Section 1 Project Description

1.1 General

The Taum Sauk Project is located in Reynolds County, Missouri, on the East Fork of the Black River approximately 90 miles southwest of St. Louis, Missouri. The project is a reversible pumped storage project used to supplement the generation and transmission facilities of AmerenUE, and consists basically of a mountain ridge top upper reservoir, a shaft and tunnel conduit, a 450-MW, two-unit pump-turbine, motor-generator plant and a lower reservoir. It was the first of the large capacity pumped-storage stations to begin operation in the United States.

1.2 Dams

The Taum Sauk Project has two dams, known as the Upper Dam and the Lower Dam.

1.2.1 Upper Dam

The Upper Dam is a continuous hilltop dike 6,562-ft-long forming a kidney-shaped reservoir. The dike is a concrete-faced dumped rockfill dam from the foundation level to elevation 1570.0 ft and a rolled rockfill between Elevation 1570 and 1589. A 10-foot-high, l-foot-thick reinforced concrete parapet wall atop the fill extended the crest to elevation 1599 ft at the time of original construction. Since construction, settlement of the rockfill varied between 1 and 2 ft with the lowest area found after the breach at panel 72. At panel 72, the top of the embankment is at elevation 1586.99 ft and top of the parapet wall is at elevation 1596.99 ft.

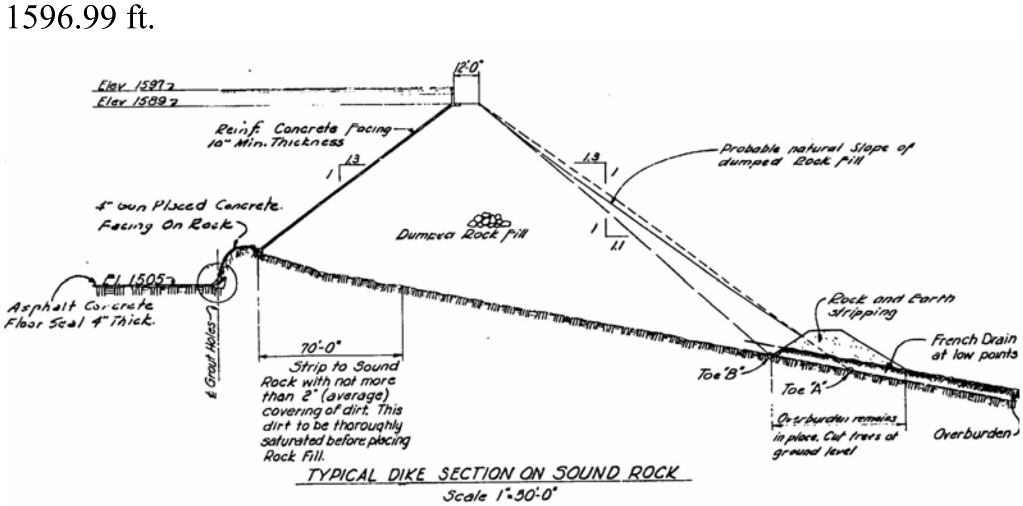

Figure 1.1- Cross section from original design drawings

Both the upstream and downstream slopes are 1.3H:1V which is likely the natural angle of repose of the material. The crest is 12 feet wide. The pneumatically placed upstream concrete face slab has a design thickness of 10 inches, and is reinforced with No. 7 bars at 12 inches both ways. In actual placement, the slab thickness averaged nearly 18 inches due to the unevenness of the rockfill. The upstream concrete face had joints (with copper waterstops) located at the junctures with the parapet wall, the toe block and adjacent face panels. The face slab was placed in panels, 60 feet wide at their widest dimension. Expansion joints between the slabs to accommodate movement, caused by settlement of the rockfill, used 3/4-in asphaltic expansion joint material and U-shaped copper water stops. The construction video shows the "expansion joint" with the copper waterstops was formed as a narrow section with the sprayed concrete placed later.

A reinforced concrete plinth (toe block) was provided at the toe of the concrete face. Where the natural rock surface was substantially higher than the reservoir floor, the rock was excavated on a near vertical slope and the plinth was at the top of the excavated rock. In these areas, the rock cut between the reservoir floor and the plinth was sealed with a 4-inch-thick layer of wire mesh-reinforced shotcrete. The entire reservoir bottom was sealed with two 2-inch-thick layers of hot-mix asphalt concrete placed over leveled and compacted quarry muck. Around the edge of the asphaltic concrete, a single line grout curtain was constructed to limit seepage under the dam. In 1964, a concrete cutoff up to eight feet deep was placed in front of the panel toe blocks in the fish pond area.

A tunnel through the northern side of the dam provides access to the reservoir floor. The access tunnel is a concrete lined, 19-foot-diameter, horseshoe shape. The upstream face is fitted with a hinged steel bulkhead gate that opens into the reservoir. The gate is 10.4 feet wide by 12.4 feet high and is hinged at the bottom. The gate is vertical when closed and horizontal when open.

Drainage ditches surrounding the toe of the dike direct a large portion of leakage into a collection pond. A small dike retains water in the collection pond, from where a maximum of about 10 cfs was pumped back into the upper reservoir. When the leakage rate exceeds the pump-back capacity, water spills from the collection pond small overflow spillway and eventually flows into the lower reservoir.

1.2.2 Lower Dam

The Lower Dam is located in a narrow steep-sided gorge just downstream of the junction of Taum Sauk Creek and the East Fork of the Black River, and forms a reservoir with a surface area of 395 acres with water level at spillway crest. The canyon at this location is in exposed hard blocky rhyolite rock of good quality. The reservoir design volume at the spillway crest is 6,350-acre-feet. This volume has been reduced by sedimentation, such that the useable volume is less than the useable volume of the upper reservoir. The Lower Dam is a concrete gravity dam founded on rock. The maximum height is 60 feet above bedrock to the spillway crest and 75 feet to the operating deck. Its height above streambed is 55 feet. The dam is 390 feet long, and except for two piers supporting the operating deck, is an uncontrolled overflow spillway. The spillway crest is at elevation 750 feet and the operating deck is at elevation 765 feet. The dam section has a base width at the maximum section equal to 1.25 of its height. The downstream slope is 0.83:1 (horizontal: vertical).

The Dam consists of 10 blocks alternatively 38 and 40 feet wide and labeled “A” to “J” from left to right. Copper waterstops are located at the joints between blocks. The joints between blocks contain no keys and were not grouted. The two piers supporting the operating deck are 4 feet and 13 wide. The 13-foot-wide pier contains a 42-inch-diameter vertical shaft and ladder that provides access to a 5-foot x 7-foot gallery with invert at elevation 720 feet. The upstream wall of the gallery is eight feet from the upstream face and extends through the middle eight blocks.

A single line grout curtain is located along the upstream side of the gallery. The grout holes are spaced 6 feet apart and extend 20 feet below the base of the dam. Foundation drainage consists of a longitudinal "box" drain formed with one-half of a 12-inch-diameter pipe. A longitudinal formed drain on the bedrock below the downstream side of the gallery connects to transverse formed "box" drains at each block joint that discharge to the downstream face of the dam. In addition, at each block joint, a formed drain extends from the foundation drain to the gallery floor. Observation wells were provided in the 8 central blocks. The piezometers consist of copper tubing extending vertically down from the middle of the gallery, then horizontally within the bottom lift of concrete to a point 10 feet downstream of the downstream gallery wall. The tubing is terminated in an excavated depression in the foundation rock filled with gravel.

1.3 Gravel Trap Dam

The gravel trap dam is a low head low hazard steel sheet-pile and rock crib structure located upstream of the powerhouse and designed to trap gravel in the river before it washes into the lower reservoir.

1.4 Spillways

1.4.1 Upper Dam Spillway

The Upper Dam was designed without a spillway, since it has a negligible drainage area and the only flow into it is by pumping and direct rainfall. Overfilling was to be prevented by a system of redundant water level controls that would automatically shut off the pumps.

1.4.2 Lower Dam Spillway

The entire 390-foot-long Lower Dam is an ungated overflow spillway. Two piers, 13- and 4-foot-wide, are located within the ogee section and support the operating deck. The spillway discharges to a reinforced concrete flip bucket with a 28-foot radius. The elevations of the flip buckets for the abutment blocks are higher than those for the center blocks.

1.5 Powerhouse

The powerhouse is located at the upstream end of the Lower Reservoir about 2-miles from the Lower dam. It is situated in a deep narrow canyon through which a tailrace channel was excavated to connect to the East Fork Black River. The Powerhouse is connected to the Upper Reservoir via a concrete and steel-lined shaft and tunnel. The initial reversible pump-turbine rating for each unit was 175 MW, but was upgraded to 204 MW in July 1972. The turbine runner upgrade conducted in 1998 resulted in a revised rating of 450 MW. The tailrace to the lower reservoir is about 65 feet wide and 2,000 feet long.

1.6 Intake and Outlet Works

1.6.1 Upper Dam Outlet Works

The Upper Dam outlet is the power conduit that consists of a 451-foot-long, 27.2-foot-diameter, vertical shaft, the top 110 feet of which is concrete lined; a 4,765-foot-long, 25-foot-diameter unlined horseshoe tunnel sloping at 5.7 percent; a horizontal 1,807-foot-long, 18.5-foot-diameter steel lined tunnel; and a short penstock that bifurcates to the pump-generating plant. The shaft bellmouth intake is located in the southwestern portion of the Upper Reservoir in an area of the floor that is 20 feet lower than the rest of the reservoir floor in order to suppress vortex development. Two 9-foot-diameter spherical valves in the powerhouse control flow through the outlet. Being a reversible pumped storage facility, the intake and outlet are the same.

1.6.2 Lower Dam Outlet Works

The outlet works of the Lower Dam consists of a small and large sluice. The small sluice is a 16-inch-diameter spiral welded pipe with an upstream invert at elevation 710 feet and downstream invert at elevation 707 feet. A 20-inch cast iron slide gate on the upstream face of the dam controls flow through the small sluice. The slide gate motor operator is located on the top of the 4-foot-wide pier on the crest of the dam. An intake structure extends 7 feet upstream of the Lower Dam and provides a single set of slots for either a trashrack or stoplogs. The large sluice is a horizontal 8-foot-wide by 10-foot-high steel-lined conduit with an invert elevation of 705 feet. An 8-foot by 10-foot cast iron slide gate located on the upstream face of the dam controls flow through the sluice. The slide gate motor operator is located atop the 13-foot-wide pier on the spillway crest.

1.7 Standard Operating Procedures

The Taum Sauk project is a peaking and emergency reserve facility. During a typical 24 hour period of operation at Taum Sauk, pump back to the upper reservoir begins around 9:30 PM to 10:00 PM as excess power from the grid becomes available for pumping. Pumping continues through the night until around 5:00 AM to 6:30 AM as either the upper reservoir limit level is reached or excess grid power is no longer available. From around 6:00 AM to noon the base load plants are generally able to supply the grid power demands so Taum Sauk is usually idle during this period. Generation of power at Taum Sauk usually begins by around noon and continues for four or five hours. Generation stops around 5:00 PM to 6:00 PM as the demand for power drops off. The project is usually then idle again for an hour or more before a shorter generation cycle occurs from around 7:00 PM to 9:30 PM. The daily operation sequences through the year are similar from day to day but with adjustments in times for pump back, idle time, and generation depending upon the demands on the power grid.

The project is controlled through a microwave system from the Osage Plant at the Lake of the Ozarks, under the direction of the load dispatcher in St. Louis. Both units can be put on full load in a few minutes. Generation, pump-start and duration are determined by system needs. In the fall, winter, and spring, the number of cycles is typically less, usually pumping at night and generating during the day. At times, during periods of low demand, the facility is not operated.

The normal minimum water level in the Lower Reservoir is elevation 736 feet. Although this is above the bottom of the Lower Reservoir, operation below this elevation pulls debris up the pump-generating station tailrace channel. The debris interferes with the pumping operations and sets the practical minimum water level elevation. The normal maximum water level is 749.5 feet or 6 inches below the spillway crest.

An automatic volume control system was installed to discharge through the sluice gates or over the lower dam an amount equal to the inflow from the East Fork of the Black River into the reservoir. Storm flows are passed over the Lower Dam spillway. Typically, the spillway discharges occur every spring.

As originally designed and constructed, the useable volume in the lower Reservoir was greater than the volume of the Upper Reservoir. The design volume of the Lower Reservoir was reduced by the need to raise the minimum operating water level from 734 feet to 736 feet due to the debris being pulled up the tailrace channel. Although trashracks prevented the debris from being pulled into the pumps, it interfered with pumping operations. Normal sedimentation over the years has reduced the useable volume above elevation 736 ft further, such that currently it is less than the volume of the Upper Reservoir. As a result, the full generating potential of the Upper Reservoir cannot be realized. According to the August 2003 Eighth Independent Consultant's Safety Inspection Report (Part 12D Report), the Upper Reservoir minimum level is limited to elevation 1,535 ft, or 30 feet above the bottom of the reservoir, to prevent discharging water over the Lower Dam spillway. Before the installation of the geomembrane liner in 2004, the normal automatic settings were as follows:

	UPPER RESERVOIR ELEVATIONS		LOWER RESERVOIR ELEVATIONS
	Summer [feet]	Winter [feet]	All seasons [feet]
1-st pump OFF	1595	1588	739
2-nd pump OFF	1596	1589	736.2
All pumps OFF	1597	1590	736

Prior to the installation of the geomembrane liner, upper reservoir levels were verified by a staff gage attached to the parapet wall near the gage house. Because the staff gage was affixed to the parapet wall, it settled about one foot along with the parapet wall. Due to the settling, AmerenUE believes the upper reservoir was actually operating at 1595 feet instead of 1596 ft. The staff gage was removed during the geomembrane liner replacement in the fall 2004. After the installation of the liner, operations typically pumped the upper reservoir to elevation 1596 ft.

Prior to installation of the geomembrane liner, reservoir levels were kept lower during the winter to limit leakage through the parapet walls. During winter months, the leakage would collect on the embankment crest and become ice, making it difficult for crest access. Since the liner extended near the top of the parapet wall, leakage through the parapet walls was longer a factor during the winter. According to the February 8, 2006 interview with Mr. Richard Cooper, AmerenUE had decided to no longer lower the reservoir during winter months after the liner was installed.

A detailed description of the project's instrumentation and reservoir control system at that time of the December 14, 2005 breach is presented in Section 5.