What U.S. Nuclear Plant Operators Need to Know (and Do) Right Now to Address Post-Fukushima Flooding Concerns

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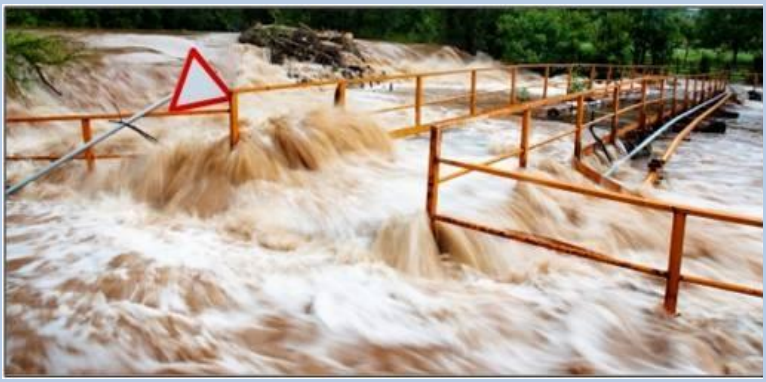
Introduction

Nuclear energy facilities across the United States are now weighing the impacts of the U.S. Nuclear Regulatory Commission's (NRC) first recommendations based on its study of Japan's Fukushima Dai-ichi nuclear accident. Since the announcement in March, 2012 that the NRC would require all operating reactor licensees to complete new, updated flooding analyses, there's been a flurry of activity to determine what's required and get safety reviews underway.



The flood analyses are part of a comprehensive beyond-design-basis safety review that also includes seismic assessments. Plants are required to reassess their risk profile for flooding based on present-day methods and current site and upland characteristics, and compare that new analysis to the basis used for flood protection measures in place. The end goal is to reassess water levels in the event of a variety of potential flood hazards and keep the plant's structures, systems and components (SSCs) well protected.

While the NRC estimates that the flooding reassessment will take 1,300 man hours, that time is likely to vary widely between plants. Depending on what the initial assessment reveals, operators may also need to evaluate protection measures for safety equipment and controls, and develop an integrated assessment that could take as long as 2,700 man hours to complete. Some sites may be further required to take new counter measures for mitigating potential risk scenarios, ranging from fixes as simple as installing higher door sills to those as complex as relocating critical equipment.

Understanding the Timeframe

With the new requirements expected to be finalized by August, 2011 and all plants required to comply by December 31, 2016, the timeframe for getting organized around compliance is short. No matter where a licensee falls on the NRC's official priority list—in Category 1, 2 or 3— it's important to understand the risk profiles of each individual site and plan the response timeline accordingly.

The quickest response – within the next 12 months – is required from plants where new data collection is expected to be minimal, for example, sites that are co-located with an Early Site Permit (ESP) or combined license (COL) for a new unit, or that already have a new flooding analysis well underway. A few cases where NRC staff suspects that the more involved integrated assessment may be necessary are also included in Category 1.

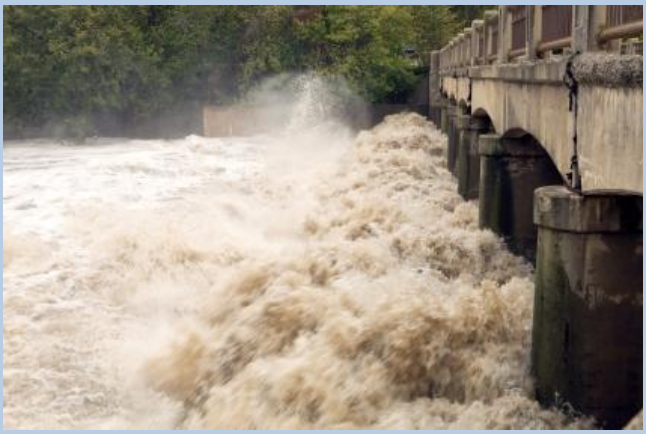
Many of the facilities that will likely need more time to comply have been given a wider berth. These include sites where the re-analysis could prove more complex, that require more new data collection or where a more involved comprehensive evaluation is already underway. The latter would include sites that are evaluating the potential for storm surge, tsunami and multiple dam failures, or those located in a large watershed.

Evaluating the Scope

To fully understand how these new requirements will impact a particular site, it's important to review NUREG-0800 and NUREG/CR-7046 to know what's needed in the areas of field data collection, site review and hydrologic, hydraulic and sedimentation modeling studies.

While determination of design basis floods for U.S. nuclear power plants is defined in Regulatory Guide 1.59, flood prediction and modeling technologies have changed since the 1970s, and that rule is still being updated. Instead, all flood risk reevaluations should follow the guidance and methodologies now being used for ESP and COL reviews, including those laid out in NUREG-0800 and NUREG/CR-7046.

One major component of the reassessment is the "walk-downs"—on-site studies designed to characterize potential risks and hazards. Among the information to be assessed through the walk-down process is where the plant's essential equipment is located and its current flood protection measures. Site observation is also required to assess hydraulic and hydrologic characteristics and thereby provide accurate modeling data.



A thorough hydrologic site examination should determine whether water is running onto or off the site, how it travels off the site, as well as the proximity, influence and risk hazard potential of nearby rivers, lakes or coastal areas. In some locations, the modeling team may need to review the entire model domain, which could include property adjacent to the plant. For efficiency's sake, walk-downs may include the engineers participating in modeling studies and combine the dual purposes of evaluating current flooding safety measures and gathering input site assessment data for modeling studies.

All of the required modeling must be based on the site's current topography and, where applicable, existing river bathymetry. Unless recent bathymetric and flow data is available, facilities may need to collect updated field data in order to complete an accurate flood margin assessment. Dependable field data, which could include bathymetric surveys, topographic data, velocity profiles and sediment characterization, is essential in developing models and in validating them.

It is suggested that any new data be collected during periods of higher flow, but not during flood flows, a restriction that could impact the overall scheduling of the re-evaluation compliance effort. To ensure a smooth process, timely compliance and thorough modeling, it's critical for facility managers to plan well ahead.

NUREG-0800 Chapter 2 requires that a flood margin assessment look conservatively at common risk factors such as hydrologic characterization, flooding from extreme precipitation or snowmelt, and probable maximum flooding from rivers and streams, as well surge and seiche flooding for coastal or lakeside facilities. It also must address the effects of dam failure, or multiple (domino) dam failures, investigating scenarios ranging from the potential loss of water supply from downstream dams to catastrophic failure of upstream dams and the resulting flood wave.

Model Conservatively and Thoroughly

In many cases, using a one-dimensional model for a runoff model or a river model might be adequate when evaluating a variety of potential scenarios. However, more sophisticated two- and three-dimensional modeling provides additional detail that can be useful in validating the existing protection for or identifying new counter measures for protecting SSCs.

Two-dimensional modeling is useful in evaluating how water would move through a plant site in the event of a flood due to inadequate drainage or flood wave propagating onto the site. Completing the more sophisticated modeling studies also allows facilities to be thorough in predicting both the local and reach-wise effects of erosion and sedimentation, from sediment deposition at a cooling water intake to a large sediment release or erosion caused by the failure of a dam.

Models for evaluating probable maximum flood should take a comprehensive look at the basin, taking into account the unique characteristics of the watershed, the accumulation of runoff in river channels and reservoirs, drainage areas, and impervious surfaces.

Some sites may also need to evaluate risks such as ice effects, river channel diversions, blockages due to seismic activity, tsunami hazards, cooling water channels and reservoirs or low water concerns. For some nuclear facilities, erosion and sedimentation can be significant during flooding and this should also be considered in the new analysis.

Identifying and Procuring Resources

Flood modeling as required by the NRC is a highly specialized area, and one that many nuclear facilities are not equipped to complete in-house. NUREG-0800/CR-7046 also requires that 10CFR Part 50

Appendix B quality assurance requirements be met, and while many civil and engineering firms perform flood plain studies, fewer also have an Appendix B program in place.

The walk-downs will require training for all participants. In-house or contracted flood plain and sedimentation experts should be involved early. If a combined flood protection and hydrologic walk-down approach is chosen, then the flood plain experts should participate in the planning to effectively gather the data they will need to complete accurate and thorough flooding simulations. Plants that wish to contract out to meet these requirements must begin interviewing vendors as soon as they are able or face a potential resource crunch.

As the first few plants go through the process of addressing the new NRC safety requirements, the industry as a whole can expect a learning curve. Smart plant operators are already getting a head start on planning, and will continue to modify their approach as necessary based on the experiences of those Category 1 facilities that complete their re-assessments within the next year.

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Mitchell Peters is a Professional Engineer with over 21 years of working experience in the areas of water-centric civil engineering analysis and design, and water conservation and sustainability engineering. He is presently a CFD and Water Resource Engineer working on stormwater, hydraulic and hydrologic engineering and sedimentation studies. In addition to extensive one- and two- dimensional stormwater runoff and sedimentation modeling, evaluation of urban drainage systems, and water harvesting system design, Mr. Peters is experienced in evaluating, restoring, and constructing riparian and wetland habitat, and utilizing stormwater Best Management Practice (BMP) design to control site runoff and minimize environmental impacts.