U.S. House of Representatives
Committee on Transportation and Infrastructure
Washington, DC 20515

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July 27, 2009

SUMMARY OF SUBJECT MATTER

TO: Members of the Subcommittee on Water Resources and Environment

FROM: Subcommittee on Water Resources and Environment Staff

SUBJECT: Hearing on "The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Updates on Cleanup Efforts"

PURPOSE OF HEARING

The Subcommittee on Water Resources and Environment will meet on Tuesday, July 28, 2009, at 10:30 a.m., in room 2167 of the Rayburn House Office Building to receive testimony from representatives from the U.S. Environmental Protection Agency (EPA), the Tennessee Valley Authority (TVA), the TVA Office of Inspector General (OIG), and engineering firms. The purpose of this hearing is to receive updates as to the status of the Kingston ash slide cleanup efforts, and also analyses of the root cause of the Kingston surface impoundment collapse.

This hearing is being conducted as one of several hearings that meet the oversight requirements under clauses 2(n), (o), and (p) of Rule XI of the Rules of the House of Representatives.

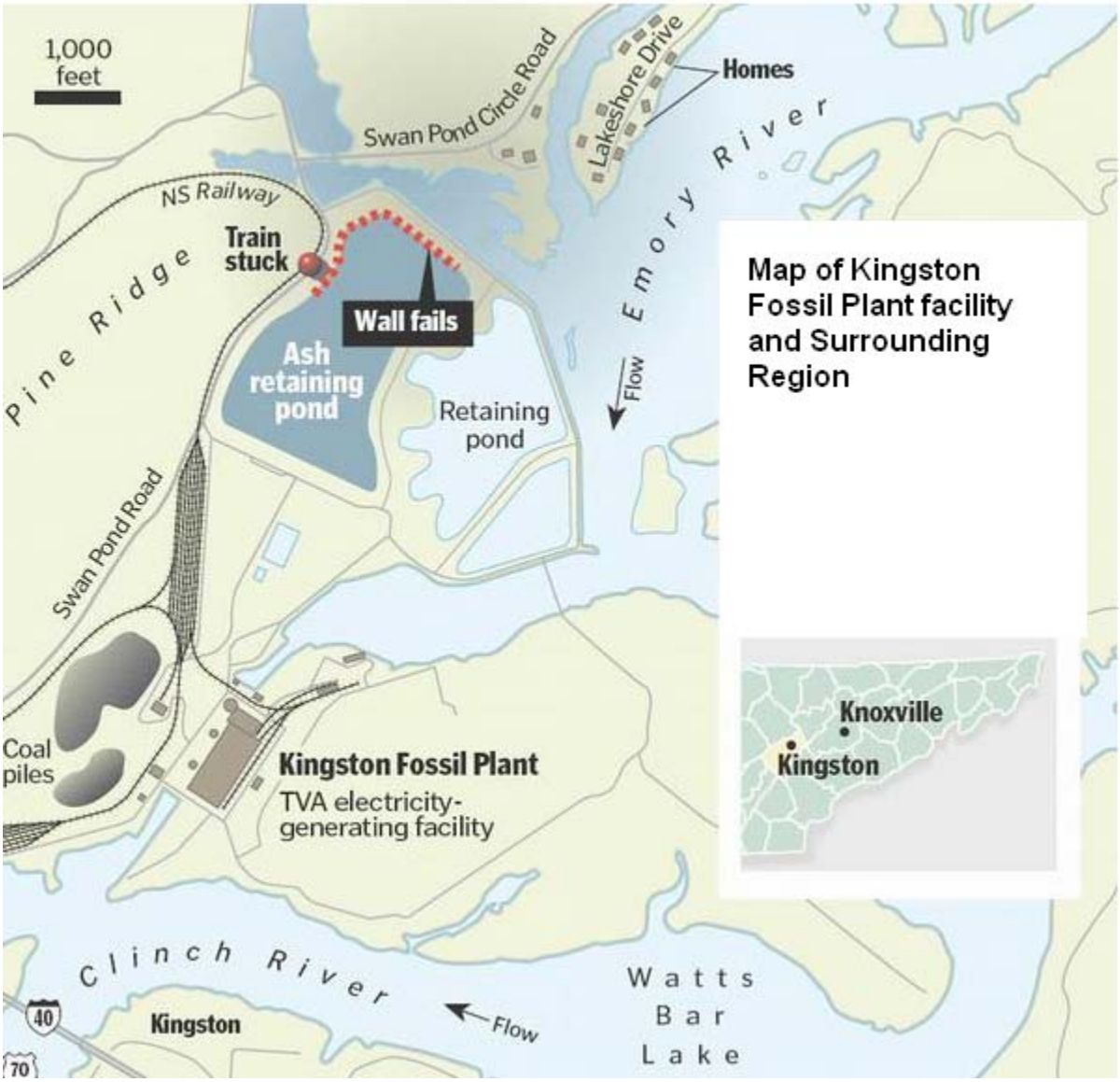
BACKGROUND

This memorandum provides information on the TVA Root Cause Analysis (RCA), as well as other evaluations.

The Kingston Fossil Plant is a coal-fired power plant located in Harriman, Tennessee, 40 miles west of Knoxville, Tennessee. It is owned and operated by TVA. The facility is located at the confluence of tributaries of the Tennessee River: the Clinch and Emory Rivers. It is one of TVA's larger coal-fired power plants and produces 1,700 megawatts per day, or 10 billion kilowatts per year (enough to supply power for 670,000 households). At full power, the Kingston Fossil Plant burns

about 14,000 tons of coal every day. This results in about 1,000 tons of fly ash produced per day. The plant was completed in 1955.

Figure 1: Map of Kingston Fossil Plant Facility and Surrounding Region



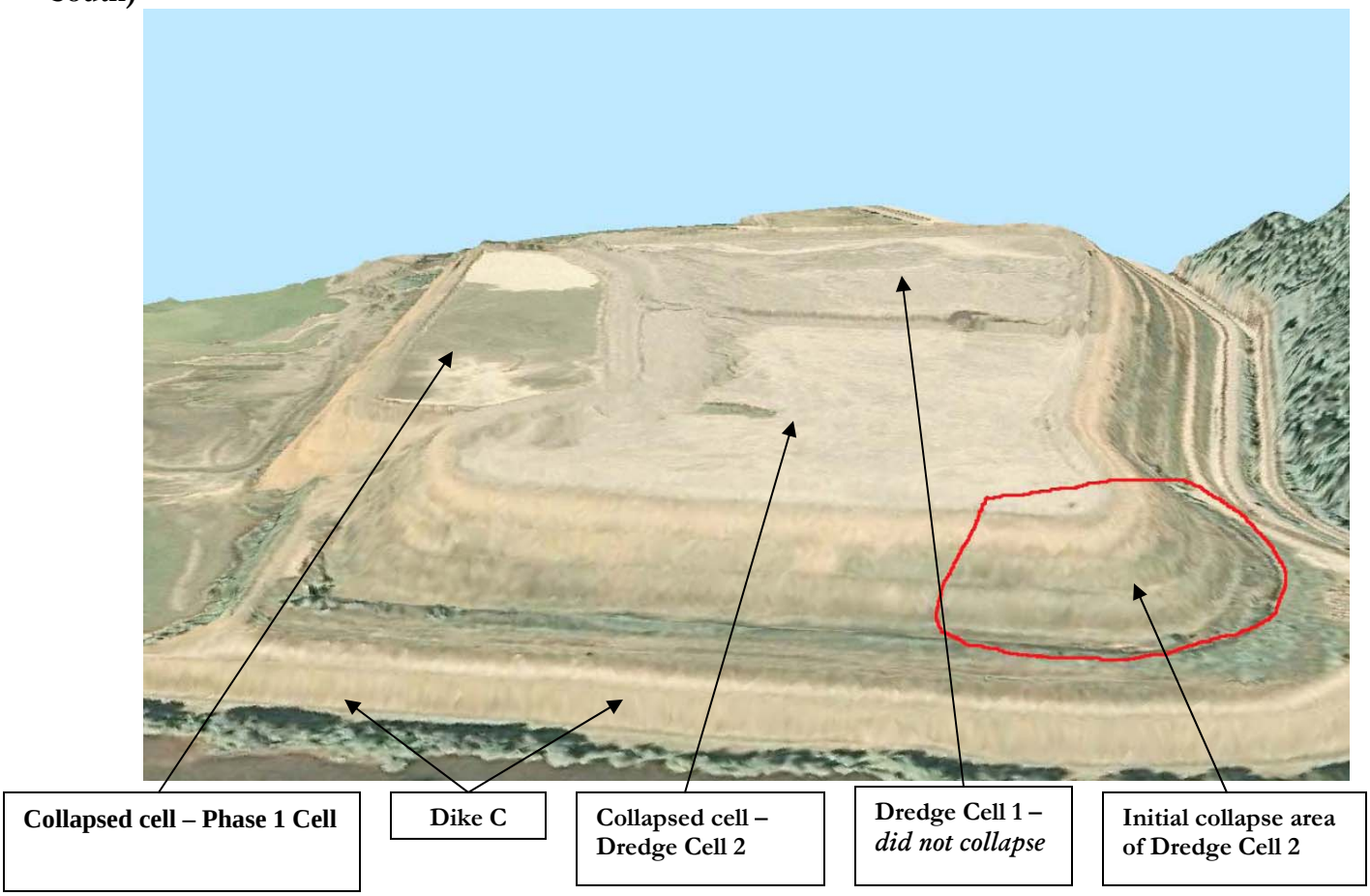
Source: Knoxville News Sentinel

I. <u>December 22, 2008 Ash Spill</u>

At 1 a.m., on Monday, December 22, 2008, a retaining wall failed at a coal ash retention pond at TVA's Kingston Fossil Plant. The breach in the retaining wall resulted in the release of 5.4 million cubic yards of ash and 327 million gallons of water onto land adjacent to the plant, as well as into the nearby Clinch and Emory Rivers. The surface impoundment in question was comprised of Dredge Cell 1, Dredge Cell 2, and the Phase 1 Cell. The northern edge of the impoundment was bounded by a 200 foot wide setback, and then a final dike, Dike C (*see Figure* 2). The dikes were

initially built of naturally silty clays, and then bottom ash and fly ash. On December 22, 2008, Dredge Cell 2 and the Phase 1 Cell collapsed, but, for the most part, Dredge Cell 1 remained intact.

Figure 2: Three-Dimensional View of TVA Kingston Impoundment Pre-Collapse (Facing South)[1]



In terms of actual coverage on the land, over 300 acres have been affected by sludge, at points up to six feet deep. According to the Tennessee Department of Environment and Conservation (TDEC), over 5,000,000 cubic yards of coal ash were deposited into the Emory River and Emory River embayments. The Swan Pond Embayment, an inlet directly north of the impoundment, was largely filled with coal ash. Approximately 110,000 cubic yards were deposited on the ground surface.

EPA noted that the initial release of materials from the plant's retention facility "created a tidal wave of water and ash." While the ash spill rendered three homes uninhabitable and damaged the property of 42 property owners, much of the affected land area impacted by the spill is located on property managed by TVA. Immediately after the spill, a nearby community was evacuated. In addition, power to surrounding communities was disrupted, a major gas line and water main were ruptured, and nearby transportation routes (rail and road) were covered with the ash. No serious

[1] AECOM, *Executive Summary for Root Cause Analysis of Kingston Dredge Cell Failure* (2009) at 9.

injuries were reported as a result of the immediate spill, but one fatality occurred in July 2009 during the clean-up efforts.

II. TVA Root Cause Analysis

In January, 2009, following the collapse, TVA contracted an engineering firm, AECOM, to identify and assess the immediate causes of the impoundment failure. This study is referred to as the RCA. TVA also entered into a contract with a geotechnical consultant, Gonzalo Castro, to peer review the AECOM study while it was being conducted.

Principal Drivers of the Failure: According to AECOM, the initial failure likely occurred in the northwest corner of Dredge Cell 2. The collapse was initially contained within the perimeter of the structure by Dike C. This initial failure was likely followed by a series of rapid and progressive failures that ultimately resulted in the breach of Dike C.

AECOM describes the ash involved in the slide as having undergone static liquefaction. Under these conditions, loose wet ash within Dredge Cell 2 began to flow as if it were a viscous liquid. AECOM and its peer reviewer attribute a loss of strength and stability to have occurred as a function of conditions within the dredge cell that did not allow for proper draining of liquids contained therein (referred to as 'undrained conditions'). This loss of strength and the resultant instability ultimately resulted in the dredge cell failure. This process can also be referred to as a liquefaction failure.

The change from drained (strong, stable) to undrained (weak, unstable) behavior in the dredge cell required a trigger condition, or conditions. According to AECOM, four principal factors worked in conjunction and constituted these trigger conditions. AECOM has stressed that it will not attribute the collapse to any single one of these drivers. AECOM also states that Dredge Cell 2 was "on the verge of deep failure."[2]

1. Increased Loads Due to Higher Fill: Because the Kingston coal ash impoundment could not expand laterally – i.e., its footprint could not get larger – more coal ash required more vertical expansion. For stability reasons, however, each successive layer of coal ash had to have a smaller surface area than the one below it – creating a pyramid, or mound-like structure. Given approximately constant annual ash generation, this resulted in the height of the entire structure growing at increasing rates. AECOM notes, "[t]he added height of ash behind the upstream dike construction added load to the wet ash and to the unusual slimes at the dredge cell foundation level."[3]

2. Fill Geometry and Setbacks: The dikes directly containing the wet ash dredge cells (known as the "upstream dikes") were composed of fly ash and bottom ash, and were also constructed on 35 to 40 feet of wet ash. As such, AECOM found "…the upstream dikes

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[2] AECOM, 2009, *Kingston RCA: Kingston Dredge Cell Failure – Root Cause Failure Analysis, 6/25/09* (http://www.tva.gov/kingston/rca/aecom.pdf (accessed 21 July, 2009)) at 163.
[3] AECOM, *Executive Summary for Root Cause Analysis of Kingston Dredge Cell Failure* (http://www.tva.gov/kingston/rca/FINAL-062609_Executive_Summary-REV3.pdf (accessed 21 July, 2009)) at 5.

did not benefit from the better foundation conditions under the original conditions under the original Dike C, where no slimes were found."[4]

3. Slime Foundation: Prior to the construction of Dike C in 1958, the water-ash slurry was discharged directly into the river. At that time, the water itself extended to the power plant. In other words, the current location of the failed surface impoundment was originally open water. As the ash slurry made its way across the water, the slurry eventually became stagnant and suspended solids (ash components) began to precipitate out. The result "was a thin (less than six inches thick) laminated structure of interbedded flyash, eroded dike soils and re-deposited river sediments within the footprint of the future ash storage cell...This small grained material is referred to as "slimes" as this term applies to the fine-size sediments having a slippery, viscous fill."[5] Slimes are also often found in mine tailing impoundments. Dike C was constructed in 1958, and included a spillway until 1977, over which the liquids from the ash slurry were eventually discharged into the river.

   The slimes identified by AECOM in the Kingston debris field were soft, wet, and had structural characteristics that resulted in their becoming unstable, or creeping. AECOM identified slimes underlying portions of Cell 2, but not in Cell 1 or the Phase 1 Cell. AECOM goes on to note: "Creep failure of the loose slimes was occurring under the loose wet ash, reducing the available strength of the slimes."[6]

4. Loose Wet Ash: The disposal or transport of coal ash in a wet form is alternately referred to as sluiced ash, hydraulically placed ash, or an ash slurry. AECOM found that the wet ash in the failed surface impoundment had not become more dense or consolidated over time. Instead, the wet ash retained a relatively substantial volume of water between ash particles. "As a result, the wet ash remained very loose and susceptible to collapse if subject to rapid loading or rapid displacement."[7]

AECOM has excluded a number of possible other drivers as playing substantive roles in the collapse of Dredge Cell 2. These include rainfall, earthquakes or seismic instability cause by rail traffic, sinkholes or bedrock instability, and instability in the foundation due to groundwater.

Gonzalo Castro, the peer reviewer under contract with TVA to review the AECOM RCA, agreed with the principal AECOM findings.

III. TVA OIG REVIEW OF THE TVA ROOT CAUSE ANALYSIS

The TVA OIG is in the process of evaluating TVA's RCA. The TVA OIG anticipates releasing its report on July 28, 2009. The TVA OIG contracted the engineering firm Marshall Miller & Associates to review the AECOM geotechnical evaluation and findings.

Findings: While the TVA OIG evaluation is supportive of some conclusions in the TVA RCA, it diverges on a number of points. Chief among the TVA OIG findings is that it was not

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[4] *Id.*
[5] *Id.* at 3.
[6] *Id.* at 5.
[7] *Id.*

necessary for all four of the AECOM-identified triggering factors to have been present for the collapse to have occurred. Instead, it was sufficient that less than four of the factors be present for the Kingston collapse to have occurred. The TVA OIG findings include:

1. AECOM's RCA focused disproportionately on the significance of the slime layer as a necessary trigger for the static liquefaction of the ash.

2. More emphasis should have been placed on the role of wet ash in the collapse. The TVA OIG noted that this ash management practice is used at other TVA facilities and could be an instability factor at those sites.

3. The dredge cell and dike construction geometry played a principal role in the collapse. Marshall Miller & Associates have identified these same approaches being used at other TVA surface impoundments and therefore this factor is a cause for concern elsewhere.

IV. LAW FIRM REPORT TO TVA BOARD ON KINGSTON SPILL

Following the Kingston spill, the TVA Board of Directors (Board) retained the law firm McKenna Long & Aldridge LLP (MLA) to advise the Board on its legal duties and potential litigation exposure, as well as to provide other advice related to Board oversight. On July 21, 2009, MLA released a report,[8] based on MLA's factual investigation, on the circumstances surrounding the spill, and that provided recommendations to improve TVA's governance, systems, and controls to reduce the likelihood of similar or other harmful incidents.

On July 21st, 2009, following the release of this report, TVA President and Chief Executive Officer Tom Kilgore states that:

> "We will use it to make improvements in our practices and procedures, and in our organization and its culture. Our goal is always to make sure that TVA's facilities are as safe and efficient as we can make them – for our employees, for our neighbors in the communities where we operate, and for the customers we serve.
>
> We have fallen short of that goal. In retrospect, regardless of the details of the exact failure mechanism, the design and construction of this ash pond was not adequate for the stresses to which it was subjected. We want our neighbors to be proud that TVA is part of their community. We know we have a big job ahead of us in achieving that goal, but we're determined to succeed. It won't be easy, and it won't be quick. But we are committed to get the job done."[9]

MLA's report centers on two fundamental points. First, the AECOM RCA and the scope of work for the TVA RCA, missed what MLA believes is "the fundamental question, which is: did system and culture failures allow such conditions to occur and remain undetected or

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[8] Ide, R. William, III, and Joseph O. Blanco, *A Report to the Board of Directors of the Tennessee Valley Authority Regarding Kingston Factual Findings* (July 21, 2009) (http://www.tva.com/kingston/board_report/mla_kingston_report.pdf (accessed 21 July, 2009)).
[9] Kilgore, Tom, *Remarks by Tom Kilgore at TVA Board Meeting* (2009) (email communication from TVA staff).

unaddressed [?]"[10] The "conditions" MLA refers to are some of the central findings of the AECOM report: height, the wetness of the ash, and the structural geometry of impoundment. Second, MLA found that "the necessary systems, controls, standards and culture were not in place."[11]

Specific MLA findings include:

- **Lack of Clarity and Accountability for Ultimate Responsibility:** The number of TVA groups involved with coal combustion waste led to a lack of accountability. In addition, MLA notes that engineering staff lacked tools or authority to enforce their decisions and recommendations: "The engineers conducted annual inspections, but did not follow-up on the recommendations until the next annual inspection, often repeating the same recommendations year after year."[12]

- **Lack of Standardization, Training and Metrics:** TVA did not have any standard procedures regarding operations and maintenance of wet ash ponds (surface impoundments) at any of the five TVA power plants that produce wet ash. Operations were developed per location by local personnel.[13]

- **Siloed Responsibilities and Poor Communication:** Four separate TVA divisions have responsibilities concerning TVA's coal combustion waste facilities. MLA notes that "communication between the groups was strained and in some instances, non-existent."[14]

- **Lack of Checks and Balances:** The lack of quality assurance and quality control measures for ash storage and disposal facilities "created an environment where employees felt empowered to ignore engineers and 'build it better' than the [engineering] drawings."[15]

- **Lack of Prevention Priority and Resources:** The internal TVA budget process was not adequate to allow for routine maintenance. This created "a situation in which adequate inspections were impossible because the sides of the dikes were overgrown and maintenance needs compounded over time."[16] MLA provided a post-Kingston spill case highlighting this point: "During the remediation efforts following the Kingston Spill, seventeen dump trucks of material were removed from dikes at the Paradise Fossil Plant, which does not include the relatively large trees growing on the dikes, the removal of which had been recommended sporadically in the annual inspection reports since at least 1995."[17]

- **Reactive Instead of Proactive:** TVA management practices included reacting to only the immediate problems and not addressing any systemic management issues that may have driven the problems. The Kingston dredge cell [that ultimately collapsed] developed seeping issues in 2003, and again in 2006. TVA's response was limited to patching the specific leaks. MLA provides a similar example occurring at the TVA Widows Creek facility:

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[10] *Id.* at 2.
[11] *Id.*
[12] *Id.* at 2-3.
[13] *Id.* at 3.
[14] *Id.*
[15] *Id.*
[16] *Id.* at 4.
[17] *Id.*

> "…in 2000, Widows Creek experienced an incident very similar to its highly publicized gypsum spill that occurred in January 2009, less than three weeks after the Kingston Spill. The plant's staff determined that the 2000 incident was caused by the failure of an abandoned weir. The fix was to remove the failed weir without addressing the other abandoned weirs at Widows Creek (such as the abandoned weir that gave way in 2009), or any other TVA facility."[18]

PRIOR LEGISLATIVE AND OVERSIGHT ACTIVITY

Since the Kingston spill occurred in December 2008, the Subcommittee has engaged in a number of oversight activities. These include written information requests and briefings from TVA, EPA, the State of Tennessee, and other parties. The Subcommittee held a hearing on the spill on March 31, 2009 titled "The Tennessee Valley Authority's Kingston Ash Slide and Potential Water Quality Impacts of Coal Combustion Waste Storage", and another hearing on the impacts of coal combustion waste storage on water quality on April 30, 2009 titled "Coal Combustion Waste Storage and Water Quality".

[18] *Id.*

WITNESSES

Panel I

The Honorable Mathy Stanislaus
Assistant Administrator
Office of Solid Waste and Emergency Response
United States Environmental Protection Agency

Accompanied by Mr. Stan Meiburg – Acting Regional Administrator, EPA Region 4

Mr. Tom Kilgore
President and Chief Executive Officer
Tennessee Valley Authority

Mr. William H. Walton, P.E., S.E.
Vice President and Senior Principal Engineer
AECOM

The Honorable Richard Moore
Inspector General
Office of Inspector General
Tennessee Valley Authority

Mr. William S. Almes, P.E.
Senior Engineer and Director of Geotechnical Services
Marshall Miller & Associates, Inc.