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Center Hill Briefing

2008

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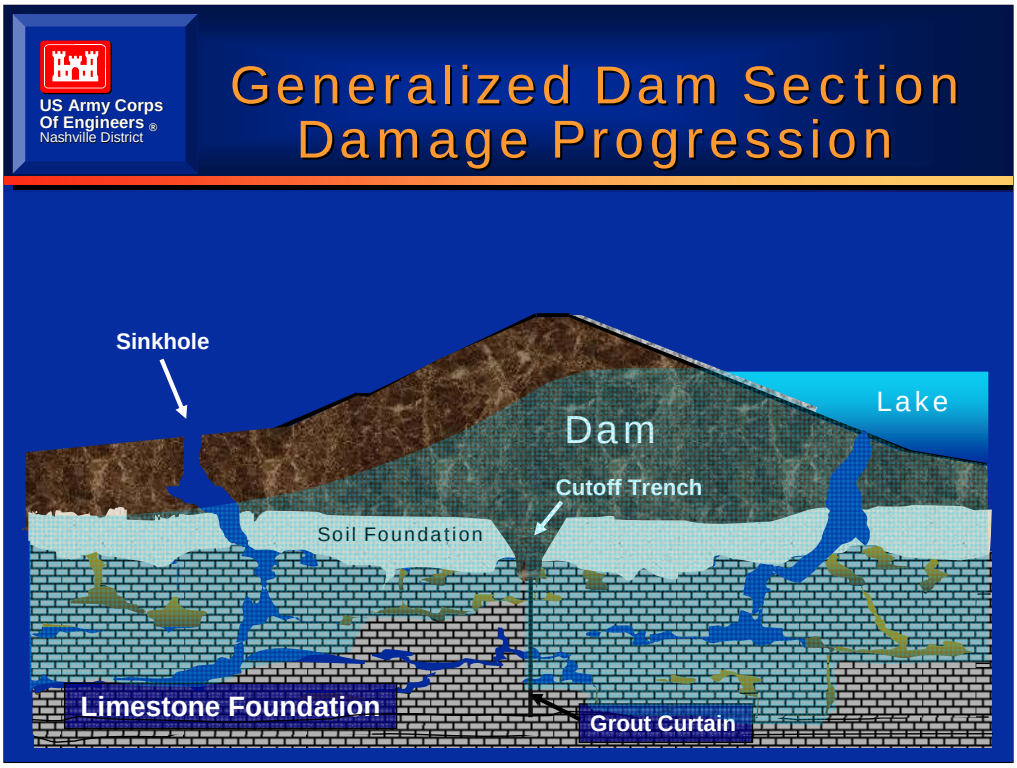
Center Hill Briefing Outline

- The Underlying Problem
- Project Specific Information
  - Project Features/Problems
  - Proposed Fix
  - Interim Risk Reduction Measures

In this presentation, we will describe the underlying problem at Center Hill Dam, looking at various project features. We will discuss the proposed fix, and also lay out the risk reduction measures we have in place until that fix is completed.

The limestone rock in our area is referred to as “karst” geology. It typically has cracks and joints like you can see at road cuts and in this picture. Water flows through, and over time, can erode the clay and other materials in these cracks and joints. Center Hill Dam is built on this type of geology. Our current seepage problems are due to this karst rock AND the limited understanding of foundation design in this type geology in the 1940’s. The original designers of the dam did, however, recognize the foundation would require continual maintenance to remain safe. Typically, a process called *grouting* is used to close up these openings. Grout, or a mixture of cement and water, is pumped under pressure into the rock through deeply-drilled holes, filling up the open features.



This slide illustrates a typical cross-section of the earthen portion of the dam and the foundation. It further illustrates the danger of an inadequate foundation in karst geology. The brown area represents the large compacted clay embankment at Center Hill. It is well constructed in 4 to 6-inch lifts and sits on soils that were left in place. Beneath the soil is the karst limestone with open and clay-filled, sand or silt-filled cracks and joints called *features*. Lake water normally moves slowly through and under the earthen part of the dam. As water moves normally through the foundation, it begins to remove the materials from these features, allowing more water to move through faster and further erode the materials. This action progresses as water moves through these interconnected open features. When one of these features opens to the surface, overlying material falls into the cavities and is washed downstream, causing a sinkhole at the surface. When the openings lead back to the lake, this is a very serious situation because there can be a direct connection from the reservoir to the downstream side, with water flowing under the dam unchecked.

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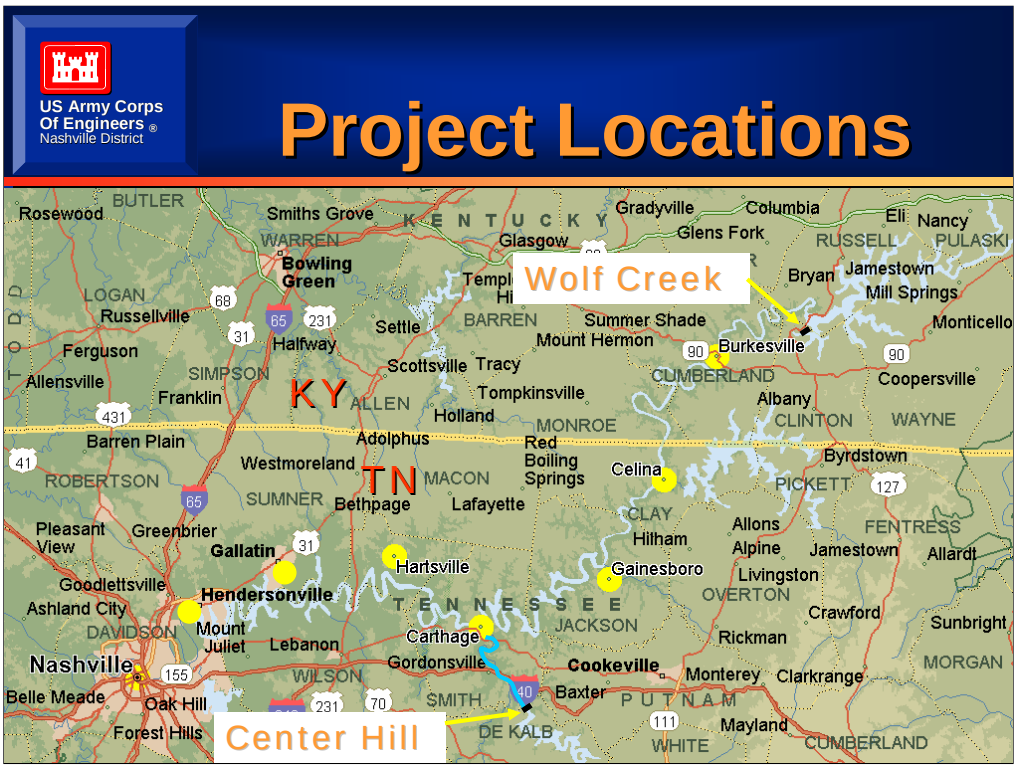
Project Information



Center Hill is 27 miles upstream from the Cumberland River on a tributary called the Caney Fork. The Caney Fork runs into the Cumberland River at Carthage. Wolf Creek is 160 river miles above Carthage. Nashville is about 100 river miles downstream from Carthage.

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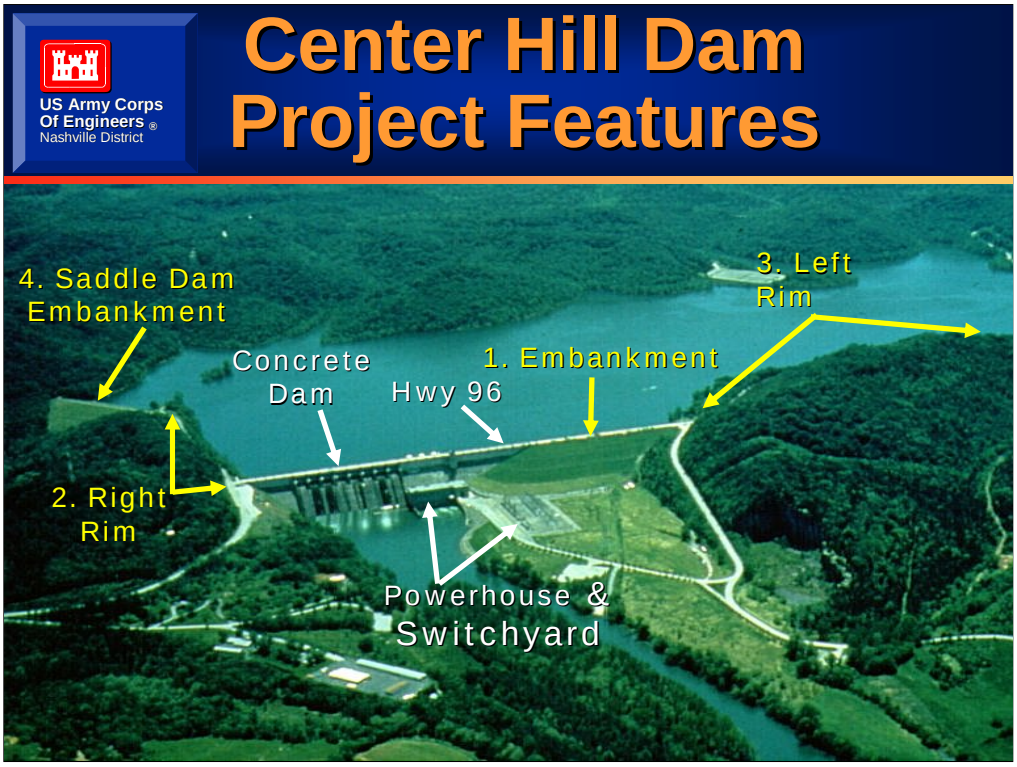
Project Benefits

- Flood Control
  - Average annual flood damages prevented = $20m
- Hydropower
  - $40 million / year
- Recreation
  - 3.9 million visitors per year
  - $36 million in annual benefits
- Water Supply
  - Cookeville, Smithville and Riverwatch Resort
- Water Quality
- Navigation

The dam and Center Hill Lake provide significant benefits to our region. Flood damage reduction benefits average $20,000,000 a year. Hydro (peaking power) capability is enough to meet the demand of 30,000 homes. The dam also provides significant recreation benefits to the region. Water quality and navigation benefits from waters held at Center Hill are realized as far as the Ohio and Mississippi Rivers during drought.



This aerial photograph shows the various components of Center Hill Dam. The main dam is a combination dam, with 1,382' long **concrete dam** and a 778' long **earthen** (Homogeneous Rolled Clay) **embankment**. Facing downstream, two sections of natural topography, the **right rim** and **left rim**, sit on either side of the main dam. A **saddle dam** (770' wide and 125' high) sits in the right rim to fill a low area in the topography. The **powerhouse** contains 3 hydropower units at 45,000 kw each; the **switchyard** sits adjacent to the Powerhouse.
The four sections shown in yellow are the areas at Center Hill where seepage problems are occurring.

Some Facts about Center Hill Dam:

•Concrete dam is 1382' long; earthen dam is 778' long

•Main dam is 226' Max. Height Above Streambed

•A 770'- wide x 125'- high Saddle Dam is in the Right Rim

•Maximum Storage 2 Million ac-ft (625 Elevation = 943,000 acre-feet)

•The top of the Spillway Gates is elevation 685'.

•The Pool of Record was 10 May 1984 at elevation 681.3'.

•Spillway section in the concrete is 470' wide and has (8) 37X50 foot tainter gates to pass flood flows.

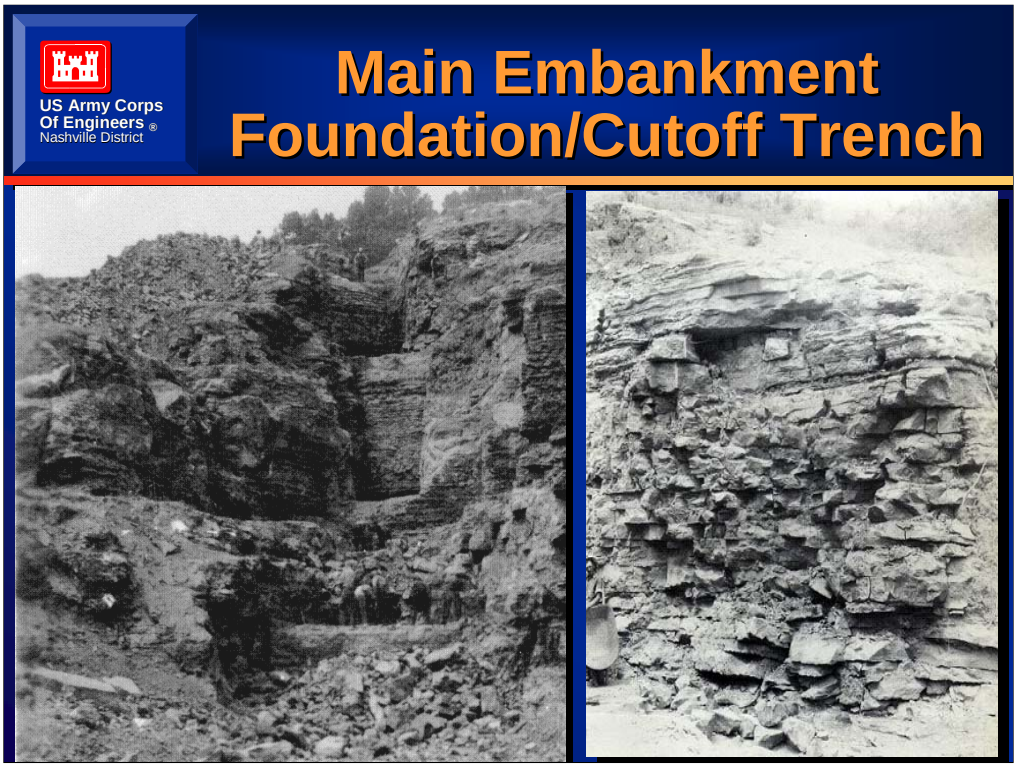
•Low level outlet (6) 4X6 sluices

•Powerhouse contains 3 hydropower units @ 45,000 kw each.

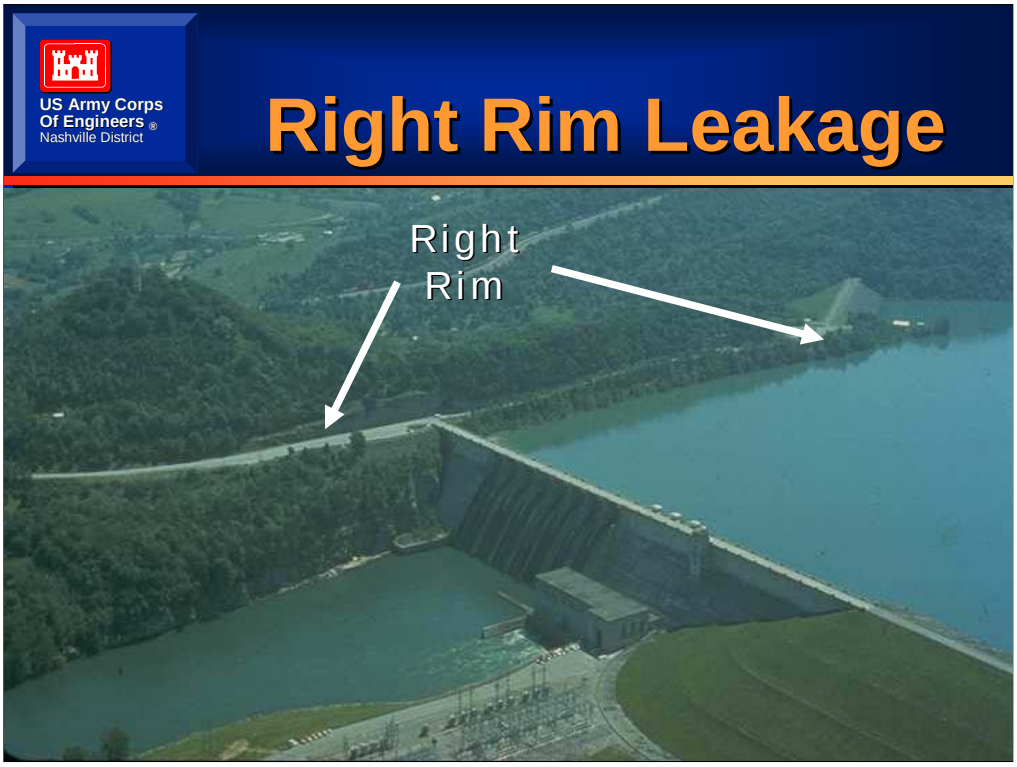
•Highway 96 runs over the dam

•Construction of Center Hill converted the lower Caney Fork River to a cold water fishery.

We'll first look at seepage problems in the earthen embankment.



These photographs show the cut-off trench in the main embankment at the time of the dam's construction. This cut-off trench is narrow, steeply-sloped and of insufficient design to adequately serve as a cut-off over time. Note the highly weathered, fractured rock in the foundation.



Next, we will look at seepage issues in the right rim.

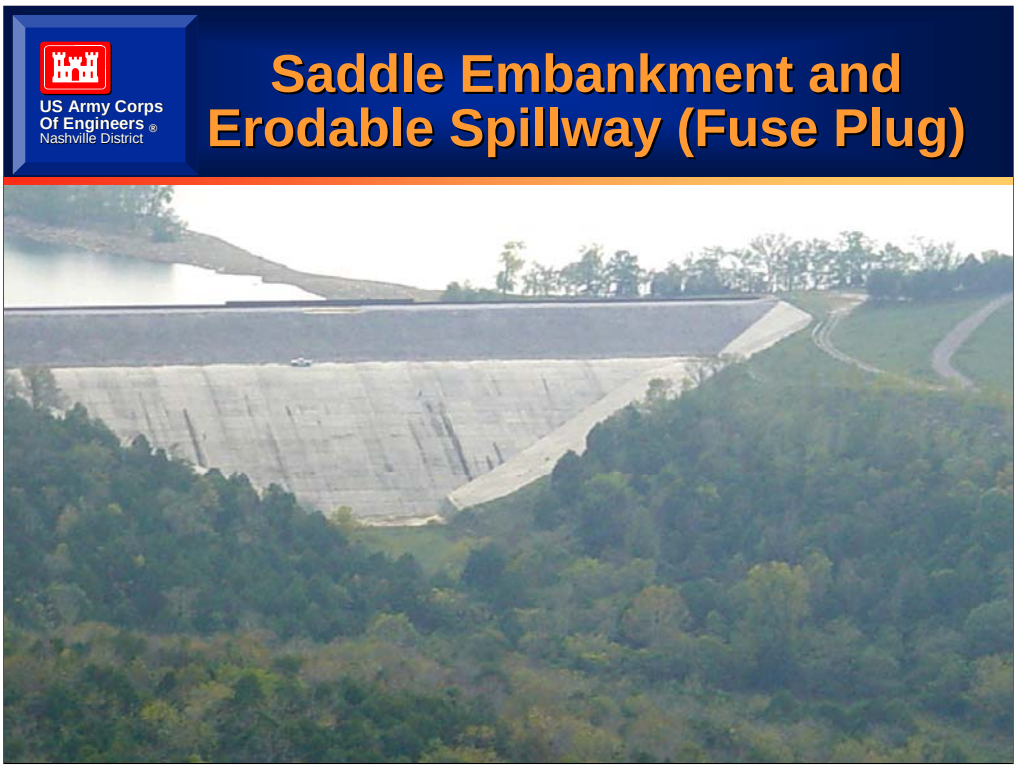
You have seen the leaks in this bluff through the limestone layers for many years. The upper leak began within 2 years of impoundment in the mid 1950's. Water from the lake also created openings over 17 years that became connected to several existing caves creating the lower leak, beginning in the late seventies. We have monitored these leaks and have grouted from the roadway in attempt to close them. Were successful in the 60's and 80's with the upper leak, not the lower. We now have information to help close the lower leak.

These photographs are often used to illustrate the seepage problems at Center Hill; however, these particular features are not critical to the dam's safety. These features represent a water loss problem; water is passing through these openings instead of through our hydropower turbines. We plan to address these features to control them while they are manageable.

The long left rim was of concern to the original designers. In 1948, a 3,500-long grout curtain was placed in the left rim to slow seepage at a spring down near the quarry referred to as Picnic Spring. It was successful in keeping the seepage low for many years, but the spring has slowly increased since. We monitor the flow by measuring it. Through years of investigation we have traced open solution features in the left rim. There are also about 15 sinkholes in the left rim that we monitor.

Following several years of high lake elevation, we first noted and began to monitor the sinkholes downstream of the left rim. This is the largest, which was about 25-feet in diameter when found in 1992. We dug into the sinkhole in 1999 to map it and better understand how to close the opening from the lake to the sinkhole. The rock joints were filled with clay and we couldn't get very far. We flagged the area and continued to monitor it. In the spring of 2003, with a high lake elevation (of over 672), the bottom clay began to sink and clay material was washed out of the picnic spring.

When the lake is at normal level (photo on left), minimal clear flow can be seen exiting from the picnic springs. However, with elevated lake levels (right photo), muddy flow indicated that water moving through the left rim was further eroding the clay materials in the solution features. This is a sign of advanced seepage and illustrates why lake lowering is an important risk reduction action until the left rim is sealed during our rehabilitation effort.



A 770 ft by 125 ft. – high Saddle Dam with Fuse Plug section is about 1,500 feet upstream from the main dam. In the 1980's, the Nashville Corps office determined the Center Hill project needed additional spillway capacity to adequately pass the updated design flow. A study was completed on various alternatives. The study concluded a fuse plug section on the saddle dam would be the most cost efficient and effective means of adding spillway capacity to the project. In the 1990's, the top 40' of the saddle dam was excavated and replaced with the self-eroding section you see here above the elevation of the white truck. In the event of this extreme flood event, water would overtop the fuse plug at the center weir, eroding the structure down to the concrete- lined saddle dam (elevation of the white truck); thereby keeping the main dam embankment from overtopping.

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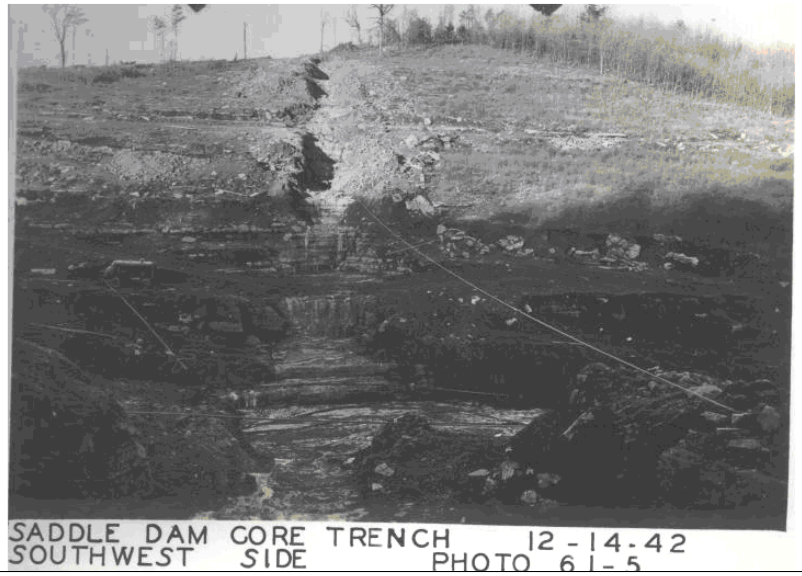
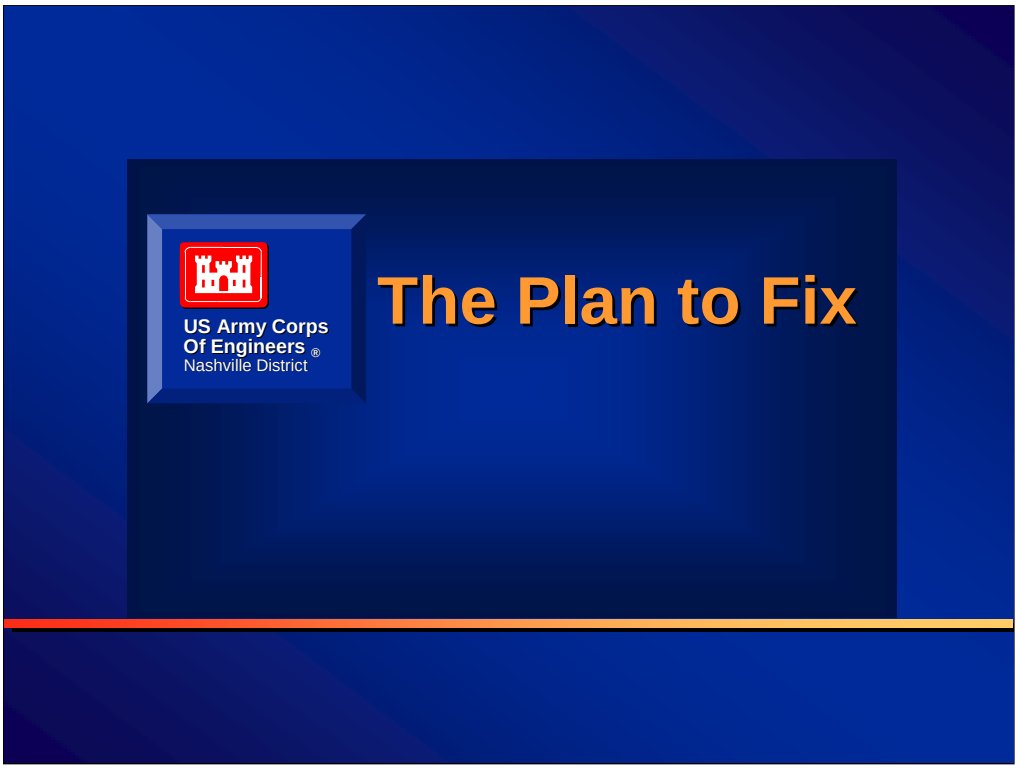
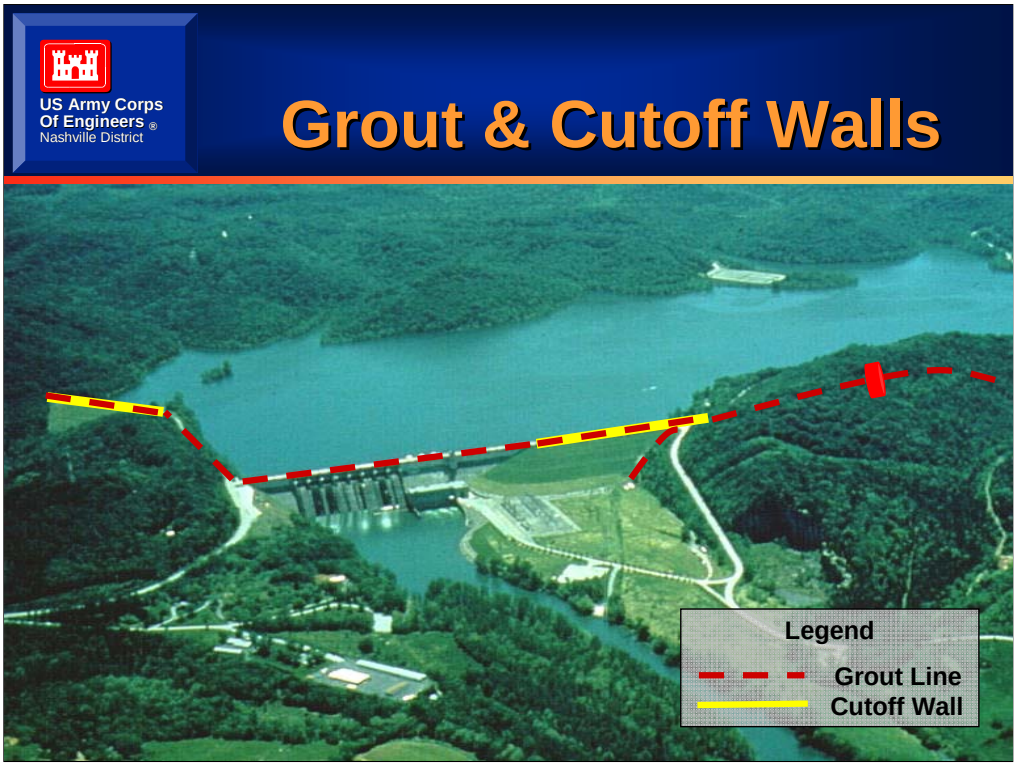
Saddle Dam Cutoff Trench



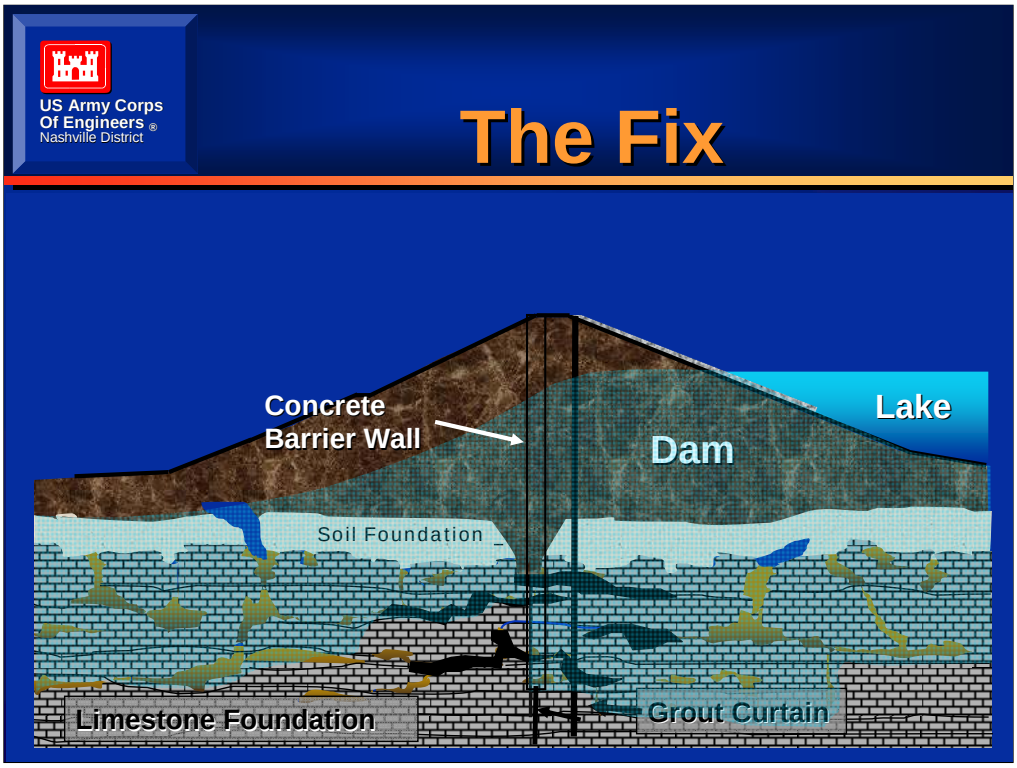
This is a photograph showing the cut-off trench in the saddle dam embankment. The foundation of this saddle dam was prepared much like the main dam. During removal of the weathered zones, numerous shallow open joints were exposed and eliminated so far as was practical. A bottom width of 10 feet was provided in the core trench by drilling and blasting. Due to the steepness of the hillside along the axis, power shovels could reach the trench at only a few places. During grouting operations, one hole intersected an open joint crossing the axis of the dam. A total of 6,198 linear feet of holes were drilled which consumed 3,494.7 cubic feet of grout (18 bags/hole). Of the 193 holes drilled and grouted only 148 were ever grouted to refusal at the required pressure.



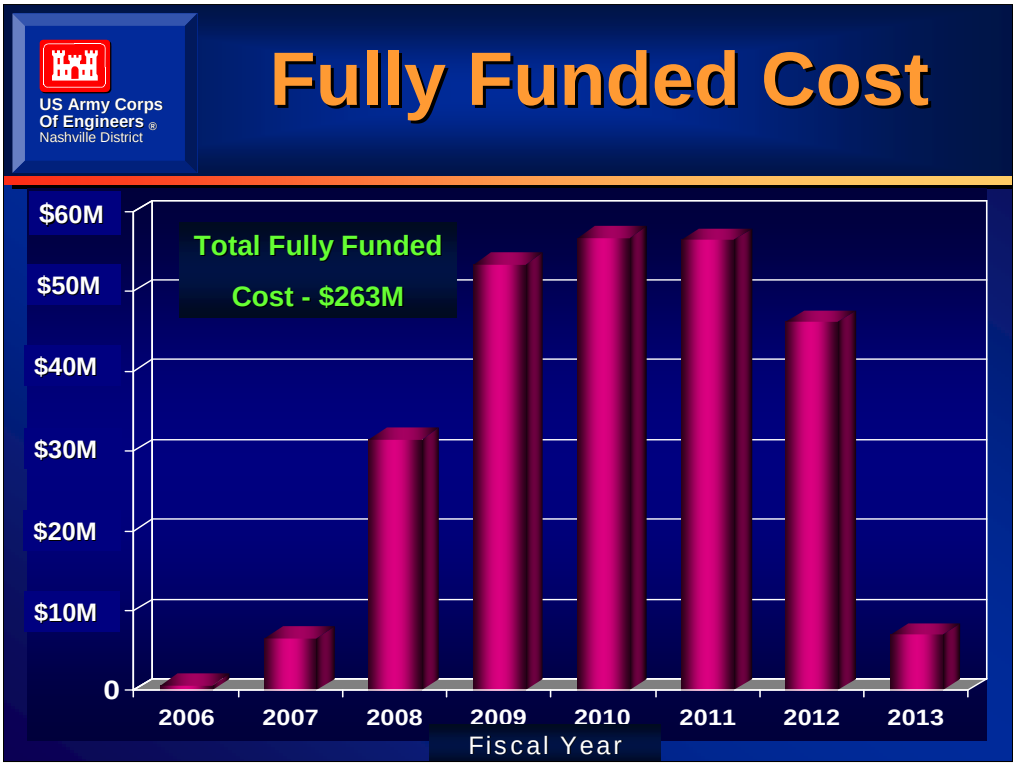
We will now illustrate our proposed plan to fix seepage problems at Center Hill Dam.



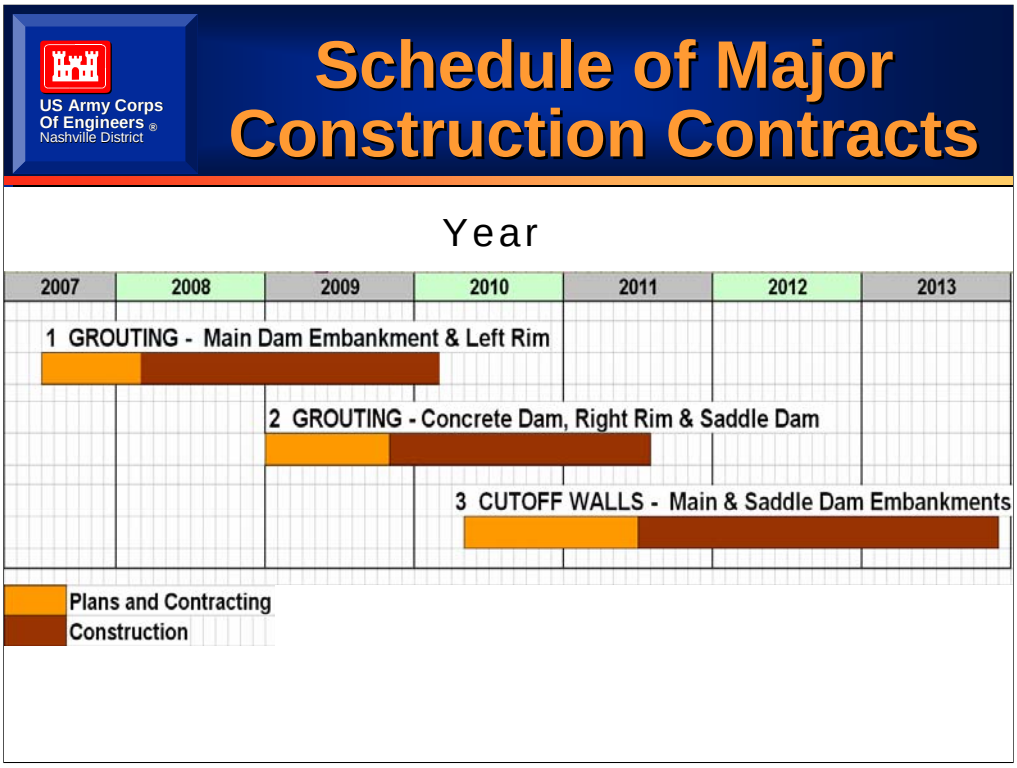
The long-term remediation plan is to construct both grout curtains and concrete cut-off walls into the foundation and rims of the dams. The large red square indicates an area where we will "plug" a cave-like feature in the left rim.



This slide illustrates the grouting and cut-off wall construction concept. Grouting is initially completed first to 1) gain information about the solution features and rock hardness and 2) to seal any openings so the cut-off wall construction is safe. A hole is drilled through the embankment into the foundation, represented by the vertical black line. The rock-core removed from this hole is used for analysis, and grout is pumped into the hole to fill any openings it intercepts, as illustrated by the black areas in the foundation. The concrete barrier wall will be constructed in sections approximately 2 to 4 feet thick, eventually creating a continuous barrier the length of the embankment. Beneath the cut-off wall will be an additional grout curtain to ensure a barrier extends through the karst geology, down into solid rock.



This chart illustrates the fully funded cost of the project over time. *Fully funded* indicates inflation costs are included. To date, the project has received all requested funds from Congress. This project is very high priority, and we expect to receive the needed funds every year until the fix is completed (estimated completion date: 2013).



This is the anticipated construction schedule.

Until the fix at Center Hill Dam is complete, we are taking actions to lower the risk and ensure public safety.

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Risk Reduction

- Inform Public
- Emergency Action Planning (dynamic)
  - Coordination with emergency management folks
  - Updated inundation mapping to State and local EMs
  - Revised notification procedures through NOAA
  - Emergency exercises
- Dam Safety Training of Project Staff
- Independent Review

We are working to keep the public informed through public meetings, brochures, website, and news releases. We believe that we are fixing Center Hill Dam well in advance of a catastrophic failure; however, we are taking strong steps to be prepared for any scenario. We are coordinating closely with state and local emergency management for emergency action planning. This process is multi-faceted, and is dynamic and always improving. Project Staff at Center Hill Dam have received thorough Dam Safety Training, and our plans for Center Hill have been independently reviewed and approved.

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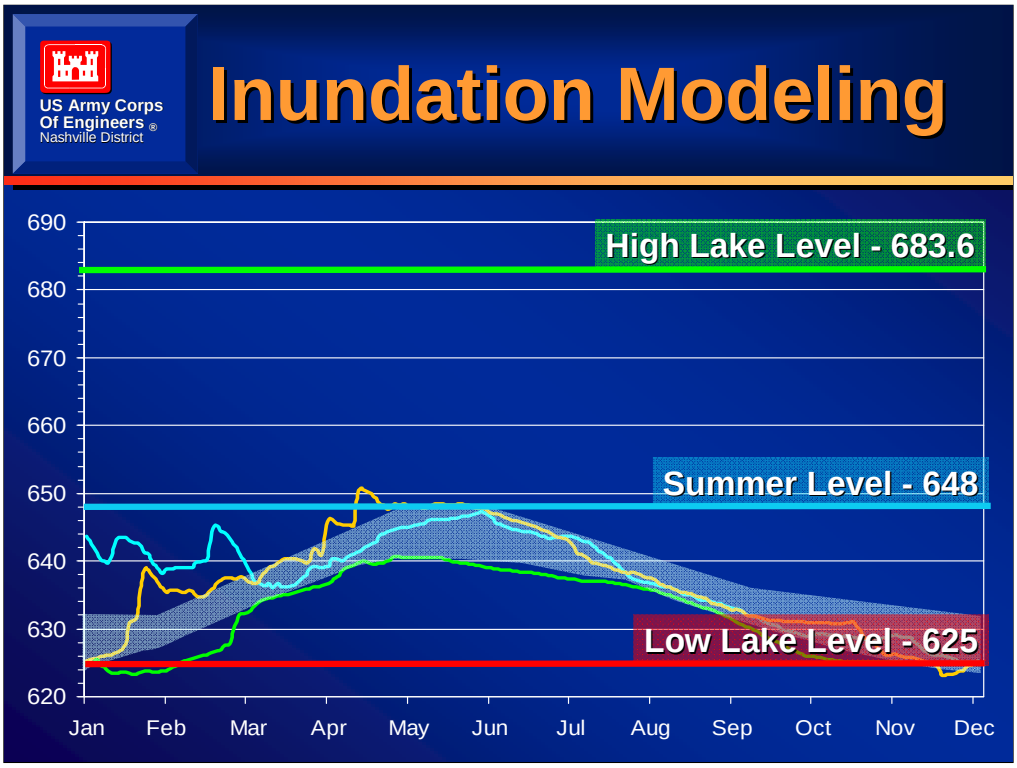
Risk Reduction

- Increased Monitoring
  - 24/7 monitoring
  - Additional instruments
  - Detailed monthly inspection
  - Weekly / Daily instrumentation evaluation
- Grouting
  - Prioritize Critical Areas (Main Embankment and Left Rim)
- Lake Level Restrictions (dynamic)
  - Mar ’05, Dec ’06, Early 2008 (Environmental Impact Statement)

We have increased monitoring at Center Hill Dam. On-the-ground inspections are now conducted twenty-four hours a day, seven days a week. Additional instruments and readings of those instruments, along with detailed monthly inspections, help us to be aware of any changes in the foundation around the clock. Preparations are being made for grouting in the critical areas. We have also implemented restrictions on the lake level in an attempt to lower pressure on the foundation.

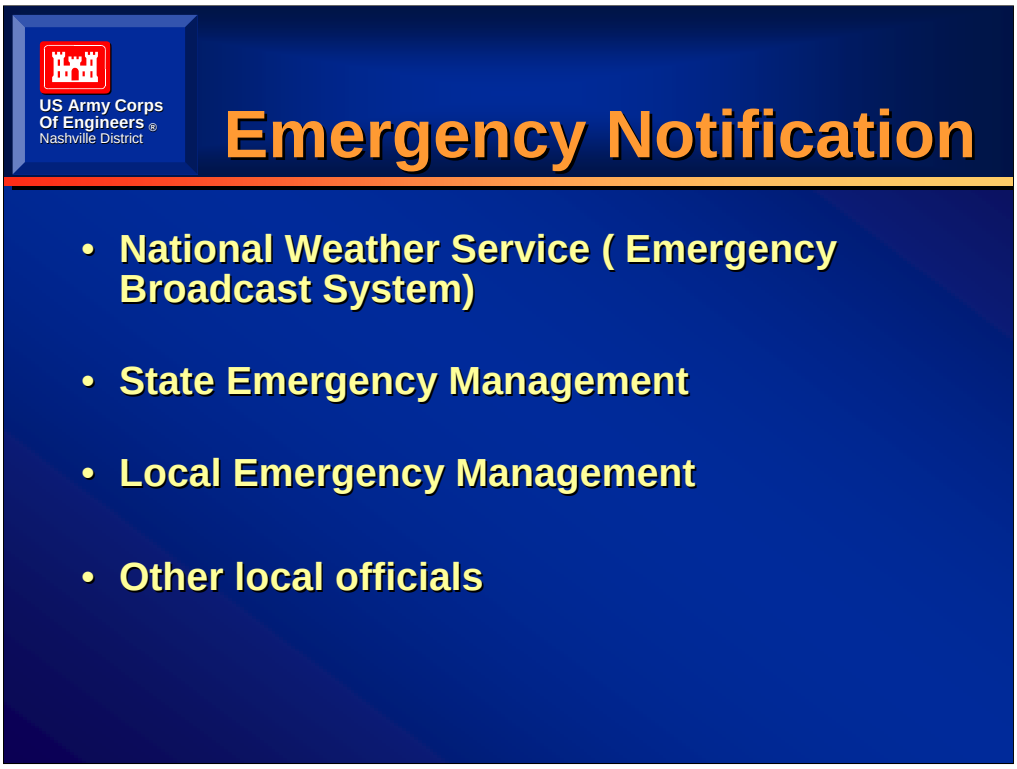
This graph indicates actual lake levels over the past several years. We are currently attempting to keep the lake at the low end of this shaded operating band.

We have completed a Final Environmental Impact Statement (FEIS) to address the potential impacts of further lake level reduction. A final decision on lake level operation may be made through this process in early 2008.

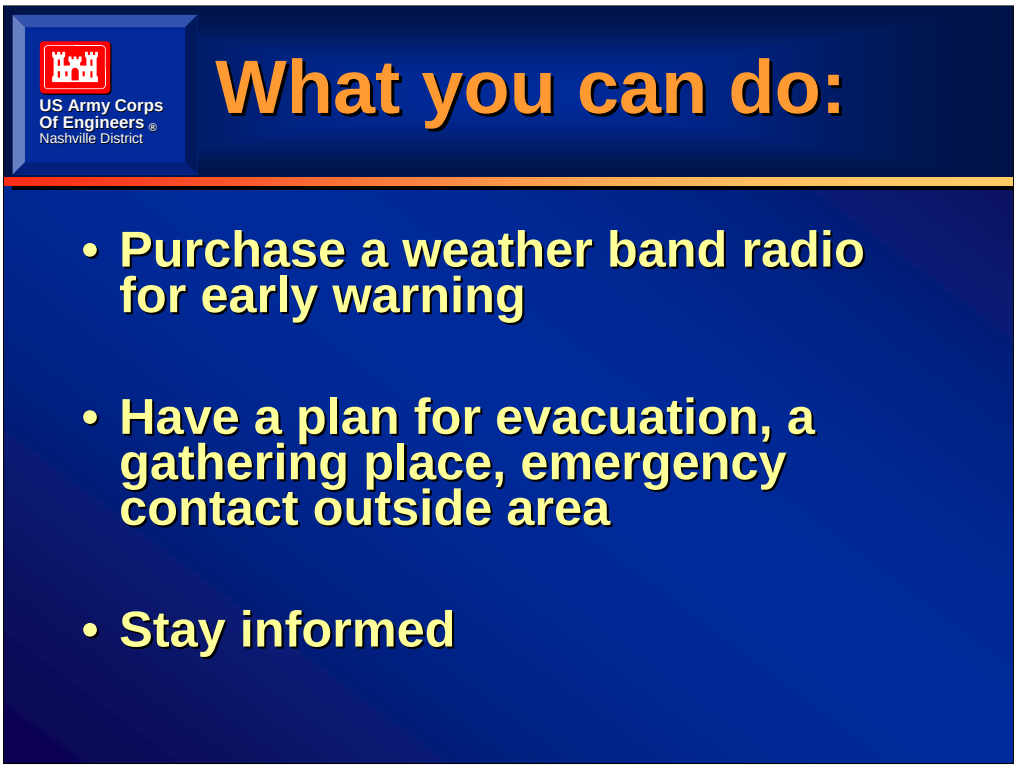


To better understand what a dam failure might mean for downstream areas, we utilized a computer model and simulated a dam failure. Inundation maps were developed from this simulation that illustrate what areas would likely be flooded in the event of a dam failure. For this mapping, we assumed an aggressive embankment failure, or worst-case scenario.

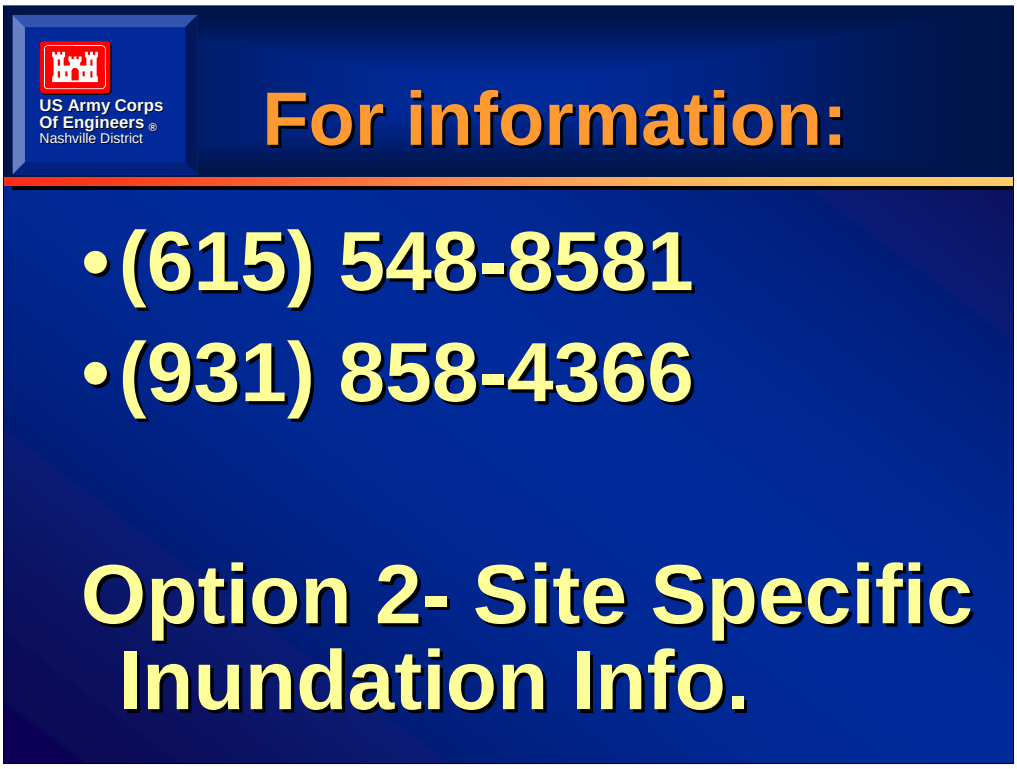
In the simulation, we modeled a dam failure at three different lake elevations, shown on this chart. The green, blue, and red lake levels correspond to green, blue, and red inundation (flooded) areas on our inundation maps. The maps also show how soon water would arrive at various points down the river, how quickly it would rise and recede, and how high it would likely rise. These maps are available for viewing at Corps Resource Management offices and County Emergency Management offices.



In the unlikely event of a dam failure, we will first notify the National Weather Service's Emergency Broadcast System. This system would immediately put the message out to weather radios, radio and TV stations, and emergency management offices. We would next contact state and local Emergency Managers, starting with those closest to dam and working downstream. Local Emergency Managers and officials are responsible for activating and implementing local notification and evacuation plans.



We all have a personal responsibility to ensure we are prepared for any type of emergency. You can begin that preparation by purchasing a weather-band radio to quickly receive emergency notifications through the National Weather Service. You can also have a plan for evacuation that includes a gathering place for you and your family, as well as an emergency contact outside the affected area. Finally, stay informed by attending public meetings, utilizing Corps and emergency management websites, and asking questions.



Information concerning potential flooded areas may be obtained by calling one of the two numbers listed above. After calling the automated system, choose option 2 for site specific inundation information and you will be prompted to leave your name, physical address, phone number, and e-mail address (if you have one) and someone will call or e-mail you with the site specific inundation information within two business days.

Please visit our Web site for more information and to submit questions.