U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 2.4.2 FLOODS

REVIEW RESPONSIBILITIES

Primary - Site Analysis Branch (SAB)

Secondary - None

I. AREAS OF REVIEW

This section of the safety analysis report (SAR) identifies historical flooding (defined as occurrences of abnormally high water stage, or overflow from a stream, floodway, lake, or coastal area) at the proposed site or in the region of the site. It summarizes and identifies the individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. It also covers the potential effects of local intense precipitation. Although the material may appear in another SAR section, the following matters are included with review of this subject.

The history and the potential for flooding from each of the following sources and events are reviewed:

1. Stream flooding;
   a. Probable maximum flood (PMF) with coincident wind-induced waves, considering dam failure potential due to inadequate capacity, inadequate flood-discharge capability, or existing physical condition.
   b. Ice jams, both independently and coincident with a winter probable maximum storm.
   c. Tributary drainage area PMF potential.
   d. Combinations of less severe river floods, coincident with surges and seiches.
2. Surges;
   a. Probable maximum hurricane (PMH) at coastal sites.
   b. PMH wind translated inland and resulting wave action coincident with runoff-induced flood levels.
   c. Probable maximum wind-induced (non-hurricane) storm surges and waves.
   d. Combinations of less severe surges, coincident with runoff floods.

3. Seiches;
   a. Meteorologically-induced in inland lakes (e.g. Great Lakes and harbors) and at coastal harbors and embayments.
   b. Seismically-induced in inland lakes.
   c. Seismically-induced by tsunamis (seismic sea waves) on coastal embayments.
   d. Combinations of less severe surges and seiches coincident with runoff floods.
4. Tsunamis;
   a. Near field, or local, excitation.
   b. Far field, or distant, excitation.
5. Seismically-induced dam failures (or breaches), and maximum water level at site from;
   a. Failure of dam (or dams) during safe shutdown earthquake (SSE) coincident with 25-year flood.
   b. Failure during operating basis earthquake (OBE) coincident with standard project flood (SPF).
   c. Failure during other earthquakes, coincident with runoff, surge, or seiche floods where the coincidence is at least as likely as for 5.a. and 5.b. above.
6. Ice loadings from water bodies.

II. ACCEPTANCE CRITERIA

For SAR Section 2.4.2.1 (Flood History): the potential flood sources and flood response characteristics identified by the staff's review (described in Review Procedures) are compared to those of the applicant. If similar, the applicant's conclusions are accepted. If, in the staff's opinion, significant discrepancies exist, the applicant will be requested to provide additional data, reestimate the effects on the plant, or revise the applicable flood design bases, as appropriate.

For SAR Section 2.4.2.2 (Flood Design Considerations): the controlling flood levels independently determined (or verified) by the staff will be compared with the applicant's. The two levels, referenced to mean or normal water levels, should be within about 5 percent. If the SAR estimate is more than 5 percent low, the applicant should fully document and justify the SAR estimate of the controlling level, or accept the staff estimate and redesign applicable flood protection.

For SAR Section 2.4.2.3 (Effect of Intense Precipitation): the staff estimate of local probable maximum precipitation (PMP) and the capacity of site drainage facilities (including drainage from the roofs of buildings and site ponding) are compared with values in the SAR. The applicant's SAR estimates of PMP and capacity of site drainage facilities should be within about 5 percent of corresponding staff estimates; or, using the staff estimates, no hazard must be judged to exist to safety-related facilities for the SAR estimate to be acceptable. Similarly, conclusions relating to the potential for any adverse affects of blockage of site drainage facilities by debris, ice, or snow should be based upon conservative assumptions of storm and vegetation conditions likely to exist during storm periods. If a potential hazard does exist (e.g., the elevation of ponding exceeds the elevation of plant access openings) the applicant should document and justify his local PMP basis and analysis and redesign any affected facilities.

III. REVIEW PROCEDURES

For SAR Section 2.4.2.1 (Flood History): the staff will review publications of the U. S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Soil Conservation Service (SCS), Corps of Engineers, applicable state and river basin agencies, and others to ensure that historical maximum events and the flood response characteristics of the region and site have been identified. Similar material, in addition to applicant-supplied information, will be reviewed to identify independently the potential sources of site flooding.

For SAR Section 2.4.2.2 (Flood Design Considerations): the flood potential (level) from consideration of the worst single phenomenon, and combinations of less severe phenomena, as discussed in Regulatory Guides 1.27 (Ultimate Heat Sink) and 1.59 (Design Basis Floods), are compared with the proposed protection levels of safety-related facilities. Methods of analysis to determine the individual flood-producing phenomena are discussed in Standard Review Plans 2.4.3 through 2.4.7.

For SAR Section 2.4.2.3 (Effect of Local Intense Precipitation): staff estimates of flooding potential are based on 24-hour PMP estimates (from Hydrometeorological Report 33 and similar NOAA publications for western sites), with time distributions from the Corps of Engineers EM 1110-2-1411, and are developed by the staff for comparison with the applicant's estimate. Runoff models, such as the unit hydrograph if applicable, or other runoff discharge estimates presented in standard texts, are used to estimate discharge on the site drainage system. Where generalized runoff models are used, coefficients used for the site and region are compared to information available at documented locations to evaluate hydrologic conditions used in determining the probable maximum flood for the site-drainage system. Potential ponding on the site is also determined.

Construction permit (CP) stage reviews are carried out as indicated in this plan and to evaluate its significance with regard to the plant design basis for flood protection. At the operating license (OL) stage, a brief review is carried out to determine if new information has become available since the CP review and to evaluate its significance with regard to the plant design basis for flood protection. New information might arise, for instance, from the occurrence of a new maximum flood of record in the site region, from identification of a source of major flooding not previously considered, construction of new dams, flood plain incroachments, or from advances in predictive models and analytical techniques. If the CP-stage evaluation of flooding potential has been carefully done, all sources of major flooding should have been considered and any new floods of record should fall well within the design basis. Improvements in calculational methods may occur, but generally will be concerned with increased accuracy in stream flow and water level predictions rather than with substantive changes in the flows and levels predicted. It is not the intention of the staff to request adjustments in the flood design basis for a plant because "improved," OL-stage calculations of flows and water levels result in slightly different values than those accepted at the CP stage. Where the OL review does reveal significant differences from the CP evaluation, any supplemental provisions needed in the flood protection design basis should be directed primarily toward early warning measures and procedures for assuring safe shutdown of the plant.

Consultants may be employed by the staff in an advisory role in developing independent staff analyses of the potential for flooding, or in independently making other specific assessments, depending on the complexity of the analysis and the availability of staff manpower. The consultants may be from Coastal Engineering Research Center (CERC) or private contractors.

The above reviews are performed only when applicable to the site or site region. Some items of review may be done on a generic basis.

IV. EVALUATION FINDINGS

For construction permit reviews, the findings will consist of a statement indicating the completeness of the identification of site flood characteristics and flood design bases. For OL reviews, the flood history will be updated if necessary, with special attention to any new flood of record. Sample statements for CP reviews follow:

"The maximum flood known to have occurred on the A River was in 1796. The peak discharge at the B City, Montana, was estimated to be 360,000 cubic feet per second (cfs). The applicant estimated that a comparable flood would produce a water surface elevation at the site of 116 feet MSL. The maximum flood during the period since records were maintained (1883) at B City was 350,000 cfs and occurred on October 3, 1929. These floods occurred prior to construction of several upstream dams. Flood flows are now regulated by C and D Reservoirs as well as by upstream hydropower plants.

"The applicant has estimated potential flooding from rainfall over the E River basin upstream from the site. The probable maximum flood (PMF), the upper level of flooding the staff considers to be reasonably possible, was estimated to produce a flow of 5,000,000 cfs near the City of F. This estimate was made by using 165% of the Corps of Engineers project design flood (PDF) estimate of 3,030,000 cfs at the same location, as modified by upstream flood control reservoirs. The 3,030,000 cfs project design flood flow is estimated to be partially diverted to the leveed G and H Floodways upstream of the site, with 1,500,000 cfs continuing downstream within the levee system past the plant site. The applicant concluded that the PMF could result in overtopping of levees and flooding of the river valley well upstream from the site, thereby causing generally low level flooding in the plant area. The upstream levee overtopping and resulting valley flow during such an event would reduce the flow in the main levee channel adjacent to the site to levels equal to or less than those that would exist during a project design flood. We conclude that the combination of a runoff-type flood less severe than a PMF, but more severe than a PDF, and a coincident levee break in the vicinity of the site could occur before water approaches levee grade upstream. A failure or levee breach, when the levee is full to design capacity (3 feet below the top of the levee adjacent to the site plus the effects of any coincident wind-generated wave activity), would result in a higher water surface at the plant than a PMF spread over the valley as a result of

levee failures upstream. At our request the applicant evaluated various modes of levee failure in the vicinity of the plant. One of the conditions postulated is that of a flood, approaching the severity of a PMF, causing a massive failure of the upstream left bank levee along the G Floodway, resulting in flooding around the plant, coincident with a failure of the levee adjacent to the plant site. The applicant estimated the resulting water level at the plant would reach elevation 22.5 feet MSL for this case. The case of an instantaneous levee failure adjacent to the plant, with no upstream levee failure, resulted in an estimated water level of 24.6 feet MSL. The staff concludes that the applicant should design for the conditions associated with the 24.6 feet MSL water level."

V. REFERENCES[1/]

1. "Surface Water Supply of the United States,"[2/] U.S. Geological Survey.

2. "Tide Tables," National Oceanic and Atmospheric Administration (similar situation as identified in footnote 2).

3. Reports of Great Lakes levels by Lake Survey Denver, National Oceanic and Atmospheric Administration.

4. Corps of Engineers records maintained in District and Division Offices, Coastal Engineering Research Center, and Waterways Experiment Station.

5. Regulatory Guide 1.27, "Ultimate Heat Sink," (Revision 2).

6. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants."

7. "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours," Hydrometeorological Report No. 33, U.S. Weather Bureau (1956).

8. "Standard Project Flood Determinations," Engineering Manual 1110-2-1411, Corps of Engineers, 26 March 1952 (rev. March 1965).

9. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 2.

1/ References for PMP estimates, time distribution, etc., are in Standard Review Plan 2.4.3.

2/ "Surface Water Supply" is a continuing series of water discharge measurements by the USGS and others. It is not practical to list all the volumes (called "Water-Supply Papers") that are available. Numerous state and local authorities maintain river discharge, lake level, and tide data.

11/24/75

SRP 2.4.3