and Atmospheric Administration Technical Memorandum NWS TPC-4, "The Deadliest, Costliest, and Most Intense United States Cyclones From 1851-2004 (And other Frequently Requested Hurricane Facts)", updated August 2005.

NOAA, 2006a. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Integrated Surface Hourly Observations, received on separate CD's for each year 2000-2005.

NOAA, 2006b. Precipitation-Frequency Atlas of the United States NOAA Atlas 14, Wilkes-Barre-Scranton, Pennsylvania (36-9705), Volume 2, Version 3.0, NOAA, National Weather Service, Silver Spring, Maryland, revised 2006.

NOAA, 2007a. Lightning Flash Density Map of the United States, National Oceanic and Atmospheric Administration, Website: http://www.crh.noaa.gov/Image/pub/ltg2/usa_ltg_fdm.gif, date accessed: March 13, 2007.

NOAA, 2007b. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, U.S. Summary of Day Climate Data (DS 3200/3210) 2002-2006.

FSAR Table 2.3-21 will be deleted in its entirety.

FSAR Table 2.3-22 will be revised as follows:

Table 2.3-22 – {Zero Percent Exceedance Temperature Values for Wilkes-Barre/Scranton, Pennsylvania}

Maximum Dry Bulb Temperature (°F)	Coincident Wet Bulb Temperature (°F)	Non-Coincident Wet Bulb Temperature (°F)	Minimum Dry Bulb Temperature (°F)
100.0	71.7	~~78.9~~ 81.0	~~-15.1~~ -17.5

FSAR Table 2.3-23 will be deleted in its entirety and be replaced with the following:

Table 2.3-23 – {One Percent Exceedance Seasonal Basis Temperature Values for Wilkes-Barre/Scranton, Pennsylvania}

Maximum Dry Bulb Temperature (°F)	Coincident Wet Bulb Temperature (°F)	Non-Coincident Wet Bulb Temperature (°F)	Minimum Dry Bulb Temperature (°F)
89.1	65.1	75.0	1.0

FSAR Table 2.3-24 will be deleted in its entirety.

FSAR Table 2.3-25 will be deleted in its entirety.

FSAR Table 2.3-26 will be deleted in its entirety.

FSAR Table 2.3-27 will be deleted in its entirety.

FSAR Table 2.0-1 will be revised as follows:

Table 2.0-1 – {U.S. EPR Site Design Envelope Comparison}
(Page 3 of 4)

	U.S. EPR FSAR Design Parameter Value/Characteristic			BBNPP Design Parameter Value/Characteristic
			Temperature	
Air	0% Exceedance Values (annual basis)	Maximum	115°F Dry Bulb / 80°F Wet Bulb (coincident)	100°F (37.8°C) Dry Bulb / 71.7°F (22.1°C) Wet Bulb (coincident) (See Section ~~9.2.1~~ 2.3.1)
			81°F Wet Bulb (non-coincident) UHS Design only	~~78.9°F (26.1°C)~~ 81.0°F (27.2°C) Wet Bulb (non-coincident) for UHS Design only (See Section ~~9.2.1~~ 2.3.1)
		Minimum	-40°F	~~-15.1°F (-26.2°C)~~ -17.5°F (-27.5°C) (See Section 2.3.1)
	1% Exceedance Values (seasonal basis)	Maximum	100°F Dry Bulb / 77°F Wet Bulb (coincident)	~~85.8°F (29.9°C)~~ 89.1°F (31.7°C) Dry Bulb / 65.1°F (18.4°C) Wet Bulb (coincident)
			81°F Wet Bulb (non-coincident) UHS Design only	~~76.2°F (24.6°C)~~ 75.0°F (23.9°C) (non-coincident)
		Minimum	-10°F	~~27.9°F (-2.3°C)~~ 1.0°F (-17.2°C)

Question 02.03.01-4:

Standard Review Plan (SRP) Section 2.3.1, Section II (Acceptance Criteria), SRP Acceptance Criterion (2) states, in part, that the applicability of data on severe weather phenomena used to represent site conditions during the expected period of reactor operation should be substantiated. SRP Section 2.3.1, Section III (Review Procedures), Item 2, Paragraph 2 states, in part, that "[t]he historical data used to characterize a site should extend over a significant time interval to capture cyclical extremes" and that "[c]urrent literature on possible changes in the weather in the site region should also be reviewed to be confident that the methods used to predict weather extremes are reasonable".

Revise COL FSAR Section 2.3.1 to include a discussion on possible changes in climate conditions in the site region during the expected period of reactor operation and any potential impact on the proposed climate-related site characteristics addressed in COL FSAR Section 2.3.1 or other related FSAR sections that utilize this information.

Response:

The BBNPP FSAR will include a discussion of potential climate change and potential impacts on the climate-related site characteristics as shown below.

COLA Impact:

The BBNPP FSAR will be supplemented as follows:

2.3.1.2.2.17 Possible Changes in Climate and Potential Impact on the Proposed Climate-Related Site Characteristics

Historical data and current literature on postulated long-term environmental changes were reviewed to provide assurance that the methods to predict weather extremes are appropriate and reasonable. Globally, reports issued by the International Panel on Climate Change (IPCC, 2007) and the U.S. Global Change Research Program (GCRP, 2009) indicate that global average air temperatures are increasing. However, there is insufficient evidence to determine whether trends exist in small-scale phenomena such as tornadoes, hail, lightning, and dust storms, and there is no clear trend in the annual number of tropical storms (IPCC, 2007).

Regionally, the Pennsylvania Department of Environmental Protection reports (ENRI, 2009) that climate change could result in the following impacts in Pennsylvania:

- Temperature is projected to increase throughout the century, but is dependent on emissions scenario, especially by late century. The temperature rise for a high emission scenario at the end of the century, for instance, is nearly twice that of a low emission scenario.
- Precipitation is projected to increase during the winter, with small to no increase in summer. There is also a potential increase in heavy precipitation events. As a result, a substantial decrease in snow cover extent and duration is expected.
- Tropical and extratropical storms may increase in intensity, but there is substantial uncertainty in their future projections.

The Pennsylvania Department of Environmental Protection further reports that the potential impacts over the next 20 years do not differ between a high and low emission scenario. However, Pennsylvania's projected climate by the end of the century differs significantly between the two emissions scenarios.

As a result, the above described climate change projections have a degree of uncertainty. Although broad trends that may result as a consequence of climate change are identified, such projections are so general that an assessment of the potential impact on design site characteristics is inherently limited. However, these potential climate-related changes were considered and addressed as follows:

- The amount of air temperature increase later in the century is dependent on factors such as the mitigation of greenhouse gas emissions and cannot be predicted accurately. However, even if the high emission projected average temperature increase at the end of the century of nearly 7°F is added to the average maximum temperature in the site area of 92.4°F for the 45-year period 1961-2005, the result is comparable to the calculated 100-year return period dry-bulb temperature of 101.5°F (AREVA, 2010). The highest recorded temperature within the region of 105°F is also comparable with the 100-year projected maximum dry-bulb temperature value. Thus, the method used to calculate the extreme dry-bulb temperature is appropriate and reasonable. The calculated extreme temperature also is considerably less than the U.S. EPR design parameter of 115°F.
- The maximum rainfall rate is generally associated with tropical and extratropical storms (which include hurricanes), whose frequency and storm tracks cannot be predicted. However, for the site region (Berwick, PA), the National Weather Service calculated a 100-year annual recurrence interval of 2.46 in/hr (NOAA, 2006b). This value is considerably less than the U.S. EPR design parameter of 19.4 in/hr.
- Winter snow volumes are projected to decrease while winter precipitation amounts are projected to increase. Thus, there is likely no impact on the snow roof loads.
- There are no specific projections regarding wind speed. Although winds from tropical and extratropical storms are likely to increase, there is substantial uncertainty in their future projections, e.g., their frequency and whether storm tracks will impact the state. Thus, there is no basis to assess the potential impact on the U.S. EPR design parameter, which is the ASCE 7-05 Basic Wind Speed (3-second gust).
- There is insufficient evidence to determine whether trends exist in small-scale phenomena such as tornadoes. Thus, there is no basis to assess the potential impact on the U.S. EPR design parameter for the tornado maximum wind speed.

2.3.1.2.3 References

AREVA, 2010. AREVA NP Document 32-9075363-002, "Calculation for Bell Bend Nuclear Power Plant FSAR Section 2.3", May 2010.

CFR, 2008c. U.S. Code of Federal Regulations, Title 40 – Protection of Environment, Chapter 1 – Environmental Protection Agency, Part 81 – Designation of Areas for Air Quality Planning Purposes, Subpart B – Designation of Air Quality Control Regions, Section 81.104 – Central Pennsylvania Interstate Air Quality Control region (40CFR81.104), June 9, 2008.

ENRI, 2009. Pennsylvania Climate Impact Assessment, Report to the Pennsylvania Department of Environmental Protection, prepared by the Environment and Natural Resources Institute, the Pennsylvania State University, June 29, 2009.

GCRP, 2009. Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas Peterson (eds.) Cambridge University Press, 2009.

IPCC, 2007. Climate Change, 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change, 2007.

NCDC, 2006c. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Local Climatological Data, 2006 Annual Summary with Comparative Data, Williamsport, Pennsylvania (KIPT).

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NOAA, 2002b. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Cooperative Summary of the Day (data through 2001).

NOAA, 2005. National Oceanic and Atmospheric Administration Technical Memorandum NWS TPC-4, "The Deadliest, Costliest, and Most Intense United States Cyclones From 1851-2004 (And other Frequently Requested Hurricane Facts)", updated August 2005.

NOAA, 2006a. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, Integrated Surface Hourly Observations, received on separate CD's for each year 2000-2005.

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NOAA, 2007a. Lightning Flash Density Map of the United States, National Oceanic and Atmospheric Administration, Website: http://www.crh.noaa.gov/Image/pub/ltg2/usa_ltg_fdm.gif, date accessed: March 13, 2007.

NOAA, 2007b. U.S. Department of Commerce, NOAA/NESDIS, National Climatic Data Center, U.S. Summary of Day Climate Data (DS 3200/3210) 2002-2006.

The BBNPP Environmental Report (ER) will be supplemented as follows:

2.7.1.5 Possible Changes in Climate

Historical data and current literature on postulated long-term environmental changes were reviewed to provide assurance that the methods to predict weather extremes are appropriate and reasonable. Globally, reports issued by the International Panel on Climate Change (IPCC, 2007) and the U.S. Global Change Research Program (GCRP, 2009) indicate that global average air temperatures are increasing. However, there is insufficient evidence to determine whether trends exist in small-scale phenomena such as tornadoes, hail, lightning, and dust storms, and there is no clear trend in the annual number of tropical storms (IPCC, 2007).

Regionally, the Pennsylvania Department of Environmental Protection reports (ENRI, 2009) that climate change could result in the following impacts in Pennsylvania:

- Temperature is projected to increase throughout the century, but is dependent on emissions scenario, especially by late century. The temperature rise for a high emission scenario at the end of the century, for instance, is nearly twice that of a low emission scenario.
- Precipitation is projected to increase during the winter, with small to no increase in summer. There is also a potential increase in heavy precipitation events. As a result, a substantial decrease in snow cover extent and duration is expected.
- Tropical and extratropical storms may increase in intensity, but there is substantial uncertainty in their future projections.

The Pennsylvania Department of Environmental Protection further reports that the potential impacts over the next 20 years do not differ between a high and low emission scenario. However, Pennsylvania's projected climate by the end of the century differs significantly between the two emissions scenarios.

As a result, the above described climate change projections have a degree of uncertainty. Although broad trends that may result as a consequence of climate change are identified, such projections are so general that an assessment of the potential impact on design site characteristics is inherently limited.

2.7.8 References

ENRI, 2009. Pennsylvania Climate Impact Assessment, Report to the Pennsylvania Department of Environmental Protection, prepared by the Environment and Natural Resources Institute, the Pennsylvania State University, June 29, 2009.

GCRP, 2009. Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas Peterson (eds.) Cambridge University Press, 2009.

IPCC, 2007. Climate Change, 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change, 2007.