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# Boone Dam Seepage Remediation

## Principles, Requirements and Guidelines Review

JANUARY 2016

**TENNESSEE VALLEY AUTHORITY**

For Information Contact:
Matthew Higdon, NEPA Specialist
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, Tennessee 37902-1499
Phone: 865-632-8051
Email: mshigdon@tva.gov

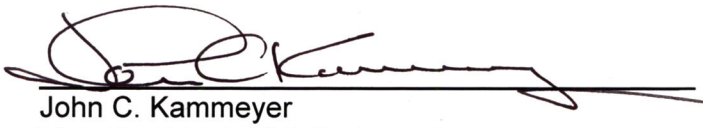
**Boone Dam Seepage Remediation Project**
PR&G Decision Memorandum

In October 2014, a sinkhole was discovered near the base of the embankment at Boone Dam, and water and sediment was found seeping from the riverbank below. After extensive investigation of the source of the observed seepage, the Tennessee Valley Authority (TVA) discovered a well-developed, complex network of seepage paths flowing beneath the dam. TVA has proposed to remediate the seepage by constructing a composite seepage barrier from the crest of the dam embankment downward into the foundation soils and bedrock beneath the dam. A seepage barrier would reduce the risk to the public's safety and welfare posed by seepage flows continuing to undermine the foundation of the earthen embankment of Boone Dam. In its current state, the dam cannot be relied upon to serve the functions for which it was constructed. While the safety of those downstream of the dam is TVA's paramount concern, the proposal would also allow TVA to return the Boone Dam and Reservoir to normal operations in furtherance of TVA's statutory mission to manage the Tennessee River system, its tributaries, and its associated resources.

TVA has determined that the proposal to remediate the dam constitutes a potential Federal investment in water resources, as defined by the "Principles and Requirements for Federal Investments in Water Resources" and the associated "Interagency Guidelines" issued in 2013 and 2014, respectively, by the White House Council on Environmental Quality. Consistent with these Principles, Requirements, and Guidelines (PR&G), TVA has completed a review (PR&G Review) of the proposed investment to ensure that consideration is given to sustainable economic development, the use of floodplains, protecting and restoring natural systems, and the extent to which the investment would benefit the public. TVA integrated the PR&G Review with the preparation of an Environmental Assessment of the proposal's impacts on the human environment.

The PR&G Review of the Boone Dam seepage remediation project found that constructing a composite seepage barrier maximizes public benefits relative to costs, based on the array of anticipated economic, social and environmental effects of the alternatives considered during the review. Therefore, the proposal was identified the recommended investment alternative.

I have reviewed the PR&G Review and, after carefully considering its findings, I agree that TVA's proposal to construct a composite seepage barrier to address the seepage beneath Boone Dam reasonably maximizes the public benefits relative to costs.



1/7/2016
Date

John C. Kammeyer
Vice President, Civil Projects &
Coal Combustion Products Management
Tennessee Valley Authority

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# LIST OF ACRONYMS

| Acronym | Definition |
|---|---|
| EA | Environmental Assessment |
| EIS | Environmental Impact Statement |
| IRRM | interim risk reduction measures |
| IRP | Integrated Resource Plan |
| NEPA | National Environmental Policy Act |
| NPV | Net Present Value |
| ROS | Reservoir Operations Study |
| SER | Socioeconomics Impact Analysis Report |
| USACE | U.S. Army Corps of Engineers |
| USGS | U.S. Geological Survey |

# 1.0 INTRODUCTION

During 2013 and 2014, the White House Council on Environmental Quality issued Principles and Requirements for Federal Investments in Water Resources (P&R) and associated Interagency Guidelines (IGs) that provide new guidance to federal agencies in evaluating proposed water resource investment projects. In June 2015, the IGs became effective (CEQ, 2015).

In 2015, TVA established its Agency Specific Procedures (ASP) for implementing the P&R. Collectively the P&R and IG are known as the "Principles, Requirements, and Guidelines" (PR&G), and a review conducted under the PR&G and consistent with TVA's ASPs is hereafter referred to as a "PR&G review." TVA has chosen to implement the PR&G as a matter of policy to the extent consistent with its authorities and responsibilities and other applicable legal requirements.

At the center of the P&R is the Federal Objective as stated in the Water Resource Development Act of 2007 Section 2013, — that federal water resource investments reflect national priorities, encourage economic development, and protect the environment by—

- Seeking to maximize sustainable economic development;
- Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and
- Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

The updated P&R added that federal investments should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic, and social goals, both monetary and non-monetary effects, and allow for the consideration of both quantified and unquantified measures.

This document presents TVA's PR&G review of the water resource investment for Boone Dam Seepage Remediation project. The results of this PR&G review will help inform TVA decision makers and the public of various economic, environmental, and social factors considered when evaluating and ultimately making an investment decision for the Boone Dam Seepage Remediation project (the project).

**Goal of the PR&G Review**

TVA's goal in the PR&G Review is to improve decision making for investments that affect water resources through a comprehensive evaluation of a range of investment alternatives.

## 1.1 BACKGROUND

In October 2014, a sinkhole was discovered near the base of the embankment at TVA's Boone Dam, and water and sediment were found seeping from the riverbank below (see Figure 1 for

project location). Tennessee Valley Authority (TVA) responded by assembling a team of TVA dam safety engineers and external experts to investigate the source of the observed seepage. The experts determined dam safety was compromised and TVA staff and external experts implemented a number of interim risk reduction measures (IRRMs), including lowering the pool elevation below winter pool levels to between 1,350 feet and 1,355 feet. As part of the IRRMs, TVA also began Interim Operations at Boone Dam that included lower reservoir levels, limited seasonal reservoir pool fluctuation, modified releases into the tailwater for hydropower generation, 24-hour inspection, and modified flood control operations. The change in operations was integral to the continued operation of the dam. Normal Operations are those prior to October 2014 when the Boone Project was being operated in a manner consistent with TVA's current Reservoir Operations Policy; a summary of reservoir levels, turbine capacities, and typical hydroelectric generation flow releases is provided in the Draft Environmental Assessment completed by TVA in October 2015 to consider the proposed remediation of the dam (TVA 2015).

After lowering the pool elevation in November 2014, TVA evaluated the risks of the seepage. The experts determined that in its current state, the dam could not be relied upon to serve the functions for which it was constructed. In the unlikely event of a dam failure, risks to the public would include

- Flooding
- Property damage
- Economic losses
- Environmental impacts
- Loss of critical infrastructure
- Potential loss of life

TVA's experienced team of dam engineers and safety experts evaluated a number of methods for repairing the dam. Subsequently, TVA identified a preferred option to remediate the problems at Boone Dam, pending additional environmental review. Shortly after TVA's experts had implemented the IRRMs and identified the preferred remediation option, TVA began the necessary National Environmental Policy Act (NEPA) environmental review so that the project could proceed as quickly as possible.

The environmental review for the Boone Dam Seepage Remediation is an Environmental Assessment (EA) being completed pursuant to NEPA and TVA's NEPA procedures. A key supporting document for the EA – the Boone Dam Seepage Remediation Socioeconomics Impact Analysis Report of the Two-County Region Surrounding Boone Reservoir (SER) – was developed to assess the potential socioeconomics impacts for the project. The costs and benefits of the Boone Dam Seepage Remediation project to the two-county area surrounding Boone Dam are estimated in the SER.

## 1.2 APPLICABILITY OF THE PR&G REVIEW TO THE BOONE DAM SEEPAGE REMEDIATION PROJECT; EXCLUSIONS, ANALYSIS TYPE, AND INTEGRATION WITH NEPA

The IGs require Agencies to 'describe the process for determining appropriate levels of analysis in their ASPs' (page 4). TVA's ASPs detail the following general process for a PR&G review (TVA 2014):

- For each new significant water resource investment, TVA will determine if the monetary thresholds or other exclusions established in the ASP apply to the investment.
- If the investment is not excluded and TVA determines the PR&G should be applied, TVA will decide whether to employ a "standard analysis" or "scaled analysis" in the evaluation of the investment, and whether the PR&G review should be integrated with a review conducted under NEPA.
- To conduct the PR&G review, TVA will implement a set of analytical steps, including identification and evaluation of a reasonable range of investment alternatives.
- TVA will prepare a document or documents (hereafter, the "PR&G document") describing the analysis and findings and identifying one or more recommended investment alternatives based on PR&G criteria. The PR&G document will be made available to the public.
- TVA decision makers should consider results and recommendations of the PR&G review with information from other planning and evaluation processes when making a final investment decision. A decision memorandum will identify how the PR&G review was considered in making the final decision.

The remainder of this section addresses the first two steps of TVA's ASPs by addressing the monetary thresholds, exclusions and type of analysis. Additionally, the integration with existing planning processes including NEPA and land management planning efforts is described.

### 1.2.1 Monetary Threshold

The estimated construction cost of the project is between $200 million and $300 million. TVA's ASPs establish a monetary threshold criteria for applicability of the PR&Gs to any project. Any project greater than $20 million may be subject to a PR&G review. Since the estimated construction cost of the project is greater than $20 million, a PR&G review may be applicable.

### 1.2.2 Exclusions

Excluded projects include emergency activities, defined as (page 3, TVA 2014):

> *[an emergency activity is]… undertaken to remove immediate danger to public health and safety or to prevent imminent harm to property or the environment, such as emergency repair of dams or levees to prevent flood breech and short-term containment*

*and clean-up of toxic chemical spills, are not subject to PR&G review. Longer-term activities to rehabilitate damaged assets or resources or better prepare for emergencies in the future are potentially subject to PR&G review.*

The project has characteristics of both an "emergency activity" and a "longer-term activity". As noted above, TVA took emergency action upon discovery of a sinkhole and seepage with the development of numerous IRRMs to protect public safety, including beginning Interim Operations at Boone Dam that included lower reservoir levels, limited seasonal reservoir pool fluctuation, modified releases into the tailwater for hydropower generation, 24-hour inspection, and modified flood control operations.

The need for the project arises from the ongoing seepage flows of water and sediment beneath the dam that with time would undermine the foundation of the embankment dam. If left unaddressed, continued internal erosion may lead to enlargement of the network of underground voids, at which time a large influx of water into the voids could rapidly accelerate erosion and eventually breach the dam. The project would remediate the seepage and allow TVA to continue normal operation of the dam for flood control, water supply, hydroelectric power, and recreation—both in the reservoir and in the dam's tailwater. Although dam failure is unlikely given the IRRM measures, the continued safety of the communities downstream of Boone Dam is TVA's paramount concern.

Although the immediate danger to public health was addressed through implementation of the IRRMs, there is still an urgency associated with the project. With the IRRMs in place, the dam has a low probability of dam failure. However, without taking action, the risk of the eventual breaching of the dam would continue. In the event of such a failure, there could be loss of life; destruction of property (including downstream facilities); loss of delivery of critical services to communities such as electric service; and impacts to basic infrastructure such as roads and bridges. Economic losses would be substantial. Downstream environmental resources in and along the river system also would be severely impacted. The severity and breadth of impacts would be influenced by a variety of factors, including how quickly a breach occurs and time of day. Portions of communities along the South Fork Holston River in Sullivan County, including Kingsport, and potentially Hawkins County would be impacted. Eventually, release waters would be contained within TVA's Cherokee Reservoir (TVA 2015).

Despite the urgency of the project and potential harm to public safety, TVA considers the project as a longer-term action under the definitions of an emergency action in the PR&Gs and therefore is proceeding with the PR&G review.

### 1.2.3 Type and Scale of Analysis

TVA is applying a project-level type of analysis to this PR&G review, versus a programmatic-level analysis. The project-level type of analysis is appropriate because the project requires a site-specific design and investment, versus a programmatic-level of analysis which have limited discretion in designing site-specific alternatives for addressing water resources issues. However, because the Boone project is in integral part of TVA's integrated reservoir operations (see call-out), a wide range of considerations apply to decisions that may affect its role in the reservoir system.

**TVA Integrated Reservoir Operations**

In 2004, after extensive study and public involvement, TVA revised its Reservoir Operations Policy, which guides the day-to-day management of the Tennessee Reservoir system. The new reservoir operations policy establishes a balance of reservoir system operating objectives to produce a mix of benefits that is more responsive to the values expressed by the public during the Reservoir Operations Study (ROS) and greater overall public value for the people of the Tennessee Valley. This includes enhancing recreational opportunities while avoiding unacceptable effects on flood risk, water quality, and TVA electric power system costs. Under the Reservoir Operations Policy, TVA operates its system of dams and reservoirs with associated facilities—its water control system as an integrated system within with each reservoir is operated according to a set of water level guidelines and operating ranges.

Source: TVA 2015c

Under the IGs and TVA's ASPs, two types of analysis are defined: a standard analysis and a scaled analysis. A standard analysis is a more comprehensive application of the PR&G to a water resources investment than scaled analysis. A standard analysis is typically used for new or significantly modified projects, programs or plans. A scaled analysis involves a more limited scope investigation. It is appropriate for (Page 7 of the IGs, emphasis added):

> *…low risk/low cost projects, programs, or plans, as well as those with minimal consequences of failure and which pose a minimal threat to human life or safety, or do not result in significant impacts to the environment*.

Implementation of the project's Proposed Alternative will allow TVA to once again operate Boone Reservoir under the Normal Operations policy as detailed in the ROS. The ROS policy sets the balance of trade-offs among competing uses of the water in the system to produce the greatest public value. As such implementing the project will not have significant impacts to the environment that have not already been evaluated under the ROS as the optimal tradeoffs to maximize public benefit. In addition, TVA determined when initially screening the Proposed Alternative that it was appropriate to complete an EA analyzing the proposal because significant impacts to the human environment were not foreseen. TVA's Draft EA, released in October 2015 for public review and comment, supports this initial determination.

Therefore, the PR&G review is being analyzed using a scaled approach. Impacts during the construction phase are described in the EA and will be temporary and are mitigated where appropriate. Despite the fact that consequences of a dam failure of the project pose a threat to human life and safety, it is appropriate to review the project using a scaled analysis because the proposed investment would not result in significant impacts to the environment.

### 1.2.4 Integration with NEPA

The timing of the Boone Dam Seepage Remediation project has influenced TVA's ability to fully integrate the PR&G review with the development of the EA and the SER. This is because the sinkhole near the base of the Boone Dam embankment was found in October 2014 and the seepage shortly thereafter in November 2014. Emergency measures were put in place in late 2014, and remediation alternatives were evaluated in late 2014 and early 2015. These activities were occurring just as the IGs and TVA's ASPs were finalized in June 2015.

However, TVA has incorporated the PR&G review into its decision making process and will consider information presented in the EA and the SER that addresses:

- How alternatives perform with respect to the following Guiding Principles of the P&R:
    - Healthy and Resilient Ecosystems
    - Sustainable Economic Development
    - Floodplains
    - Public Safety
    - Environmental Justice
    - Watershed Approach
- How public benefits of an alternative compare to its costs. The public benefits and costs of the federal water resource investment are framed in a complete accounting of the environmental, social (and health) and economic costs and benefits expected from the federal investment.

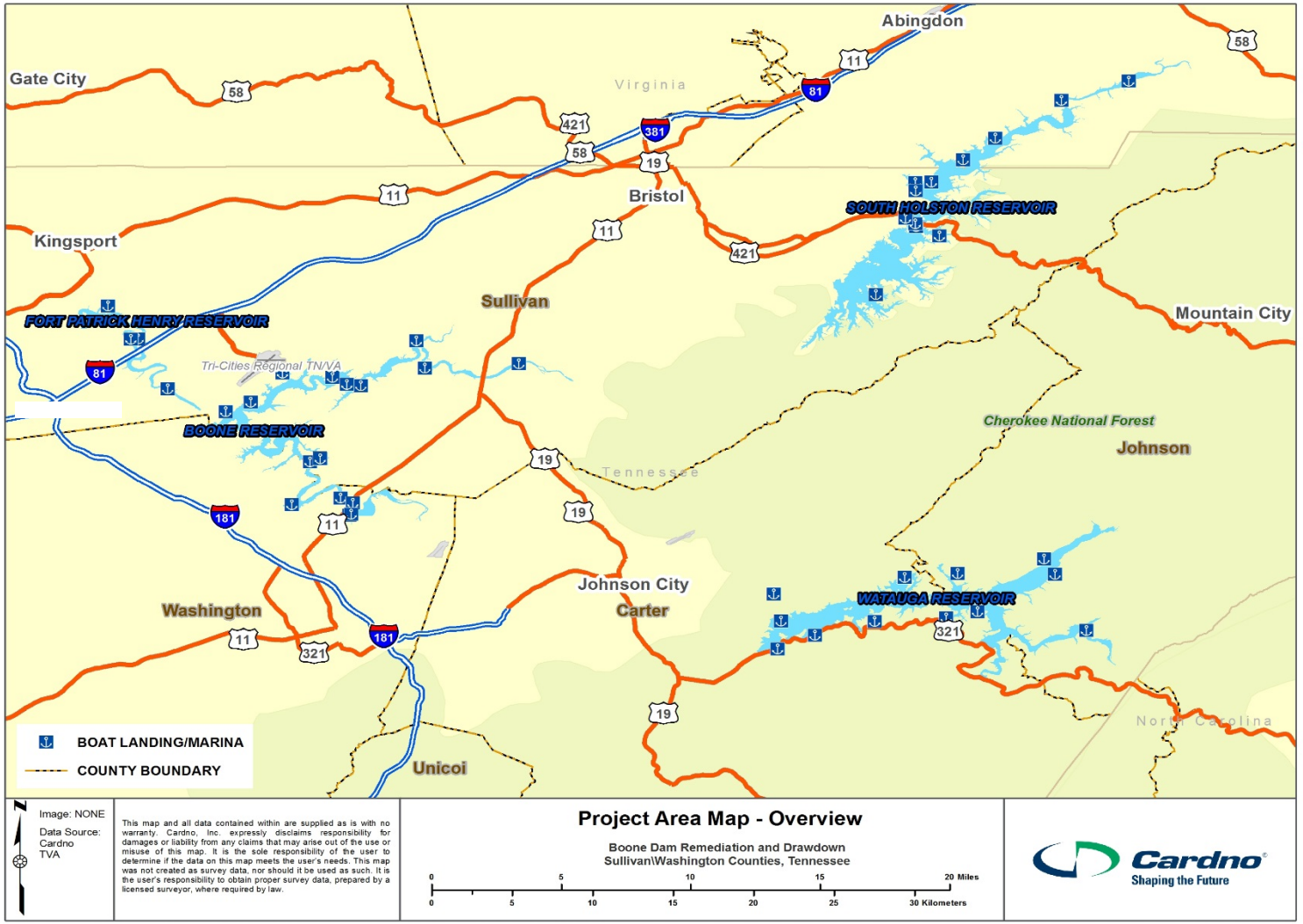



**Figure 1 Project Location**

## 2.0 SCOPE AND CHALLENGES

The purpose of the project is to reduce the current risk to the public's safety and welfare posed by seepage flows eroding soils from under Boone Dam and the potential erosion of the earthen embankment of Boone Dam (TVA 2015a). The project also would allow TVA to return the Boone Dam and Reservoir to Normal Operations under the Reservoir Operations Policy and in furtherance of TVA's statutory mission to manage the Tennessee River system, its tributaries, and its associated resources to provide power and support economic development in the Valley.

With the IRRMs in place, the dam has a low probability of dam failure in the current configuration. However, without taking action, the risk of the eventual breaching of the dam would continue. In the event of such a failure, there could be loss of life; destruction of property (including downstream facilities); loss of delivery of critical services to communities such as electric service; and impacts to basic infrastructure such as roads and bridges. Economic losses would be substantial. Downstream environmental resources in and along the river system also would be severely impacted. The severity and breadth of impacts would be influenced by a variety of factors, including how quickly a breach occurs and time of day. Portions of communities along the South Fork Holston River in Sullivan County, including Kingsport, a city of approximately 50,000 residents (U.S. Census, 2014), and potentially Hawkins County would be impacted. Flooding downstream of Cherokee Reservoir would not occur based on TVA's analysis.

## 3.0 EXISTING CONDITIONS

The existing conditions at Boone Reservoir are described in the EA (TVA 2015a). Table 1 lists the EA section number and name in the appropriate Guiding Principles category.

**Table 1. Existing Conditions Categorized by Guiding Principle.**

| Guiding Principle | Section Number and Name in Boone Dam Seepage Remediation Environmental Assessment. |
|---|---|
| Healthy and Resilient Ecosystems | 3.2 Geological Resources<br>3.3 Water Resources<br>3.4 Wetlands<br>3.6 Terrestrial Ecology<br>3.7 Aquatic Ecology<br>3.8 Threatened and Endangered Species<br>3.10 Air Quality |
| Sustainable Economic Development | 3.11 Socioeconomics<br>3.12 Recreation |
| Floodplains | 3.4 Floodplains and Flood Risk |
| Public Safety | 3.15 Public and Occupational Health and Safety |
| Environmental Justice | 3.11 Socioeconomics |
| Watershed Approach | 3.1 Boone Project Operations |

# 4.0 FUTURE CONDITIONS OF THE STUDY AREA

According to the Interagency Guidelines, when conducting PR&G reviews agencies should consider the future conditions of the project area, including uncertainties, to ensure all relevant impacts are analyzed. The Draft EA of the proposed remediation alternative and the environmental review conducted for the ROS provide information about future conditions of the reservoir.

## 4.1 UNCERTAINTY

TVA assumes that completing the proposed remediation of the dam would allow TVA to return the reservoir to Normal Operations. The Draft EA analyzes the extent to which the conditions in and around the reservoir may change during the project period (5 to 7 years). In the analysis, TVA assumes that the reservoir and area conditions would return to normal conditions (i.e., pre-October 2014 operations, based on the ROS) soon after the project is completed. TVA does not foresee that after the project is complete there would be changes to key resources or services resulting from the investment. Based on the initial investigation of the seepage issue and the expert elicitation on effective remedies, TVA also assumes that the Proposed Alternative will adequately remediate the seepage issue beneath the dam and that TVA can continue the operational life of the dam and reservoir in the future.

If TVA does not take action to address the seepage of the dam, there would be substantial uncertainty regarding the future condition of the dam given the continued risk of failure. Seepage and erosion of underlying soils and bedrock beneath the dam would continue and the potential for dam failure would persist. In addition to the uncertainty associated with potential impacts to downstream communities and resources of dam failure, TVA would not return the reservoir to Normal Operations as discussed under the Draft EA's No Action alternative, and significant impacts to the local economy and to land development patterns near the reservoir would occur. The extent to which the area over time would adjust to such a scenario is uncertain, whereas TVA assumes that remediating the seepage issue and returning the reservoir to Normal Operations would dramatically reduce uncertainty about the future conditions in the area.

## 4.2 CLIMATE CHANGE

Temperatures are projected to increase and annual water yield (equivalent to water availability) is expected to decline in the Tennessee Valley by climate computer models due to climate change (U.S. Global Change Research Program, 2014). In addition to changes in average temperatures and rainfall, precipitation extremes are expected to change in both frequency and severity of flood events (USACE, 2015).

TVA manages the effects of climate change on its mission, programs, and operations within its environmental management processes. Its primary planning processes are its Integrated Resource Plan (IRP) and its Natural Resource Plan (NRP). As a Federal agency, TVA also complies with the NEPA as well as applicable Executive Orders, such as E.O. 13514, TVA has completed a high-level climate change vulnerability assessment as required by E.O. 13514.

In addition, TVA utilizes an integrated planning process to periodically review its Reservoir Operations Policy. This process would allow TVA to adjust operations to address changes to the region's precipitation rates or other changes to the climate affecting reservoir operations. TVA expects the remediation proposal under consideration would extend the operational life of the dam indefinitely. While the extent to which the region's climate will change during the dam's operation life and the extent to which such changes would affect resources and services are uncertain, TVA's planning processes and integrated approach to reservoir operations allows TVA to address such impacts.

With three generating units, Boone Dam is an important source of hydropower, $CO_2$-free generation, on the TVA system. TVA's Climate Change Adaptation Action Plan (TVA 2012) states (Page 4):

> *Greenhouse Gas Reduction: TVA's Environmental Policy states the environmental objective that TVA "will stop the growth of emissions and reduce the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower CO2 energy-supply opportunities and energy efficiency. In accordance with EO 13514, TVA has set additional GHG reduction targets … and annually reports its progress as part of its Strategic Sustainability Performance Plan.*

## 5.0 FORMULATING A RANGE OF INVESTMENT ALTERNATIVES

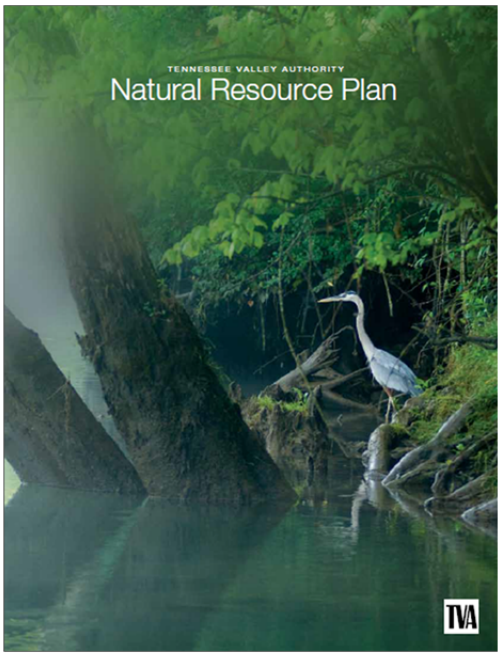
The Proposed Alternative under consideration by TVA was formulated to address the paramount concern of reducing risk to the public's safety and welfare posed by the increased potential for failure of Boone Dam resulting from seepage. In addition to reducing risk, the proposal addresses multiple objectives for water resources investments, as required by the federal IGs (CEQ, 2015).

Two alternatives were analyzed in the EA – the No Action Alternative and the Proposed Alternative. Under the No Action Alternative, TVA would not remediate the seepage flow of water beneath the dam and erosion would continue. TVA would not implement additional risk reduction measures beyond the IRRMs and the reservoir would be operated at reduced pool elevation. See the EA, Section 2.1 for complete details of the No Action Alternative. This alternative would carry with it a greater risk of dam failure than under the Proposed Alternative.

Under the Proposed Alternative, TVA would construct a composite seepage barrier at Boone Dam over a period of 5 to 7 years, during which time Interim Reservoir Operations would continue. Construction of the seepage barrier, which would begin in 2016, would require numerous support activities on the dam reservation and at nearby Construction Support Areas. After construction is substantially completed, the reservoir would return to Normal Operations. See the EA, Section 2.2 for complete details of the Proposed Alternative.

The Proposed Alternative reduces risk of dam failure and integrates multiple objectives for water resource investment – simply by the nature of TVA's integrated operations of resource

management. Boone Dam and Reservoir are components of TVA's integrated environmental management infrastructure. TVA's major environmental management planning processes are its Integrated Resource Plan (IRP) and its Natural Resource Plan (NRP), both of which recognize the tradeoffs between optimizing the value of TVA's asset portfolio and being responsible stewards of the Tennessee Valley's environment and natural resources (TVA 2015c). In addition, both were written assuming Boone Dam would be operated under Normal Reservoir Operations.




The Tennessee Valley Authority (TVA) adopted a Natural Resource Plan (NRP) to guide how TVA will manage its natural resources over the next 20 years. In 2008, the TVA Board of Directors approved the TVA Environmental Policy, which sets forth principles to guide TVA in reducing the environmental impacts of its activities while continuing to provide reliable and affordable power to the Valley. By establishing the Environmental Policy, TVA committed to a more systematic and integrated approach to managing stewardship. The NRP addresses the planning processes and Environmental Policy objectives related to Water Resource Protection and Improvement, Sustainable Land Use, and Natural Resource Management. Source: TVA 2011

Returning Boone Dam to Normal Operations contributes to the ability of TVA to implement these multi-objective resource plans. For example, the IRP (see Integrated Resource Plan call-out box) describes a plan to retire existing assets, in the form of coal plants, to reduce greenhouse gas emissions ($CO_2$) in its commitment to environmental stewardship. The power generating capacity that is lost from these coal plants will be partially replaced with an additional 50 MW of hydro capacity (TVA 2015c). Boone Dam is a hydroelectric facility, generating 89 MW of energy. Returning Boone Dam to Normal Operations contributes to TVA's ability to meet this IRP environmental stewardship goal.

Another example of the TVA's integrated environmental management planning process is taken from the NRP (see Natural Resource Plan call-out box). One of three components of the water resource management program focuses on the benefit of shoreline stabilization, to prevent erosion and improve water quality by reducing sediment in the water (TVA 2015d). Returning Boone Dam to Normal Operations contributes to TVA's ability to meet this water resource goal because it returns the reservoir to normal levels, reducing the area of exposed reservoir bottom that would have to be managed to prevent erosion under the No Action Alternative (see Figure 2).

The EA describes 13 potential engineering plans, all of which would remediate the seepage problem. The EA refers to these 13 plans as Alternatives; however, they are all functionally

equivalent under the PR&G review because each of the alternatives would remediate the seepage and restore reservoir operations to normal. These 13 construction plans were analyzed using Kepner Tregoe Analysis. Kepner Tregoe decision making is a rational model used for structured decision making that assesses and prioritizes risks. The alternatives are described in Section 2.3 of the EA.

The EA also considered removing Boone Dam. This option would not achieve TVA's objective to return the Boone Dam and Reservoir to Normal operations in furtherance of TVA's statutory mission and integrated resource plans and therefore was dismissed. TVA also determined that the dam's removal would greatly increase flood risks to downstream communities from localized flooding events, likely resulting in adverse effects to those communities.

**Figure 2. Photograph Showing Exposed Reservoir Bottom at Boone Reservoir under Interim Operation.**

## 6.0 EVALUATING AND COMPARING ALTERNATIVES

The IGs recommend that agencies ensure that alternatives evaluate environmental, social (and health) and economic factors, and that agency procedures incorporate methods to evaluate:

- How alternatives perform with respect to the Guiding Principles and
- How public benefits of an alternative compare to its costs,
- How alternatives perform against the four formulation criteria: completeness effectiveness, efficiency and acceptability.

Each of these factors is summarized below from information that is detailed in the SER (TVA 2015b). Table 2 shows the category of benefits assessed (e.g. environmental, social and

economic) and the impact on each federal IG. Under the No Action Alternative, the risk of a dam failure threatens not only public safety but also the natural resources downstream of Boone Reservoir. Potentially impacted resources include water quality, habitat, floodplains, wildlife, etc. The impacts to the environment of dam failure were not quantified for this review because of the timing of the alternative development in relation to the effective date of the federal IGs and TVAs ASPs. In addition, impacts were not quantified because dam failure is unlikely and potential effects are speculative given that the magnitude and severity of a dam failure would be dependent on failure mode scenarios, time of day, day of the week, etc. Under the Proposed Alternative, the current risk to all downstream resources would be resolved when the project is completed, as appropriate.

## 6.1 ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS OF THE ALTERNATIVES AND DESCRIPTION OF CONTRIBUTION TO FEDERAL INTERAGENCY GUIDELINES

Table 2 summarizes the contribution the alternative makes to the federal IGs, categorized according to the most relevant impact measure for the project: Environmental, Social (including Health) and Economic.

**Table 2. Contribution of each alternative to the Federal Guiding Principles**

| Category of Impact | Guiding Principle | No Action Alternative | Proposed Alternative |
|---|---|---|---|
| Environmental | **Healthy and Resilient Ecosystems** | ↓ Risk of eventual dam breach continues, environmental resource in and along the river system could be severely impacted. | ↑ Provides for level of services selected in the TVA's environmental planning documents; NRP and IRP. |
| | **Floodplains** | — | — |
| | **Watershed Approach** | ↓ TVA cannot operate the Boone Reservoir as per the ROS and the environmental planning documents; NRP and IRP. | ↑ TVA operates the Boone Reservoir as per the ROS and the environmental planning documents; NRP and IRP. |
| Social | **Public Safety** | ↓ Risk of eventual dam breach continues, there could be loss of life; destruction of property | ↑ Risk of dam failure significantly reduced. |
| | **Environmental Justice** | — | — |
| Economic | **Sustainable Economic Development** | ↓ Permanent 24% to 52% reduction in local recreation visitation and spending.<br>↓ NPV of loss in economic output between -$32 million to -$65 million<br>↓ Reservoir shoreline property values fall between 15% to 45% | ↑ Resumption of recreation visitation to normal levels after 5 to 7 years dam remediation period.<br>↓ NPV of loss in economic output between $21 million to $44 million<br>↑ Reduces risk of dam breach and increases security of downstream property, services and infrastructure. |

**Table 2. Contribution of each alternative to the Federal Guiding Principles**

| Category of Impact | Guiding Principle | No Action Alternative | Proposed Alternative |
|---|---|---|---|
| | | ↓ Risk of eventual dam breach continues, possible destruction of downstream properties, loss of delivery of critical services, impacts to roads and bridges. | |

Source: Cardno.

↓ indicates a definitively negative impact to the user group overall, and the impact is unique to each user and therefore not practicably quantified.

— indicates potential for a slight negative to neutral impact to the user group that is unique to each user and not practicably quantified

↑ indicates a positive impact to the user group

The No Action Alternative would not provide support for the health or resiliency of the ecosystem downstream of Boone Dam. Continued risk of eventual dam breach would threaten the resources in and along the river system, particularly habitat and water quality resources. See the EA for a complete description of the potential impacted resource areas. Under the Proposed Alternative, TVA would be contributing to the health and resilience of ecosystems by reducing the risk of a dam failure and by continuing to provide the level of services selected in TVA's environmental planning documents (IRP and NRP) and the ROS.

Neither of the alternatives would be anticipated to impact the use of floodplains. However, under the Proposed Alternative, TVA would temporarily encroach on the 100-year floodplain adjacent and upstream of the dam during construction activities. If TVA does not take action to address the seepage issue, a permanent change to the 100-year flood elevation would be required upstream of Boone Dam because water levels would remain at the current, lower elevation indefinitely. Thus, the Proposed Alternative would eliminate the need for agencies and residents to make adjustments to floodplain delineations and applicable insurance policies.

The watershed approach is integrated in the Proposed Alternative because it allows TVA to operate Boone Reservoir according to the environmental and reservoir management plans TVA has adopted: the IRP, NRP, and ROS. The economic benefits of the NRP have been analyzed and are generally positive (TVA 2011b).

Environmental Justice (EJ) concerns disproportional impacts to communities that are lower income and or minorities. There is not a disproportional percentage of low income or minority populations in the two-county area surrounding Boone Dam so EJ issues do not apply to the project. See the SER and or the EA for details of the demographics in the two-county area.

Economic impacts were quantified where possible and are described in detail in the SER. In summary, under the No Action Alternative recreational visitation is expected to fall between 24 percent and 52 percent of pre-seepage levels resulting in an annual loss in economic output,

measured in terms of direct, indirect and induced economic effects is between $600,000 and $1.8 million (see Table 3). The net present value (NPV) of that loss is between $32 million and $65 million[1]. Under the Proposed Alternative, there is still an economic loss due to a reduction in recreational visitation, however the loss is much smaller, between $21 million and $44 million, because visitation is only low during the 5- to 7-year dam remediation period.

Under the No Action Alternative the shoreline property owners are estimated to lose between 15 percent and 45 percent of the values of their property. The same is not true under the Proposed Alternative it is assumed that property values will not change appreciably. However, shoreline property owners will experience a loss in the enjoyment and use of their properties.

Finally, under the No Action Alternative the downstream businesses, homes, services, and infrastructure downstream of Boone Dam are at risk. Potential economic, social, and environmental impacts of a dam failure would be significant. Under the Proposed Alternative, the risk is resolved when the project is completed.

## 6.2 PUBLIC BENEFITS AND COSTS

As noted above, the IGs direct agencies to review how the public benefits to the public of an alternative federal investment in water resources compares to its costs. The standard criterion for deciding whether a government program can be justified on economic principles is net present value (NPV). NPV is computed by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits (OMB 1992). In order to compute NPV, it is necessary to discount future benefits and costs. This discounting reflects the time value of money. Benefits and costs are worth more if they are experienced sooner. The higher the discount rate, the lower is the present value of future cash flows. A 1.4 real percent discount rate is recommended by the Office of Management and Budget (OMB) for use to estimate the NPV of the alternatives (OMB, 2015). The term of the project is assumed to be 50 years.

The IGs request that the PR&G review perform a complete accounting of the costs and benefits expected from the Federal investment. A complete accounting identifies, at a minimum, impacted ecosystem services and the projected trend of each service flow and where practicable impacts should be quantified. The ecosystem service benefits were not quantified for this PR&G review because of the timing of the alternative development and the effective dates of the IGs and TVA's ASPs and because of the limited, scaled approach taken for this PR&G review. Quantifying some ecosystem service benefits also would involve substantial speculation and likely would be contentious.

Table 3, duplicated from the SER, lists the annual impacts estimated for the project for those impacts categories that were quantified. The SER describes the methods used to estimate impacts. Cultural service benefits, in the form of recreation visitation output, and construction

[1] Assuming a 50-year project life and a 1.4% discount rate per OMB circular A-94.

spending, are the only benefits/costs that are quantified for the project. Foregone recreation opportunities are considered a cost of an alternative. Impacts to provisioning services or regulating services have not been quantified. Additionally only use values are included in the estimates presented in Table 3.

**Table 3: Estimated Annual Economic Output and Community Impacts of the Proposed Action and No Action Alternatives (2015 $s 000)**

| Potential Impact | Unit of Measure | No Action | Proposed Action | |
|---|---|---|---|---|
| | | Annual Impacts in Perpetuity | Annual Impacts during dam remediation | Post Dam Remediation |
| Recreational (annual dollars) | $ 000s | -$600.0 to -$1,800.0 | -$600.0 to -$1,800.0 | $0 |
| Property value | one-time % change from 2015 | 16% - 45% | 0% | 0% |
| Shoreline Property Owners Use of property (qualified) | Qualified | ⊖ | ⊖ | ⊙ |
| Marina Businesses (qualified) | Qualified | ⊖ | ⊖ | ⊙ / ⊖ |
| Construction on dam remediation | $ 000s | $1,117 | $317,217 to $474,317 | $0 |
| Construction on recreation access improvements | $ 000s | $1,117 | $1,117 | $0 |
| Environmental Justice | $ 000s | $0 | $0 | $0 |

Source: Cardno.

⊖ indicates a definitively negative impact to the user group that is unique to each user and not practicably quantified.

⊙ indicates potential for a slight negative to neutral impact to the user group that is unique to each user and not practicably quantified.

The NPV of the alternatives is presented in Table 4. According to TVA's analysis, the total NPV of taking no action would cost from approximately $32.2 to $65.5 million and the total NPV of implementing the Proposed Alternative would cost from $281 to $408 million. However, because the environmental, social, and economic benefits from a reduction in risk of a dam failure were not quantified for this review, the NPVs listed in Table 4 represent only part of the total economic impacts. If a dam failure were to occur, there would be significant economic, social and environmental impacts to downstream communities. TVA anticipates that costs associated with responding to and restoring damages caused by a dam failure would be in excess of the costs associated with remediating the dam. If the dam were to fail, TVA would also lose hydroelectric generation capabilities of the dam, increasing power costs to replace the generation capacity while reducing TVA's ability to meet its integrated goals under the IRP.

**Table 4. Net Present Value of Quantified Benefits/Costs (2015 $000s)**

| Time Period | | NPV (a) | Project Years (b) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | '22 thru '66 |
| **No Action Alternative** | | | | | | | | | |
| **Cost of forgone recreation spending and marina businesses** | | | | | | | | | |
| | low | **-$31,133.0** | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 |
| | high | **-$64,413.5** | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 |
| **Construction costs for access mitigation** | | | | | | | | | |
| | low | **-$1,101.6** | -$1,117.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| | high | **-$1,101.6** | -$1,117.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| **Total cost** | | | | | | | | | |
| | low | **-$32,234.5** | -$1,987.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 |
| | high | **-$65,515.1** | -$2,917.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 |
| **Total NPV** | | | | | | | | | |
| | low | **-$32,234.5** | | | | | | | |
| | high | **-$65,515.1** | | | | | | | |
| **Proposed Alternative** | | | | | | | | | |
| **Benefit - recreation and marina businesses** | | | | | | | | | |
| | low | **$21,187.0** | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | -$870.0 | $870.0 |
| | high | **$43,834.6** | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0 | -$1,800.0- | $1,800.0 |
| **Construction cost** | | | | | | | | | |
| | low | **-$302,235.4** | **-$52,869.5** | **-$52,869.5** | **-$52,869.5** | **-$52,869.5** | **-$52,869.5** | **-$52,869.5** | **$0.0** |
| | high | **-$451,916.1** | **-$79,052.8** | **-$79,052.8** | **-$79,052.8** | **-$79,052.8** | **-$79,052.8** | **-$79,052.8** | **$0.0** |
| **Total NPV** | | | | | | | | | |
| | low | **-$281,048.4** | | | | | | | |
| | high | **-$408,081.4** | | | | | | | |

Source: (a) Cardno, (b) TVA 2015b.

## 6.3 HOW ALTERNATIVES PERFORM AGAINST THE FOUR FORMULATION CRITERIA: COMPLETENESS EFFECTIVENESS, EFFICIENCY AND ACCEPTABILITY

Because the alternatives were formulated before the Federal IGs and TVA's ASPs were effective, the alternatives were not assessed against the formulation criteria presented in the P&Rs (see Table 5). However, Figure 3 presents an estimation of how the No Action Alternative and the Proposed Alternative may have been assessed against the formulation criteria.

**Table 5. Definitions of Formulation Criteria.**

| Formulation criteria | Definition |
|---|---|
| **Completeness** | The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. |
| **Effectiveness** | The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. |
| **Efficiency** | The extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. |
| **Acceptability** | Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. |

Source: USACE 2000.

As displayed in Figure 3, TVA considers the No Action Alternative to be the less complete, effective, and efficient. Because the alternative fails to address TVA's paramount concern for the public's safety, the alternative is not acceptable. The Proposed Alternative would rank relatively high on the most complete, effective and efficient scale. There is recognition and consensus among State and local entities that remediating the seepage of the dam is the only acceptable option. However, the Proposed Alternative met with some resistance from local residents in the local area surrounding Boone Reservoir, particularly owners of properties adjacent to the reservoir, over concern for the loss of access and recreational amenities during the 5- to 7-year dam remediation period.

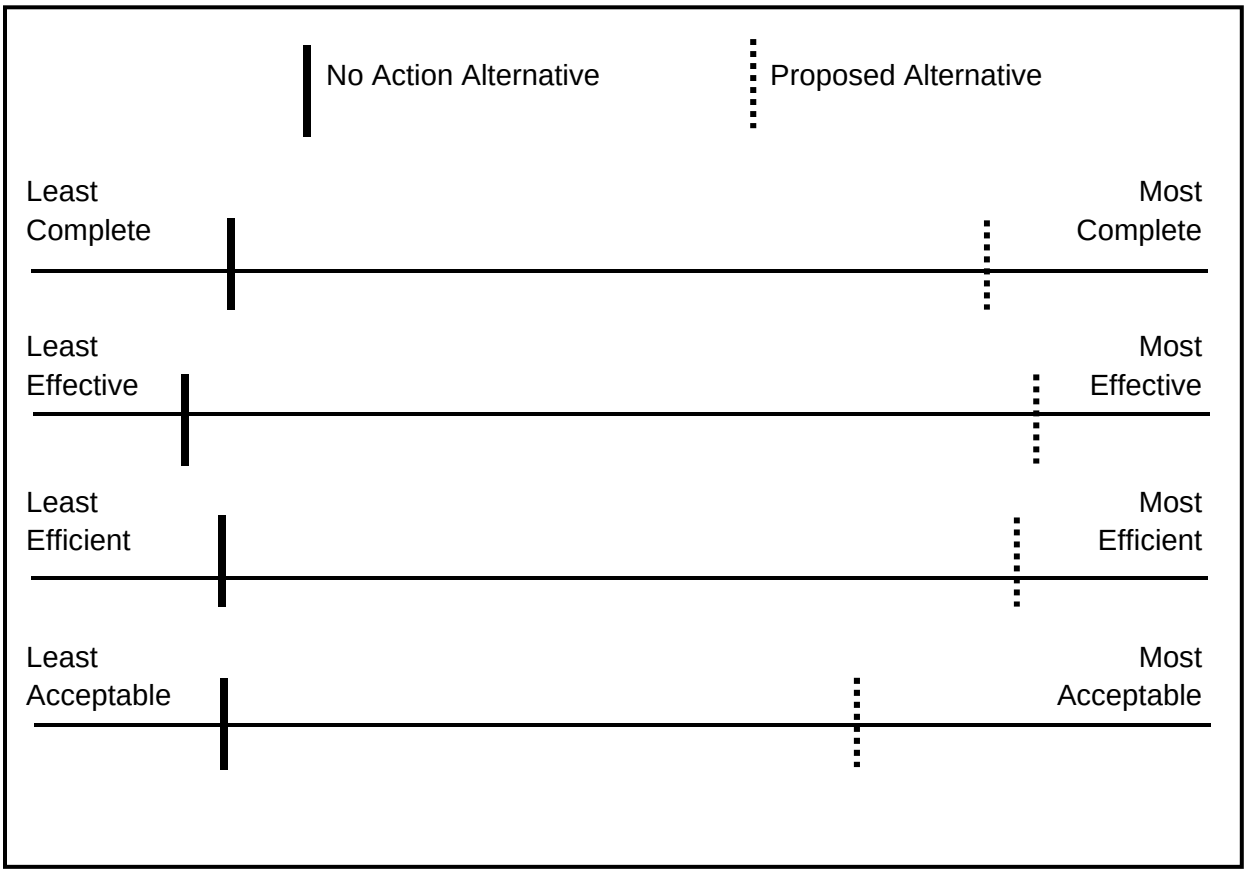



**Figure 3. No Action Alternative and Proposed Alternative Assessed Against the Formulation Criteria**

## 7.0 IDENTIFICATION OF THE RECOMMENDED INVESTMENT ALTERNATIVE

The Proposed Alternative was selected over the No Action Alternative as the recommended investment alternative because it most closely achieves the goal of reducing the current risk to the public's safety and welfare posed by seepage flows eroding soils from under Boone Dam (TVA 2015a). TVA perceives that the benefits to the public are greater than the potential costs because the Proposed Alternative:

1) Reduces the risk of dam failure, avoiding what could be substantial costs to the environment, the community (including health) and the economy downstream of Boone reservoir, and
2) Supports TVA's goals of integrating Boone Reservoir in its IRP and NRP.

The alternative is also the only viable alternative that meets the Federal Objective identified in the P&R for Federal investments in water resources.

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