Framework for Evaluating the Relative Impacts of Surface Impoundment Closure Options

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Coal-powered utilities are receiving increased pressure from regulators and the public to close unlined surface impoundments. Moreover, there is a prevailing public sentiment that human health and environmental impacts will be minimized if existing coal ash is excavated from surface impoundments, transported to a lined landfill, and re-disposed, as opposed to surface impoundments being closed with the ash in place. However, risks are often viewed through a very narrow lens, and to fully understand the potential human health and environmental risks and benefits, one must holistically consider the potential impacts associated with all remedial activities under the different closure scenarios.

To respond to this need, we are developing a comprehensive, science-based approach that allows utilities to consider the possible human health and environmental impacts under different closure scenarios. Specifically, the framework is focused on examining the relative risks and benefits surrounding the activities associated with an in-place closure *vs.* a scenario in which the ash is excavated and re-disposed in a landfill. A central tenet of the framework is that the impacts under both of these closure alternatives are compared to the "no-action" scenario, *i.e.*, a scenario under which a surface impoundment is left to operate and no remedial actions are taken.

The framework aims to take an overarching view of possible impacts surrounding surface impoundment use and closure. It goes beyond quantifying risks associated with the more traditional media-based pathways (*e.g.*, water, soil, and air), further examining impacts to worker safety and measures of "green and sustainable remediation." For each pathway, the framework defines a set of metrics that can be used to quantify impacts. The key pathways and some example impacts that can be evaluated using the framework are presented in Table 1.

Table 1: Key Framework Pathways and Examples

Pathway	Example Impacts
Groundwater Impact	• Coal Combustion Residue (CCR) concentrations at a monitoring well of interest. • Human health risk *via* drinking water for community.
Surface Water Impact	• CCR concentrations at downgradient surface impoundment. • Ecological aquatics risks. • Human health risk *via* drinking water for community.
Air Impact	• Total particulate matter ($PM_{2.5}$ and PM_{10}) air emissions. • Human health risk *via* air for workers. • Human health risk *via* air for community.
Contact with CCRs	• Human health risk from direct contact with chemicals of concern (COCs) in CCRs
Worker Safety	• Accidents and fatalities for multiple worker types. • Disruptions to the community (*e.g.*, noise, traffic, community accident risk).
Green and Sustainable Remediation	• Air emissions (nitrogen oxides, sulfur oxides, greenhouse gases, PM_{10}); energy consumption; water usage; resource consumption.

Because not all pathways will be relevant at a site, the framework is designed to be flexible. Pathways and receptors can be added and omitted as needed at the discretion of the framework user. Moreover, the framework allows the user to tailor the complexity of the analysis depending on the availability of site-specific data, the preferred choice of models and tools used to estimate impacts, and how the evaluation will be used. Currently the framework outlines three assessment tiers. A Tier 1 analysis, which has rather modest data requirements for most pathways, is intended to provide a broad perspective on the relative impacts among closure scenarios. The pathways that can be quantified under a Tier 1 analysis are more limited and the evaluation of relative impacts are not generally placed in a regulatory context. A Tier 1 analysis may be useful for giving utility managers a high-level view of the relative merits of an in-place closure *vs.* excavating and re-disposing to landfill. In contrast, at the other end of the spectrum, a Tier 3 analysis generally involves evaluating relative risks using more traditional risk assessment methodologies or more sophisticated green remediation evaluations schemes. A Tier 3 analysis allows for a the evaluation of a larger set of pathways and impacts using more refined models and more site-specific information. Such evaluations are likely to be more useful for communicating with regulators or the public. A Tier 2 analysis provides an intermediate degree of analysis and impact refinement, allowing the framework user to provide some regulatory context to results without the need to conduct detailed risk assessment calculations.

Full details on the framework, which will be available in an Electric Power Research Institute (EPRI) Report, will include recommendations on modeling tools and the specific data needed to perform an analysis at each assessment tier. The modeling approaches address groundwater, - surface water, and air modeling. Resources for evaluating human and ecological impacts are also provided.

To aid in the comparison of relative impacts among closure options, the framework will provide specific guidance on how to compare risks and benefits within and across pathways. A tool has been developed that provides a visual aid to help the framework user understand the overall risk-benefit balance as well as the relative contribution of each pathway to the result.

Overall, the framework, which outlines a step-by-step evaluation approach to compare relative impacts among different impoundment closure scenarios, relies on the application of a transparent, scientifically defensible approach. Ultimately, it enables utilities to make informed impoundment closure plans that minimize human health and environmental impacts. Analyses generated from the framework might also be useful for communicating a complete picture of potential risks and benefits to regulators and the public.