

**ASPHALT INSTITUTE**  
**Executive Offices and Research Center**  
Research Park Drive  
P.O. Box 14052  
Lexington, KY 40512-4052  
USA  
Telephone 859-288-4960  
FAX No. 859-288-4999

---

## **Asphalt Reservoir Liner Allows For State-Of-The-Art Seepage Monitoring System**

*by Bob Humer, District Engineer, Asphalt Institute*

---

The California Department of Water (CDWR) recently activated its asphalt-lined Devil Canyon Second Afterbay in San Bernardino County north of Interstates 15 and 215 near the San Andreas fault line.

The kidney-shaped, 31 million gallon Afterbay (reservoir) functions as part of the California State Water Project system that brings water from the Sierra Mountains in Northern California to the metropolitan areas in Southern California. The system runs through the Mohave Desert from a substantially higher elevation than San Bernardino County and the metropolitan Los Angeles area. CDWR uses the difference in altitude to hydraulically generate commercial electricity as well as provide domestic water for the Metropolitan Water District of Southern California.

Several considerations were critical in the design of this large reservoir. The reservoir liner had to be impermeable, durable, flexible, resistant to weather; and able to withstand rapid filling and draw-down cycles based on water usage and power generation demands. Flexibility of the liner was necessary to accommodate differential settlement over its large area.

"Seepage control was very important," says Nekane Hollister; a principal design engineer for the liner. "Even though soil cement would have limited seepage through the liner; it was still too porous."

Yet another essential design consideration was the high water table in the project area. CDWR engineers did not want to lose significant amounts of water and raise the water table.

Furthermore, high groundwater levels could potentially push up or lift the liner. Thus, an acceptable liner would have to effectively contain reservoir water as well as accommodate groundwater pressures.

### **Seepage Monitoring**

CDWR decided to use asphalt concrete for both the liner and drain elements of the Second Afterbay because it was both flexible and impervious. Its use allowed for construction of a state-of-the-art leak detection and seepage recovery system. The reservoir liner was divided into 10 sectors, with each sector having a drain pipe running through the second asphalt-treated permeable base layer to a concrete outlet. The drains also provide a means to locate leaks for repair work. CDWR can monitor all seepage and even know the exact volume of seepage. A groundwater drain provides relief for potential uplift forces.

Currently; seepage through the liner under a full reservoir is less than 20 gallons per minute. In a recent inspection by Bob Wu, CDWR Assistant Field Engineer for the Devil Canyon facility, only one of the ten sector drains showed signs of leakage, and that was very small.

## **Design**

The 19 inch thick liner on the bottom of the reservoir was composed of a 7-inch drainage layer of asphalt treated permeable base (ATPB) placed on the prepared subgrade. Two inches of hydraulic asphalt, serving as a secondary liner; was placed on the ATPB. Six inches of ATPB, designed to collect leakage, was then placed on the secondary liner. The ATPB was then overlaid with 4 inches of hydraulic asphalt, which serves as the primary impervious liner. CDWR used the "E" gradation in the Asphalt Institute's Asphalt in Hydraulics (MS-12) manual to provide the required permeability for the open graded asphalt ATPB. Mix design for the hydraulic asphalt was based on Asphalt in Hydraulics gradation "B".

The ATPB has 22 percent air voids and is a well-draining mix. The hydraulic asphalt has 7.5 to 8 percent asphalt cement and a high dust to asphalt ratio. It contains less than 3 percent air voids and is truly impervious, a guard for the leak detection system. Any seepage that gets through the first 4 inches of primary liner is recovered by the asphalt-treated drainage layer and discharged into a monitoring pump.

The reservoir slope is composed of crushed drain rock on prepared sub grade, 3 inches of ATPB, 2 inches of hydraulic asphalt, 3 more inches of ATPB drainage course, topped by 4 inches of hydraulic asphalt.

Design also included a 2 to 3 millimeter-thick mastic seal coat over the entire surface of the liner. After researching reservoirs lined with hydraulic asphalt, Hollister found that an asphaltic mastic seal coat was a common practice on European reservoirs and had been used on some U.S. reservoirs. "Based on our research, we included the mastic seal coat in the specifications" says Hollister.

The mastic seal is a mixture of hot liquid asphalt and pulverized limestone that bonds well with the underlying asphalt. The mastic seals small cracks in the liner surface and protects it from degradation due to ultra-violet rays, oxidation and algae growth.

## **Compaction**

Compaction for the liner was achieved with double drum rollers, rubber-tired rollers and vibratory drum rollers. Paving and compaction equipment were moved down the reservoir slopes with a winch. Hot-mix asphalt placed on slopes were compacted to a minimum of 96 percent of the 35-blow Marshall laboratory maximum density. Hot-mix asphalt placed on the bottom liner was compacted to a minimum of 98 percent of the 35 blow Marshall laboratory maximum density.

In applying the mastic seal to the slopes, the contractor used a three-wheeled vehicle-a trike with an insulated tank and squeegee. He used a crane to haul the trike up and down the slopes while dispensing the mastic. The mastic for the reservoir bottom was dispensed by a tank truck fitted with a squeegee. Although the actual application of the mastic was less than the specified 2 to 3 millimeters, the seal is expected to add many years to the service life of the liner.

The cost of the entire project was approximately \$50 million. It required six million cubic yards of excavation. Reservoir liner construction included 149,000 tons of hot asphalt. Advanco Constructors of Upland, California, was the general contractor; Matich Company of Banning,

California, paved the reservoir liner. The mastic seal coat was applied by Budka Construction Company of Upland, California.

***This article appeared in the Fall 1995, Volume 9, No. 2, ASPHALT magazine.***