Don Eskridge Interview

September 26, 2006

Abbreviations:
CH = Clarue Holland (Lake Tishomingo Dam Leak Cmte)
RH = Rich Hirsch (Lake Tishomingo Dam Leak Cmte)
DE = Don Eskridge (Reitz & Jens Engineering)
DT = Dave Taylor (Stratus Engineering, not present)

CH and RH of the Lake Tishomingo Dam Leak Committee met with DE of Reitz & Jens at their headquarters in Creve Coeur, MO at 10:30 AM. CH set up the interview because of DE's knowledge of our dam. DE had worked on the dam twice in the 1980s – first to repair the slide on the back of the dam (ca. 1982) and then later to install the seepage collector and raise the height of the dam (ca. 1988).

RH: I want to start by briefly explaining the focus of the Lake Tish Dam Committee:

- to document the history of the dam
- to monitor the leak at the back of the dam
- to install a weir box to measure the flow rate of the leak.

RH: The purpose of this interview is really twofold:

- to determine what had been done in the past to stop or reduce the leak
- to ask DE what he thought about the strategy to slow the leak as outlined by Dam expert Dave Taylor (DT) of Stratus Engineering.

DE: In 1982 the MO DNR made the Lake repair a slide that occurred on the back of the dam (see Figure 1). But before the slide was repaired, the lake was lowered to reduce pressure on the dam. (There was water running out of the slide area.) The lake was lowered 4.5 to 5 feet by cutting a notch out of the spillway. This notch had to be quite long (100 ft or so) to lower the lake to the desired level, as the spillway has a relatively gentle slope. The notch was later repaired by filling in the notch with a mixture of clay and rock. DE did not know if the "plug" of clay and rock had ever been permanently repaired.

DE: The slide was believed to have occurred because of excessive moisture and because the back of the dam was too steep. Although the dam was built as designed (a 3:1 slope in the front and a 2:1 slope in the back), the back slope was judged to be too steep. So as part of the repair of the slide, the dam was flattened in the area of the slide **and** for the entire length of the dam. This occurred in 1986 - 1987. Also at this time, the top of the dam was raised by building a concrete wall the length of the dam. Only the drawings of this work remain, the correspondence files have been discarded.

Figure 1. Slide on back of dam

DE: During the first repair (ca. 1982) a drain was installed in the slide area on the south side of the dam that emptied into a gulley some distance away from the toe of the dam. This drain is shown in Figure 2 labeled as "Existing Drain". Two sections of perforated pipe were installed in a sand trench at the toe of the dam. Nonperforated pipe (330 feet of 4 or 6 inch diameter PVC pipe) was "teed" in to empty several hundred feet away from the toe of the dam into a gulley. (This pipe is **not** connected to the seepage collector that was installed in 1988.)

As DE remembers it, when he was on site in the 1980s, the drain pipe was flowing about an inch full constantly. Over the years the outlet of this pipe may have become plugged, in which case the pipe may have frozen and broken. If the drain pipe is buried, DE said that water exiting this pipe would appear to come out of the ground like it was squeezed out of a sponge.

CH pointed out that there was an area near the back of the property behind the dam that we visited in July 2006 that did appear to have water coming out of the ground and that this water could be due to a plugged drain pipe. (RH**: We need to try to find this drain pipe and check its condition**. **DE warned against trying to find this drain pipe with a backhoe as that could seriously damage the pipe.**)

DE: "Phase two" of the work carried out in 1988 was just a continuation of the work begun in 1982, which was to increase the stability of the dam. Part of the work was to install the seepage collector. (See Figures 2 thru 5.) The seepage collector

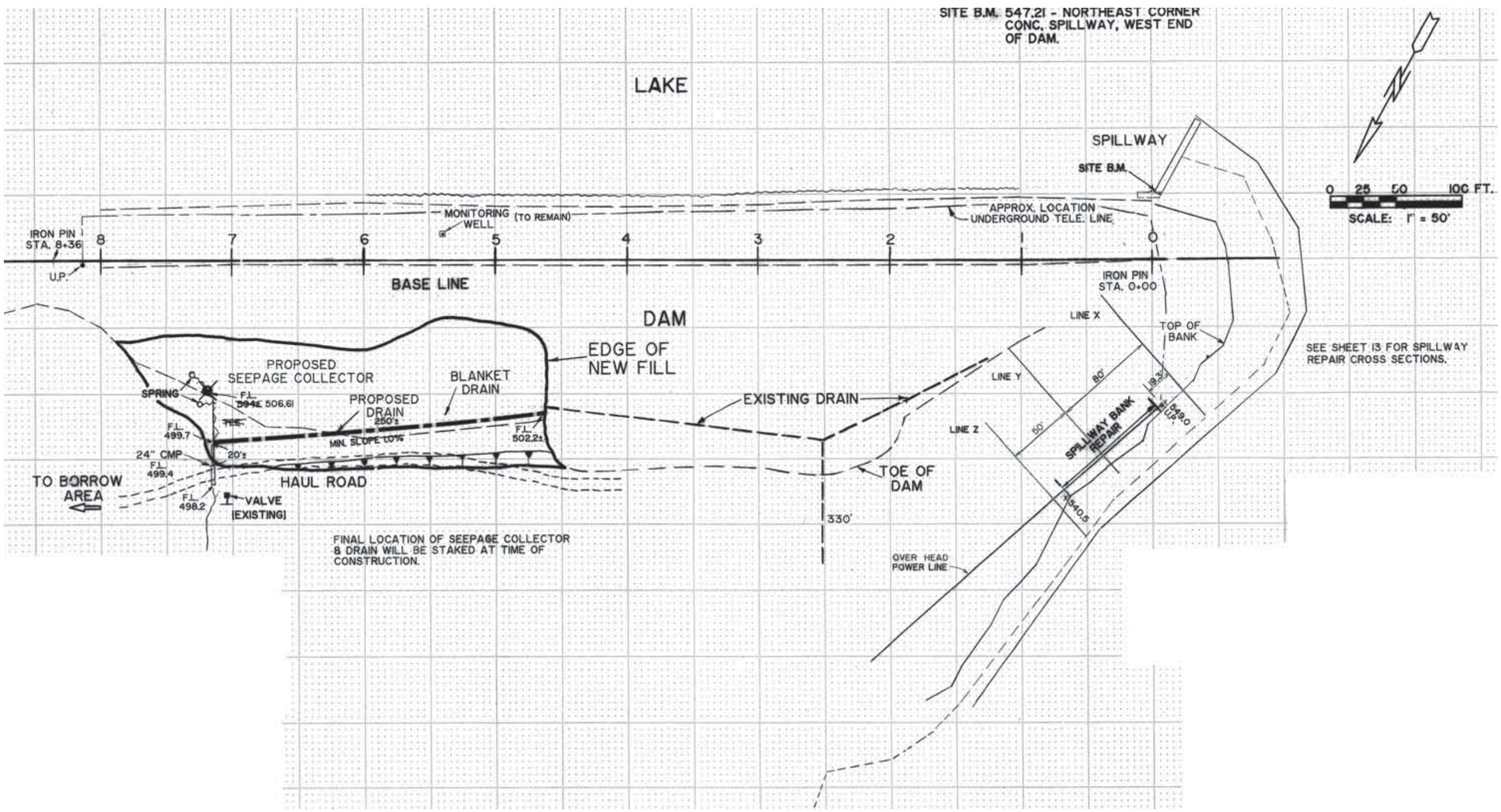

Figure 2. Various Features on Back of Dam

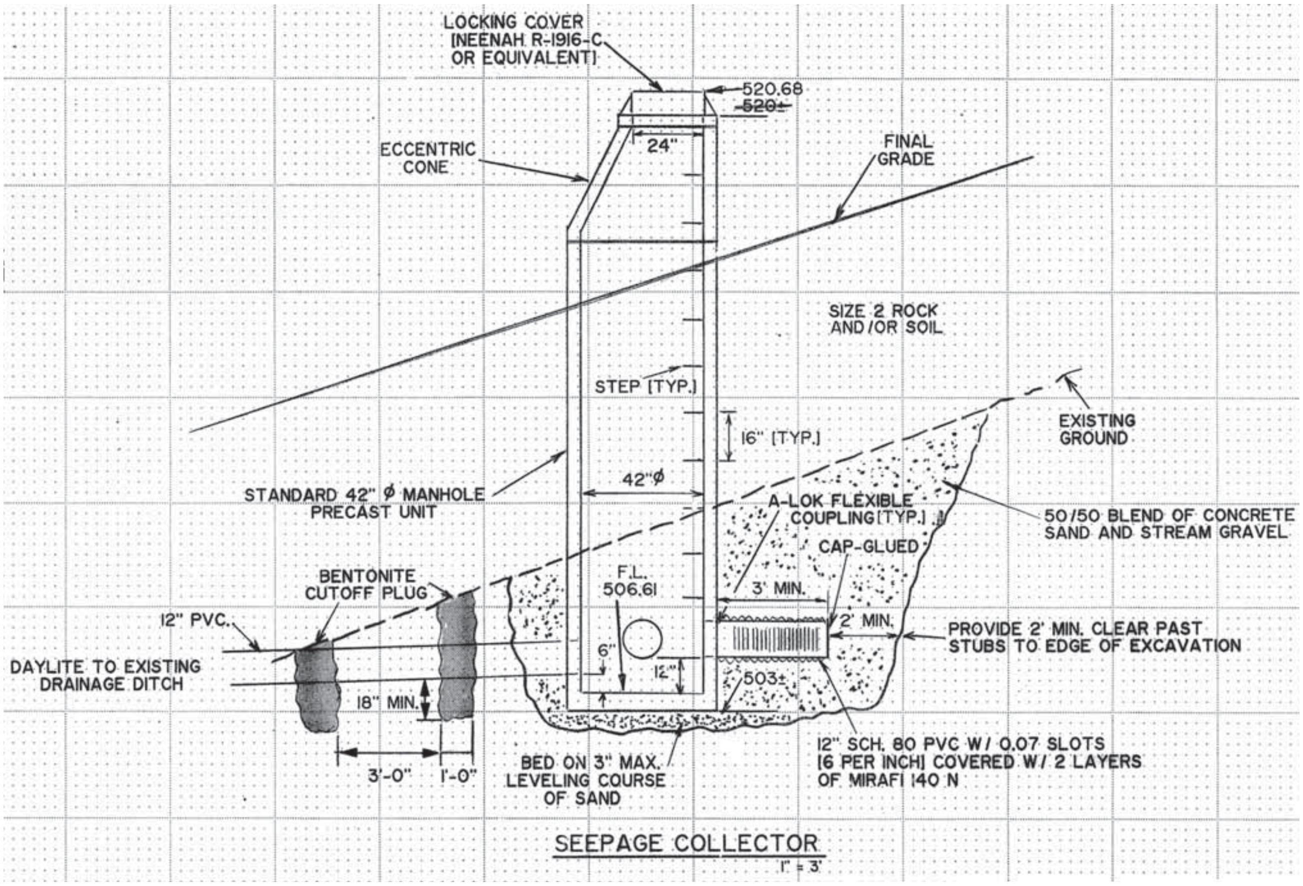

Figure 3. Seepage Collector

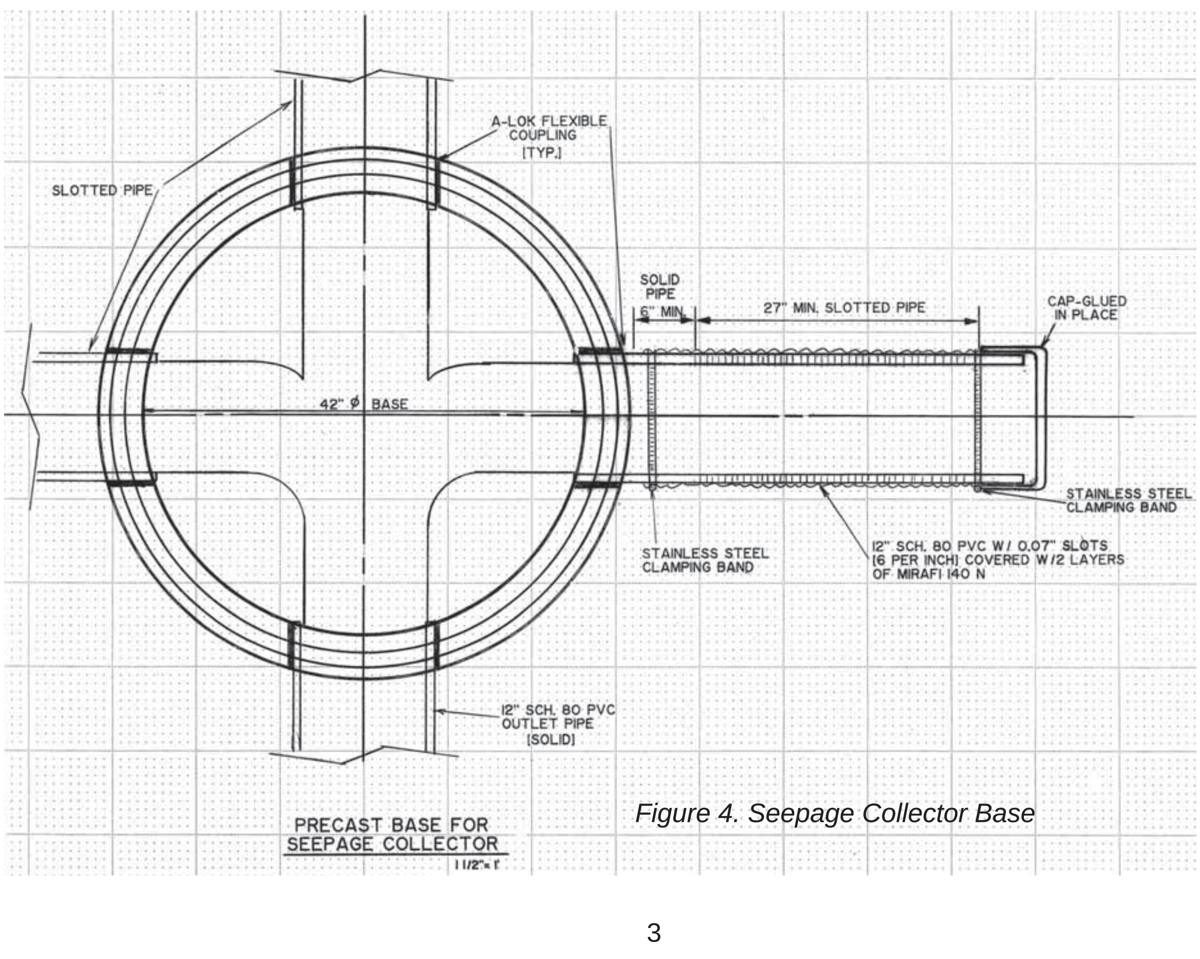

Figure 4. Seepage Collector Base

was installed to directly intercept seepage water flowing out of two springs located on the back of the dam (each spring is labeled as “Spring” in Figure 2). In addition to the seepage collector, 250 feet of perforated pipe was laid in a sand trench to collect additional seepage (labeled “proposed drain” in Figure 2). Both the seepage collector and the perforated pipe empty into the same pool that then flows under the “haul” road into a creek that connects to the spillway.

DE said that to measure the flow rate coming from the seepage collector would require a weir, because “you can’t sample what’s coming out of the pipe in a backwater situation”.

DE: In 1982 I talked to original lake developer. This guy was in his 80s at the time. He told me that there was a problem with leaks almost immediately after the dam was completed. The old guy said they sent divers down and they were able to detect a flow in “I” cove (the cove adjacent to the dam on the north side). On the back of the dam they found a large spring where a valve/pipe assembly is now located (labeled “Valve Existing” in Figure 2).

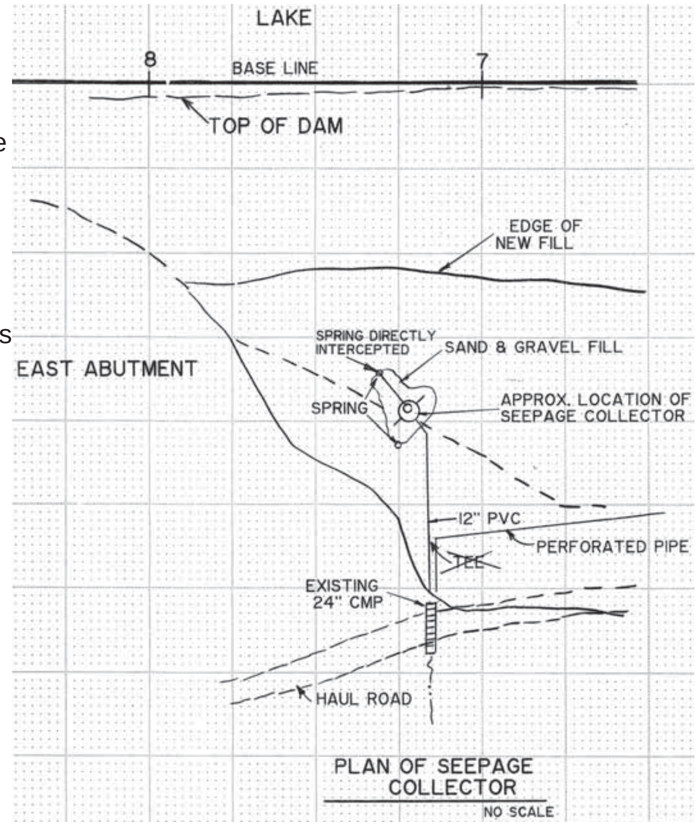

Figure 5. Seepage Collector Location

DE said that the valve/pipe assembly was installed by Wabash Drilling in 1965. The purpose of the valve/pipe was to assist in cement-grouting to stop the leak. The plan was to drill the top of the dam and install casings. Then cement (actually a mortar/sand mixture) would be pumped into the casings. This did not work since the cement was introduced into moving water and washed away. To make cement grouting possible the valve and pipe assembly was grouted into the leak. The hope was that the valve could be closed to stop the flow of water so the cement could set up. DE said that the grouting was immediately effective, “but as is typical of limestone, when you plug it up in one place it finds another place to leak, and it did.” In DE’s opinion the valve/pipe assembly probably has no relevance on a repair carried out at this time.

DE: There was a second round of grouting in 1965 that was a little more extensive in length and they used hot asphalt rather than cement. The hot asphalt solidified when it contacted the cold, moving water. This too met with initial success, but the leak did redevelop. DE said that it is typical of limestone, that if you have a porous area it will find a new area to leak. DE said that it was very possible that the springs are growing and that it would not surprise him if the leak was getting worse.

DE said that hydrogen sulfide gas (H_2S) in the leak water is confirmation that the leak water is from the lake. RH said he detected the presence of H_2S in the leak pool by its odor. DE: The H_2S is produced by leaves rotting at the bottom of the lake and the gas is carried through to the outlet. (DE said that another common odor in ground water is a “wet-rust” smell.) DE also said that the H_2S smell will not be present year round. RH said that he had observed this. DE had no explanation for the white algae observed by RH in the leak pool.

DE confirmed that one way to determine the depth of the leak was to measure the leak temperature (actually measured at 50 deg F) and then in summer make a temp. vs. lake depth graph. RH has done this and by his estimate the leak is at 33 feet. Although this tells us the approximate depth of the leak it does not tell us the location.

DE had no explanation for the casing pipes RH saw in the valley behind “I” cove.

RH explained Dave Taylor’s (DT) plan to reduce/stop the leak, which is to locate the pipes that were used to introduce asphalt into the leak cavities thru the top of the dam. DT would then drill next to these pipes and introduce material that would fill the cavities and stop the leak. (Cement would probably NOT be used, as there are now much better materials, plastics, that would react with water to form rigid long lasting plugs.)

DE’s response was that “trying to grout the leak is the biggest crapshoot there is.” DE continued, “DT will probably say he can stop the leak because he will stay there until he does.” DE then said that DT has been very successful in reducing/stopping leaks, but it is a matter of time and money. DE: “You’re shooting blind. You’re trying to stop a leak out here by drilling a small hole on the top of the dam. Part of it is experience. It is definitely an art, not a science. DT is a geologist and is very good at what he does." DE agreed with DT that there is probably a cave thru which water is traveling in the base under the dam.

DE: Once water flow starts it dissolves more limestone and enlarges the flow path. DE said he thought that it would be easier to stop the leak if the water is flowing thru a fracture, rather than thru a cave.

DE: "There isn't a dam in the world that doesn't have water moving thru it. One of the keys to design is to control this flow of water."

DE: In summer we get 0.5 to 0.75 inch per month loss due to evaporation. In winter we lose about 0.1 inch per month due to evaporation. The wind plays an important factor as to whether evaporation is on the low or high side of the range.

DE calculated that if the leak flowed at a rate of 300 gpm the lake would drop one inch in 7.5 days. (This assumes that the lake size is 120 acres and there is no loss due to evaporation.)

(RH: Adding in 0.2 inch to account for evaporation, we might expect to lose 1.1 inch per week. In July – Aug 2005 for a 40 day period we lost an average of 1.75 inch per week.)

DE: Measurement in winter is more reliable since there are very little evaporative losses.

CH: In terms of the dam what would be the signs of an emergency situation.

DE: A real sudden increase in flow along with the leak water getting dirty or milky (chalky). In other words something has collapsed in the limestone and released a lot of small limestone particles which could mean that a void was developing under the dam into which a section of the dam could drop into. DE: Even a loss of 300 gpm is not a problem if the leak water stays clear and the flow rate is constant.

DE: If there is a leak within the top five feet of the surface, you will see a whirlpool on the surface. If the leak is further down you will not see anything on the surface, even if it involves a heck of a lot of water. Only after the surface of the water gets close to the level of the leak will a whirlpool form.

DE: The accepted method of fixing a leaking lake is to drill thru the top of the dam and inject material to plug the leak, rather than to try to find the source of the leak and plug the leak at its source. DE said that even at a leak flow rate at 300 gpm divers would not necessarily be able to find the leak. DE thinks the source of the leak is the same cove as has been previously leaking ("I" cove).

CH asked DE what he would do given our situation.

DE: The grouting approach is a sound approach, though it can get expensive. The other alternative is to lower the lake and look for the leak. The lake may have to be lowered as much as 25 feet if the leak is at 33 feet. As the level of the lake approaches the level of the leak there will be some surface effect to reveal the location of the leak, perhaps a whirlpool if the leak is concentrated.

RH: I'm surprised that the leak has not been plugged over time due to all the debris (leaves and silt) in the lake.

DE: It is because there is 30 feet of head pressure that blows anything that might plug the leak right thru. The lake is a heck of a source of energy.

CH: If the Lake BOD decides we want to fix the leak, what is the procedure?

DE: Knowing the history of the dam we should be able to eliminate some of the early phases of the project. Hire a contractor that specializes in this kind of work (such as DT) to work with an engineer hired by the lake. The contractor and engineer would then get together to devise a plan of attack. This is how the large govt. projects that have problems with leakage approach it. They use a committee approach. Using just a contractor can be successful, but you can't just give the contractor a blank check.

DE: At Lake Chesterfield DT used the grouting approach and missed a few spots (probably thru no fault of his). He is now about to start a second round of grouting. DE drew an illustration similar to that shown in Figure 6 to illustrate the grouting sequence. In each phase grout is introduced thru pipes placed in holes drilled thru the top of the dam. In phase one the pipes are placed some distance away from each other. In subsequent grouting phases, pipes are placed so grout fills voids missed in the previous grouting phase. Grouting stops when the leak is sufficiently slowed or the money runs out.

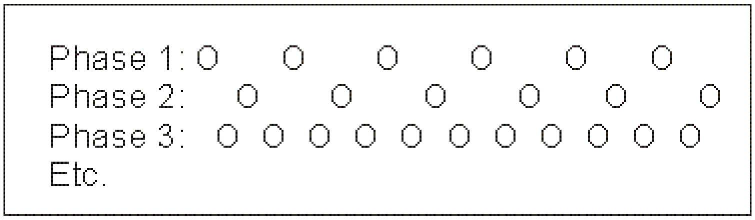

Figure 6. Grouting Sequence

DE: To grout at Lake Tishomingo the contractor would probably use a plastic grout like a urethane foam. This would solve the problem of grouting with cement into a flowing stream of water.

RH: One thing DT thought would be useful was the location of the casing pipes used to grout the dam in the 60s. When the height of the dam was raised in 1988, the tops of these pipes were buried. Do you think a metal detector could find these pipes?

DE: The grout pipes were 2 inch galvanized pipes with screw caps. When we were there in 1988, as I remember we only saw two of the pipes. A sensitive metal detector may be able to locate the pipes.

-- R Hirsch for the Dam Leak Committee