2.4.11 LOW WATER CONSIDERATIONS

<u>REVIEW RESPONSIBILITIES</u>

Primary - Mechanical and Civil Engineering Branch (EMEB)

Secondary - None

I. <u>AREAS OF REVIEW</u>

The purpose of this section of the applicant's site safety assessment for an early site permit application is to identify natural events that may reduce or limit the available cooling water supply, and to ensure that an adequate water supply will exist to operate or shut down a nuclear power plant or plants of specified type that might be constructed on the proposed site under normal operations, anticipated operational occurrences, and emergency conditions.

Depending on the site, the areas of review include:

1. The worst drought considered reasonably possible in the region.

2. Low water (setdown) resulting from surges, seiches, or tsunami.

3. Low water resulting from icing in relation to the events described in Section 2.4.7 of this review standard.

4. The effect of existing and proposed water control structures (dams, diversions, dam failures, etc.).

5. The intake structure and pump design basis in relation to the events described in SAR Subsections 2.4.11.1, 2.4.11.2, 2.4.11.3, and 2.4.11.4. (This item is to be addressed at the combined license [COL] stage.)

6. The use limitations imposed or under discussion by Federal, state, or local agencies authorizing the use of the water.

7. The range of water supply required by a plant or plants of specified type that might be constructed on the proposed site, including minimum operating and shutdown flows, compared to availability.

8. The effects of potential blockage of intakes by sediment, littoral drift, and ice.

9. The capability of the ultimate heat sink to provide adequate cooling water under normal operations, anticipated operational occurrences, and emergency conditions.

II. ACCEPTANCE CRITERIA

Acceptance criteria for this section of this review standard relate to the following regulations:

1. General Design Criterion 44 (GDC 44) requires an ultimate heat sink capable of accepting the plant's heat load under normal and accident conditions.

2. 10 CFR Parts 52 and 100 require that hydrologic characteristics be considered in the evaluation of the site.

3. 10 CFR 100.23 requires, in part, that consideration of river blockages or diversion or other failures which may block the flow of cooling water, tsunami runup and drawdown, and dam failures be included in the evaluation of the adequacy of the emergency cooling water supply.

Compliance with 10 CFR Parts 52 and 100 requires, in part, that hydrologic characteristics be considered in the evaluation of a nuclear power plant site. The regulations at 10 CFR Parts 52 and 100 apply to this section of this review standard because the reviewer verifies that the applicant's safety assessment contains a description of surface and subsurface hydrological characteristics of the site and region. The ultimate heat sink for the cooling water system consists of water sources affected by, among other things, site hydrological characteristics that may reduce or limit the available supply of cooling water for safety-related structures, systems, and components.

Meeting the requirements of 10 CFR Parts 52 and 100 provides assurance that (1) the site would be compatible with the capabilities of structures, systems, or components (SSCs) important to safety for a nuclear power plant or plants of specified type that might be constructed on the proposed site to be designed to withstand appropriately severe hydrologic phenomena, and (2) that such SSCs would remain capable of performing their intended safety functions given various hydrologic conditions.

Compliance with 10 CFR 100.23 requires, in part, that consideration of river blockages or diversion or of other failures that may block the flow of cooling water, tsunami runup and drawdown, and dam failures be included in the evaluation of the emergency cooling water supply for a nuclear power plant or plants of specified type that might be constructed on the proposed site.

The regulation at 10 CFR 100.23 applies to this section of this review standard because the ultimate heat sink for the cooling water system consists of water sources that are subject to natural events that may reduce or limit the available supply of cooling water (i.e., the heat sink). Natural events such as river blockages or diversion or other failures that may block the flow of cooling water, tsunami runup and drawdown, and dam failures must be conservatively estimated to assess the potential for these characteristics to influence the design of structures, systems, and components important to safety for a nuclear power plant of type specified by the applicant that might be constructed on the proposed site

Note: Though not required at the early site permit stage, the applicant for a COL will need to demonstrate compliance with General Design Criterion 2 as it relates to structures, systems, and components important to safety being designed to withstand the effects of natural phenomena.

To meet the requirements of the hydrologic aspects of the above regulations, the following specific criteria are used:

Acceptance is based principally on the adequacy of the ultimate heat sink to supply cooling water for normal operation, anticipated operational occurrences, safe shutdown, cooldown (first 30 days), and long-term cooling (periods in excess of 30 days) during adverse natural conditions.

Safety assessment Section 2.4.11.1 (Low Flow in Rivers and Streams): For essential water supplies, the low-flow/low-level design for the primary water supply source must be based on the probable minimum low flow and level resulting from the most severe drought that can reasonably be considered for the region. The low flow and level site parameters for operation should be such that shutdowns caused by inadequate water supply will not cause frequent use of emergency systems.

Safety assessment Section 2.4.11.2 (Low Water Resulting from Surges, Seiches, or Tsunami): For coastal sites, the appropriate probable maximum hurricane (PMH) wind fields must be postulated at the early site permit stage to give maximum winds blowing offshore, thus creating a probable minimum surge level. Low water levels on inland ponds, lakes, and rivers due to surges must be estimated from probable maximum winds oriented away from the plant site. The same general analysis methods discussed in Sections 2.4.3, 2.4.5 and 2.4.6 of this review standard are applicable to low water estimates due to the various phenomena discussed. If the site is susceptible to such phenomena, minimum water levels resulting from setdown (sometimes called runout or rundown) from hurricane surges, seiches, and tsunami must be verified at the COL stage to be higher than the intake design basis for essential water supplies.

Safety assessment Section 2.4.11.3 (Historical Low Water): If historical flows and levels are used to estimate design values by inference from frequency distribution plots, the data used must be presented so that an independent determination can be made. The data and methods of the National Oceanic and Atmospheric Administration, United States Geologic Survey, Soil Conservation Service, Bureau of Reclamation, and the Corps of Engineers are acceptable.

Safety assessment Section 2.4.11.4 (Future Controls): This section is acceptable if water use and discharge limitations (both physical and legal), already in effect or under discussion by responsible Federal, regional, state, or local authorities, that may affect water supply for a nuclear power plant of type specified by the applicant that might be constructed on the proposed site have been considered and are substantiated by reference to reports of the appropriate agencies. The most adverse possible effects of these controls must be shown and taken into account in the design basis to ensure that essential water supplies are not likely to be affected adversely in the future.

Safety Analysis Report (SAR) Section 2.4.11.5 (Plant Requirements): At the COL stage, acceptance of a plant design is based on the following required information:

1. Minimum essential cooling water flow rates and levels must be presented (or cross-referenced) and shown to be less than the probable minimum low flows and levels from the applicable sources of supply.

2. Maximum water requirements for normal operations must be presented and (if applicable) shown to be less than the water available under all likely conditions from the sources of supply.

SAR Section 2.4.11.6 (Heat Sink Dependability Requirements): At the COL stage, the required data and information are those necessary to determine that the facility meets the criteria of GDC 44 as described in Regulatory Guide 1.27. The analyses will be considered complete and acceptable if the following are adequately addressed:

1. The initial water inventory must be sufficient for shutdown and cooldown of the plant.

2. Water losses (such as seepage, drift, and evaporation) must be conservatively estimated, as suggested in Regulatory Guide 1.27.

3. The design basis hydrometeorology (temperature, dewpoint, etc.) must be as conservative as the criteria of the guide (see Section 2.3 of this review standard).

4. The limit on the heat sink return water temperature must be less than the maximum allowable cooling water inlet design temperature.

5. The heat sink intakes are located such that no potential exists for blockage by littoral drift and/or sediment that would decrease water supply below minimum required levels.

III. REVIEW PROCEDURES

Requirements and procedures governing issuance of early site permits for approval of proposed sites for nuclear power facilities are specified in 10 CFR Part 52. Information required for such a permit includes a description of the site’s hydrological and meteorological characteristics. For this type of permit, the procedures below should be followed.

For multiple purpose (normal operations, normal shutdown, and emergency shutdown) water supplies , the primary portion of the supply is first reviewed to determine that the water supply will be maintained at minimum volume requirements at all times. The secondary portion of the supply is then reviewed to determine whether an adequate emergency water supply can be expected to be available during operating conditions such as the regional drought of record (flows must be adjusted for historical and potential future effects). If not, the applicant will be required at the COL stage to provide a technical specification requiring plant shutdown at the point where an adequate shutdown water supply is still assured.

Institutional restraints on water use, such as limitations in water use and discharge permits, are reviewed to ensure that a nuclear power plant or plants of specified type that might be constructed on the proposed site would have an adequate supply and not exceed limitations imposed upon operation. If a conflict is foreseen, the applicant is requested to either obtain a variance or make a design change to accommodate the limitation.

The potential for blockage of the intakes by littoral drift and sediment is reviewed to determine if mitigative measures are required to protect safety-related facilities. Independent estimates of "worst-case" buildups, determined by a review of applicable literature describing historic sediment accumulations in the site region, will be made using statistical or deterministic techniques.

For plants that would use rivers,asymptotic extrapolations of low-flow frequency curves, which have been corrected for historical and potential future effects, will be reviewed. For ocean or estuary plants,probable maximum hurricane and tsunami-induced low water levels will be reviewed. For Great Lakes plants,minimum historical levels coincident with probable maximum surge or seiche-induced low water levels will be reviewed.

The ability of the ultimate heat sink to provide a 30-day supply of cooling water for minimum needs of a nuclear power plant or plants of specified type that might be constructed on the proposed site, as specified in Regulatory Guide 1.27, will be independently evaluated. For those cases where makeup water cannot be assured , estimates of water loss due to drift, evaporation, blowdown, and seepage are made. Techniques described in References 24 and 25 are used to evaluate the adequacy of the initial water inventory under meteorological conditions of the severity discussed in Regulatory Guide 1.27.

If the ultimate heat sink system is not capable of continued long-term water supply under the criteria in Regulatory Guide 1.27, or the above considerations, the system will be reviewed in two parts: short-term capability and long-term capability. For short-term capability,the time period for which a highly dependable water supply would be available is compared with the time required to obtain water from an alternative supply, and the natural or accident environmental conditions which could prevail.

For long-term water supply capability, different sources and means of obtaining water may be required because of the limited capability of a "short- term" supply. In those cases where different sources are necessary to ensure long-term plant heat removal capability, the alternative sources and the means of supplying water from the sources to the plant or plants of specified type should be identified.

The following guidance applies to the COL stage.

Minimum requirements (water level and flow) for a nuclear power plant or plants as specified by the applicant that are identified in safety assessment subsection 2.4.11.5 are compared to the estimated minimum water levels and flows given in section 2.4.11.1. If normal operation is not assured at the minimum water supply conditions, and loss of normal operation capability can adversely affect safety-related components, estimates of warning time are reviewed to assure that shutdown or conversion to alternate water sources can be accomplished prior to the trip. For such cases, emergency operating procedures are required, and are reviewed to assure that they are consistent with the postulated conditions. The analysis of the dependability of the ultimate heat sink is reviewed. Determination of the dependability of the ultimate heat sink is accomplished by using Regulatory Guide 1.27 as a standard of comparison.

Estimated water levels and flows provided in subsections 2.4.11.1, 2.4.11.2, 2.4.11.3, and 2.4.11.4 are reviewed to ensure adequate water supply conditions. Each source of water for normal operations, anticipated operational occurrences, or emergency shutdown and cooldown, and the natural phenomena and site-related accident design criteria for each should be identified. A systems analysis is first undertaken of all water supply sources to determine the likelihood that at least one source would survive (1) the most severe of each of the natural phenomena, (2) site-related accident phenomena, and (3) reasonable combinations of less severe natural and accident phenomena. Second, arbitrarily assumed mechanistic failures of water supply structures and conveyance systems are postulated and the systems analysis repeated, to assure that the failure of one component will not cause failure of the entire system. These analyses are coordinated with the review of the ultimate heat sink, to avoid duplication. Operating rules for each portion of the system are ascertained to determine the amount of water that can be assumed available in the event of normal or accidental shutdown. If there is evidence of potential structural or mechanical effects, the staff will ascertain whether the effects are properly considered in the structural or mechanical design bases for a nuclear power plant or plants of type specified by the applicant that might be constructed on the proposed site.

The potential for surges in intake sumps (i.e., seiching in intake structures and surges in intake pipes) that could cause adverse effects are reviewed to ensure that the effects have been properly incorporated for the intake design. The potential for adverse hydrodynamic effects of a trip of the intake pumps is evaluated based on potential surges in intake sumps.

Emergency means for obtaining long-term water supplies will be judged on the basis of the time required to obtain such supplies, natural or accident phenomena likely to prevail or to have caused the need for such supplies, and the dependability of the supply itself. The ability of the ultimate heat sink to provide a nuclear power plant or plants as specified by the applicant with cooling water below the design maximum temperature will be evaluated. The design maximum temperature and the heat load of the design basis accident, as specified in Regulatory Guide 1.27, will be evaluated. Techniques for selecting the meteorologic conditions for minimum heat transfer and for performing the transient analysis for cooling ponds and spray ponds are provided in References 23 and 24, respectively.

IV. EVALUATION FINDINGS

The findings will indicate the degree of compliance with GDC 44, 10 CFR Parts 52 and 100, and 10 CFR 100.23.

For early site permit reviews, the findings will summarize the applicant's and staff's estimates of the site minimum water flows and levels. If the applicant's estimates are no more than 5% less conservative than the staff's estimates, staff concurrence in the applicant's estimates will be stated. If the applicant's estimates are more than 5% less conservative and if a plant or plants of specified type that might be constructed on the proposed site may be adversely affected, a statement of the staff's position (bases) will be made. At COL, a similar finding on the design bases for the ultimate heat sink will be made.

A sample early site permit-stage statement follows:

> The normal water supply for the station will be obtained from Lake A. Emergency cooling water will be furnished by the ultimate heat sink reservoir, which is not dependent upon the water level in Lake A for its safety function.
>
> The lowest lake level observed at B City during the 70 years of record was 565.7 feet above International Great Lakes Datum (567.2 feet above mean sea level) on February 4, 1936. Recurrence of this low lake level would not affect the ability of a nuclear power plant of type specified by the applicant that might be constructed on the site to obtain water.
>
> The applicant calculated the probable minimum lake setdown during a postulated probable maximum windstorm using a one-dimension numerical surge model. The minimum calculated lake level, including an antecedent level equal to the minimum monthly lake level of record, is 167.3 meters (549.0 feet) above International Great Lakes Datum [167.8 meters (550.4 feet) above mean sea level]. Since this level is below the minimum necessary for pump submergence, a plant of type specified by the applicant that might be constructed on the site would have to be shut down using water

from the ultimate heat sink reservoir, which would not be affected by the postulated low lake level.

The proposed ultimate heat sink would be comprised of Lake A and a rectangular cooling pond located on the site. Normal operation and shutdown would utilize cooling water from the natural draft cooling towers; the makeup for the cooling towers would come from Lake A. If, for any reason, the natural draft cooling towers would be unavailable, the onsite pond would be used to shut down the units. The pond would be 1980 feet long and 940 feet wide. The depth of the water would be 11 feet and the pond's embankment would have a freeboard of 5 feet. The submerged intake and discharge pipes for a plant of type specified by the applicant that might be constructed on the site would be located at the same end of the pond but separated by a dike running almost the entire length of the pond to prevent short-circuiting between the intake and discharge. The pond must be capable of providing cooling water below the plant design temperature of 110° Fahrenheit under normal or emergency conditions.

The applicant analyzed the pond's thermal performance using thermal parameters for a plant of type specified by the applicant and meteorological conditions of the severity specified in Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants." The maximum pond temperature calculated was 109.3° Fahrenheit.

The staff independently modeled the thermal performance of the pond and conclude that it would be capable of providing cooling water below the design temperature of 110° Fahrenheit. The staff conservatively estimated maximum water losses from the pond, assuming meteorological conditions of the severity specified in Regulatory Guide 1.27. The staff concludes that the initial pond inventory would be sufficient to provide at least a 30-day cooling water supply without makeup for the thermal loads of a nuclear power plant of type specified by the applicant that might be constructed on the proposed site.

The staff evaluated the potential effects of freezing events on the pond's capability of providing emergency cooling water to a nuclear power plant of type specified by the applicant that might be constructed on the proposed site. The staff concluded that typical plant design measures, such as heating the intake pumphouse and burying the discharge piping below the frost line, could be implemented to prevent such events from affecting plant operation or safety.

Based on the above, the staff has evaluated the performance of the proposed cooling pond and concludes that, under meteorological conditions of the severity described in Regulatory Guide 1.27, (1) the pond would provide sufficient water to cool a nuclear power plant of type specified by the applicant that might be constructed at the site for at least 30 days without any makeup and (2) the maximum temperature of the water supplied to the plant would be below the design temperature of 43.3°C (110° F). In addition, historical data for the proposed site are consistent with the cooling water temperatures and levels identified in the safety assessment.

Based upon the evaluations described above, the staff concludes that the cooling water supply for a nuclear power plant of type specified by the applicant that might be constructed on the proposed site meets the requirements of 10 CFR Parts 52 and 100, and 10 CFR 100.23 with respect to hydrologic characteristics and that it meets the requirements of General Design Criterion 44 with respect to thermal aspects of the heat transfer system.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of early site permit applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposed an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREGs.

VI. REFERENCES[1]

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water."

3. 10 CFR Part 100, "Reactor Site Criteria."

4. L. R. Beard, "Methods for Determination of Safe Yield and Compensation Water from Storage," Seventh International Water Supply Congress, Barcelona, Spain (1966).

5. L. R. Beard, "Statistical Methods in Hydrology," Corps of Engineers (1962).

6. D. K. Brady, et al., "Surface Heat Exchange at Power Plant Cooling Lakes," EEI Publication 69901 Edison Electric Institute, New York, November 1969.

7. V. T. Chow (ed.), "Handbook of Applied Hydrology," McGraw-Hill Book Company, New York (1964).

8. J. E. Edinger and J. C. Geyer, "Heat Exchange in the Environment," EEI Publication 69-902, Edison Electric Institute, New York, June 1965.

9. G. M. Fair, et al., "Water and Wastewater Engineering," Vol. 1, John Wiley & Son, Inc., New York (1966).

10. "Scientific Hydrology," Ad Hoc Panel on Hydrology, Federal Council for Science and Technology, Washington, D.C., June 1962.

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[1]References for analysis of low water resulting from surges and seiches are in Section 2.4.5 of this review standard. References for analysis of low water resulting from tsunami are in Section 2.4.6.

11. M. B. Fiering and M. M. Hufschmidt, "Simulation Techniques for Design of Water-Resource Systems," Harvard University Press, Cambridge, Mass. (1966).

12. R. K. Linsley, et al., "Hydrology for Engineers," McGraw-Hill Book Company, New York (1958).

13. R. K. Linsley and J. B. Franzini, "Water-Resources Engineering," McGraw-Hill Book Company, New York (1964).

14. A. Maas, et al., "Design of Water-Resources Systems," Harvard University Press, Cambridge, Mass. (1962).

15. "Hydrologic Engineering Methods for Water Resources Development," Vol. 112, Corps of Engineers Hydrologic Engineering Center, Davis, California (1971).

16. "Reservoir Storage-Yield Procedures," Corps of Engineers Hydrologic Engineering Center, Davis, California (1967).

17. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."

18. "Design of Small Dams," Second Edition, Bureau of Reclamation, U.S. Department of Interior (1973).

19. "Water Surface Profiles," HEC-2, Corps of Engineers Hydrologic Engineering Center (continuously updated).

20. "Reservoir System Analysis," HEC-3, Corps of Engineers Hydrologic Engineering Center (updated).

21. "Monthly Streamflow Simulation," HEC-4, Corps of Engineers Hydrologic Engineering Center (updated).

22. Regulatory Guide 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies."

23. R. B. Codell and W. K. Nuttle, "Analysis of Ultimate Heat Sink Cooling Ponds," NUREG-0693, USNRC (1980).

24. R. B. Codell, "The Analysis of Ultimate Heat Sink Spray Ponds," NUREG-0733, USNRC 1981.

25. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

26. "Hydrologic Engineering Requirements for Reservoir, "Engineer Manual 1110-2-1420, Corps of Engineers, October 1997.