Construction

Schedule/Duration

Approximately 48 months will be required to complete the total engineering, procurement and construction for the project. The critical path will be the excavation and completion of the underground works. Additional study will be required to analyze and optimize the construction schedule for the selected powerhouse option. The following details apply only to the underground powerhouse design.

The major factors affecting the overall construction sequencing are described below:

1. The process of design, preparation of bid documents and bidding by potential constructors and equipment suppliers would require an overall period of about two years. It has been assumed that the design process would include the construction of an exploratory adit to investigate the in situ conditions in the planned underground works.

2. Unless it is decided to award the whole project to a single project delivery contractor under a turnkey arrangement, bidding and award of the equipment supply contract can take place in advance of the bidding and award of the main civil construction work. This will facilitate a reduction in overall construction duration, and will keep the equipment supply off the critical path.

3. The critical equipment supply issue is the pump/turbine and generator/motor. The following minimum times are expected:

    a. First embedded parts (draft tube liner) delivered to jobsite: 21 months after award of equipment supply contract.

    b. Installation of Unit 1 draft tube liner: 2 months.

    c. Installation of Unit 1 pump/turbine stay ring: 3 months.

    d. Installation of Unit 1 spiral case: 3 months.

    e. Installation of Unit 1 pit liner: 1 month.

    f. Installation of all other Unit 1 rotating equipment: 12 months.

    g. Testing of Unit 1: 2 months.

    h. Installation of Unit 2 draft tube liner: start upon completion of Unit 1 draft tube liner installation; pump/turbine stay ring, spiral case, pit liner and other rotating equipment to follow in accordance with the durations identified for Unit 1.

   i. Installation of Unit 3 draft tube liner: start upon completion of Unit 2 draft tube liner installation; pump/turbine stay ring, spiral case, pit liner and other rotating equipment to follow in accordance with the durations identified for Unit 1.

   j. Installation of other equipment should not be critical, however, the installation of the transformers, high-voltage cables to the surface, the switchyard and the transmission interconnection need to be complete in advance of Unit No. 1 testing.

4. The critical path of civil activities includes the construction of the main powerhouse access tunnel, the cable tunnel and the tailrace tunnel. All three should proceed simultaneously to achieve the required construction access to the underground powerhouse. The tailrace tunnel would be initiated from a construction tunnel, and later connected to the planned intake/outlet in Slab Creek. Upon advancing the excavation to the powerhouse location, the excavation of the powerhouse would proceed from the top down. When the powerhouse excavation reaches a point just below the crane rail elevation, the powerhouse bridge crane would be installed. Simultaneous to powerhouse excavation the penstock and high-pressure tunnel would be excavated, and the vertical shaft pilot hole can be drilled. Once the high-pressure tunnel excavation has reached the target vertical shaft location, full excavation of the vertical shaft can begin. The vertical shaft would likely be constructed using a raise bore (cut from the bottom up) and/or slashing from the top down, and cuttings would be removed through the high-pressure and tailrace tunnels.

5. Once all tunnel excavation is complete, concrete lining of the waterways can proceed. Lining would likely proceed from the bottom of the vertical shaft upwards, and in the high-pressure tunnel, from the intersection with the vertical shaft proceeding toward the powerhouse. A portion of the high-pressure tunnel would be lined with concrete only, and in a reach close to the powerhouse, the interior of the tunnel would be steel lined (embedded in concrete).

6. Tailrace tunnel lining can proceed after the concreting in the powerhouse and in the high-pressure segments of the tunnel have advanced so that construction access through the tailrace tunnel is no longer required.

7. The intake/outlet in Slab Creek can proceed as a separate operation. The intake would be constructed inside a vertical circular shaped caisson or cofferdam. The details of this construction would need to be carefully evaluated during feasibility planning. Once the intake is complete and bulkheads are in place, the tailrace tunnel excavation could be advanced toward the intake/outlet and completed.

8. The upper reservoir construction operations would include clearing/disposal of vegetation, stripping and disposal of overburden (this can be stockpiled and used later for restoration work), and excavation of weathered rock removed from the foundation area under the dams. Excavation in the basin portion of the reservoir

would proceed so that the intake area is available when necessary at the beginning of shaft construction. Final lining of the interior of the reservoir would be coordinated with the completion of the vertical shaft and the construction of the intake. The upper reservoir intake/outlet must be finished before the reservoir lining is complete.

Preliminary Intake Design

SMUD will construct a multi-port (e.g., octagonal) intake, approximately 80 feet below the Slab Creek Reservoir maximum water level elevation of 1,850 feet. An octagonal intake would eliminate the need to alter the mountain slope (both under water and above the shoreline) during construction.

The natural slope has existed under water for over 30 years and has existed in-the-dry for thousands of years. Similar to other slopes in other UARP reservoirs it is not anticipated to require stability enhancements. If, however, stability enhancements would be necessary the District will install minor tie-back anchors without modifying the natural mountain slope.

Because of the octagonal configuration the horizontal net velocity component on the reservoir would be minimal, greatly reducing any concern over stirring up sediment. This is unlike a horizontal, one-directional flow intake where the entire flow creates a velocity in one direction that swirls and boils as it discharges into the stationary reservoir conditions.

The intake structures would be fitted with bar racks to prevent debris from entering the intake structure. It would lie sufficiently below the water elevation of the reservoir so as not to pose a safety hazard to boaters.

To construct the octagonal intake, a steel cofferdam is floated-in and sunk in place. Rock drilling from a boat or small barge would be necessary to determine the site for the octagonal intake.

Upper Reservoir Design

The berms for the upper reservoir would be constructed from crushed rock from the tunneling operation, earth from the upper reservoir basin, a clay or high-density polyethylene (HDPE) liner to prevent leakage, and appropriate revetment/rock where needed to minimize bank erosion.

Previous concepts for the development of a pumped storage project at Iowa Hill have incorporated placement of a clay and/or bentonite layer as an impervious lining to prevent leakage from the upper reservoir. Synthetic materials such as polypropylene or

HDPE have been commonly used for water storage basins or landfills, and will be considered for the Iowa Hill Development.

For the purposes of this evaluation, the design and layout of the dike is modified somewhat in comparison with previous development concepts. The previous studies incorporated a dike design with relatively flat slopes and with an internal impervious zone of clay material. The previous concepts also incorporated a clay/bentonite reservoir floor lining. The design concept suggested in this report incorporates a synthetic or plastic liner on the reservoir floor and the inside surfaces of the reservoir dike. The impervious clay zone has therefore been eliminated. Dike and excavation slopes have also been steepened in comparison with previous layouts. These modifications should result in lower overall costs in comparison with that of the original design concept.

The layout criteria for the upper reservoir quantities are:

- Stripping of organic material overlaying the basin area to be excavated and under the dike footprint; thickness is assumed at 2 ft.; all material is stockpiled for later use in site restoration.
- Additional 3-ft. deep excavation under dike footprint (this material is processed and used later as dike fill).
- Dike outside slope: 2 H to 1 V.
- Dike inside slope and slope in excavation: 2.5 H to 1 V.
- Dam crest width of 15 ft.
- Height of freeboard above normal maximum water surface of 7 ft.
- Depth of dead storage below normal minimum water surface of 5 ft.
- Reservoir bottom will have some nominal slope for drainage.
- Reservoir floor and side slopes would be lined with a single-layer impermeable plastic membrane.
- Reservoir lining system would require a filter/bedding zone constructed of free draining gravel that would be quarried and processed. The average thickness of the filter/bedding zone under the lining would be 12 inches.
- A 10-ft.-thick transitional zone would provide the required transition from the rockfill portion of the dike to the filter/bedding zone. The material in the transition zone would be processed from materials excavated on-site.

Figure 12 below shows generally how the cut and fill volumes for upper reservoir construction would be balanced. The berm would include material from excavation of the rock for the powerhouse, tunnel, and shaft. During construction SMUD would balance the excavation and fill requirements of the total Development eliminating any need for permanent spoil and permanent spoil areas at the upper reservoir. Prior to the close of construction all temporary spoil would be eliminated by incorporation into the upper reservoir dikes and the area landscaped. Overburden would be temporarily stockpiled for use during restoration. The temporary construction access and temporary spoil areas at the upper reservoir would be fully landscaped and planted prior to the close of construction.

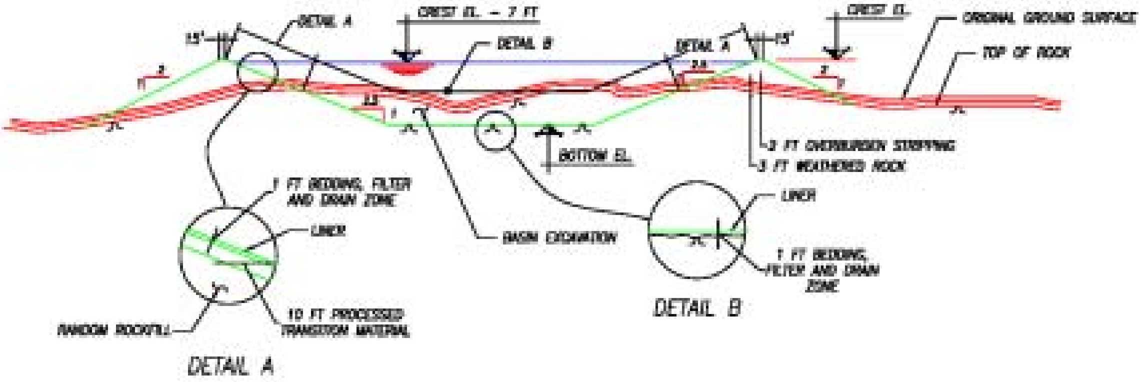

Figure 12. Balanced Cut and Fill Approach For Upper Reservoir Construction

Tunnel Construction

Recent experience with the El Dorado Irrigation District tunnel nearby points to using a conventional drilling, blasting, and mucking method rather than use of a Tunnel Boring Machine (TBM). Tunnel lengths (2,000 feet) and the shaft height (1,200 feet) are relatively short and are not amenable to using a TBM or raise bore machine.

The drill, blast, muck method of excavation in the metamorphic rock (phyllite, schist, quartzite) would produce platey/slabby material that would not be suitable as road base or rock armor. The metamorphics may contain trace amounts of pyrite (iron sulfide) and other minerals. The quartzites will be extremely hard and durable, while the schist and phyllite will break down readily upon removal and handling, particularly in the highly weathered portions near the ground surface.

The metamorphic rock consists of silica (quartzite), and calcium/potassium/aluminum silicates (schist and phyllite). These metamorphic rocks may be intruded locally with gabbro (calcium/potassium/aluminum silicates with trace amounts of chrome), felsic (quartz/feldspar), or mafic (hornblende/biotite) dikes. There may be trace amounts of iron sulfides, iron, manganese, copper, and possibly chrome present. Blasting materials would introduce residual nitrites, nitrates, RDX, nitroglycerin, and other associated materials. Storage, handling, and use of petroleum hydrocarbons would be in accordance with applicable Storm Water Pollution Prevention Plans (SWPPPs), Spill Prevention/Containment Plans (SPCPs) and Waste Discharge Requirements (WDRs) prepared for the Development.

The drill, blast, muck tunnel/shaft excavation method is not expected to generate excessive amounts of fines like a TBM operation produces. If there are highly weathered zones or shear zones encountered in the metamorphics, some fines would occur. These fines could be segregated from the coarser materials and disposed separately offsite. Best Management Practices (BMPs) such as silt fences, straw waddles, grading and berms, etc. will be employed to prevent migration of fines into surface waters.

The drill, blast, muck tunnel/shaft excavation method uses water for dust control, drill cooling, tunnel washing, wash down after blasting to remove air particulates, and other operations. Combined with the groundwater infiltration during construction, significant amounts of commingled groundwater and construction water (up to 100 gpm) could be produced. This water would require treatment to remove suspended solids, petroleum hydrocarbons, and blasting residuals introduced during excavation, and lowering of the pH and removal of chrome +6 during shotcreting, grouting, or other concrete work. The groundwater may contain iron, manganese, aluminum, chrome, and other metals in excess of receiving water limitations based on water quality objectives of the Regional Water Quality Control Board (RWQCB) Basin Plan. The treatment plant would remove these metals from the waste stream, if they are present in concentrations that exceed the Basin Plan guidelines. The treatment plant would require a NPDES permit for discharge to Slab Creek Reservoir. Treatment would have to meet the requirements of the RWQCB Basin Plan and frequent sampling and testing of the treated effluent and receiving waters would be required. Characterization (sampling and testing) of the groundwater, springs and creeks in the area would be required before operation of the treatment plant and tunnel construction to establish baseline conditions over a seasonal period of time. After construction, a groundwater management plan would require periodic sampling and testing of the groundwater, springs, and surface waters identified in the baseline studies. Sludge from the treatment plant would be hauled to a Class I disposal site by licensed waste haulers. There are several commercially available portable water treatment plants that can be leased with licensed operators for this Development. Water treatment would be required on a 24-hour basis during construction. Chemicals used in the construction water treatment would be stored, handled and controlled in accordance with applicable Storm Water Pollution Prevention Plans (SWPPPs), Spill Prevention/Containment Plans (SPCPs) and Waste Discharge Requirements (WDRs) prepared for the Development.

The pressurized portions of the intake/outlet tunnel and shaft would be fully lined, thus preventing capture of groundwater. All other tunnels would be planned with concrete. Excessive groundwater inflow in the access or electrical conduit tunnels, or underground rooms is not expected in this hydrogeologic environment. However, if excessive groundwater inflow is encountered, procedures for groundwater control using grout within tunnels, shafts, and underground cavities are well established. Grout mixes can be modified in the field to control virtually every type of flow except low flows and seepage. For example, ratios of sand, cement, and water can be adjusted to meet specific field conditions. There are numerous thickeners, such as Kellco Crete, sawdust, paper and cellulose fibers, or cellophane chips (all of which are non-toxic) that can be used as mechanical bulking agents. Calcium chloride has been successfully used as a chemical accelerator to reduce grout-hardening time. Pre-grouting can be employed if there are indications of increasing groundwater inflow as the tunnel/shaft raise advances. There is no practical method for eliminating all groundwater seepage within tunnels, shafts, and underground caverns.

During construction crews would have trailers for field offices, meetings and change rooms as well as portable sanitary facilities. OSHA and MSHA require change rooms, showers, and sanitary facilities for miners involved in daily tunneling work. It would be difficult to locate a septic/leach field on the steep rocky slope next to Slab Creek Reservoir, so wastewater would have to be temporarily stored in tanks, pumped, and hauled offsite for disposal.

Access To Site

Upper Reservoir

The primary access to the upper reservoir site off of US Highway 50 is via Carson Road, to Cable Road to Iowa Hill Road. SMUD would improve the serviceability of four miles of existing Cable Road from the end of the paved portion of Cable Road to the upper reservoir site. SMUD would either provide an unimproved gravel road or pave the four miles of existing roadway to be improved. The existing road will not be widened. Wide places in the existing road would be improved along with the rest of the road and would function as passing turnouts. If a paved road is chosen the existing dust would be eliminated. If the road were not paved, SMUD would require the construction contractor to frequently apply water to the road while in use during construction to minimize dust. Once constructed, the upper reservoir would be fenced, locked and unavailable for public recreation.

After construction, during normal O&M of the Iowa Hill Development, SMUD's vehicle trips to the upper reservoir site would be minimal, estimated at an average of no more than one (1) vehicle round-trip per day.

Powerhouse/Intake Structure/Switchyard

The primary access to the lower reservoir site is off US Highway 50 via Carson Road, to Larsen Drive, to North Canyon Road, to the Slab Creek Reservoir access road. At this time SMUD does not know the exact location of the proposed powerhouse, intake and access tunnel because rock core drilling to verify the site suitability must be done first. The preliminary location of these facilities is at the end of the existing 2-mile long Slab Creek Reservoir access road.

The first 1.1 miles of the existing 2-mile long Slab Creek Reservoir access road, starting from North Canyon Road going to a point near the dam, was constructed by SMUD as a gravel road to provide access for dam construction and O&M access to the existing Slab Creek Reservoir. This segment of road, shown in Photo 1 of Appendix C, will not be widened.

The remaining 0.9 miles of the existing access road, starting from near the dam and heading east, was originally constructed as a 10-foot-wide road and currently provides access to the existing, semi-developed boat launch site, used by SMUD for O&M activities and the public. Because of the limited turn-around area at this launch site, most boats are launched by hand and trailer launching is difficult. The lower portion of the 0.9-mile long road was partially constructed by SMUD, and a portion of the road was constructed as part of the original Chute Camp lumber industry road that was abandoned prior to the construction of Slab Creek Reservoir. This segment of road, shown in Photos 2 and 3 of Appendix C, would be widened by two feet. Figure 13 is a cross-section drawing showing the widening dimensions and associated excavation.

This 0.9-mile long segment of access road has been used for many years without the need for tie-back reinforcement to increase the roadway stability and would probably not need stability improvements. However, as a precautionary move prior to construction, SMUD would check for stability adequacy of the existing roadway cross-sectional cut-and-fill slopes, and if necessary, SMUD, over a period of years, would install tie-back rock anchors at needed locations to improve the stability of the road.

SMUD would pave the 2-mile long Slab Creek Reservoir access road from North Canyon Road to the entrance of the powerhouse access tunnel. Paving would enhance serviceability and eliminate the existing dust. Similar to SMUD’s existing access roads to other UARP powerhouses, SMUD would use a 12-foot wide asphalt pavement with widened passing turnouts. SMUD would widen and pave the existing turnaround area near the existing boat launch site to accommodate larger trucks. The widened turnaround area would also serve as a temporary access area during construction of the powerhouse access tunnel.

After construction, during normal O&M of the Iowa Hill Development, SMUD’s vehicle trips to the powerhouse are estimated to be less than an average of four round-trips per day.

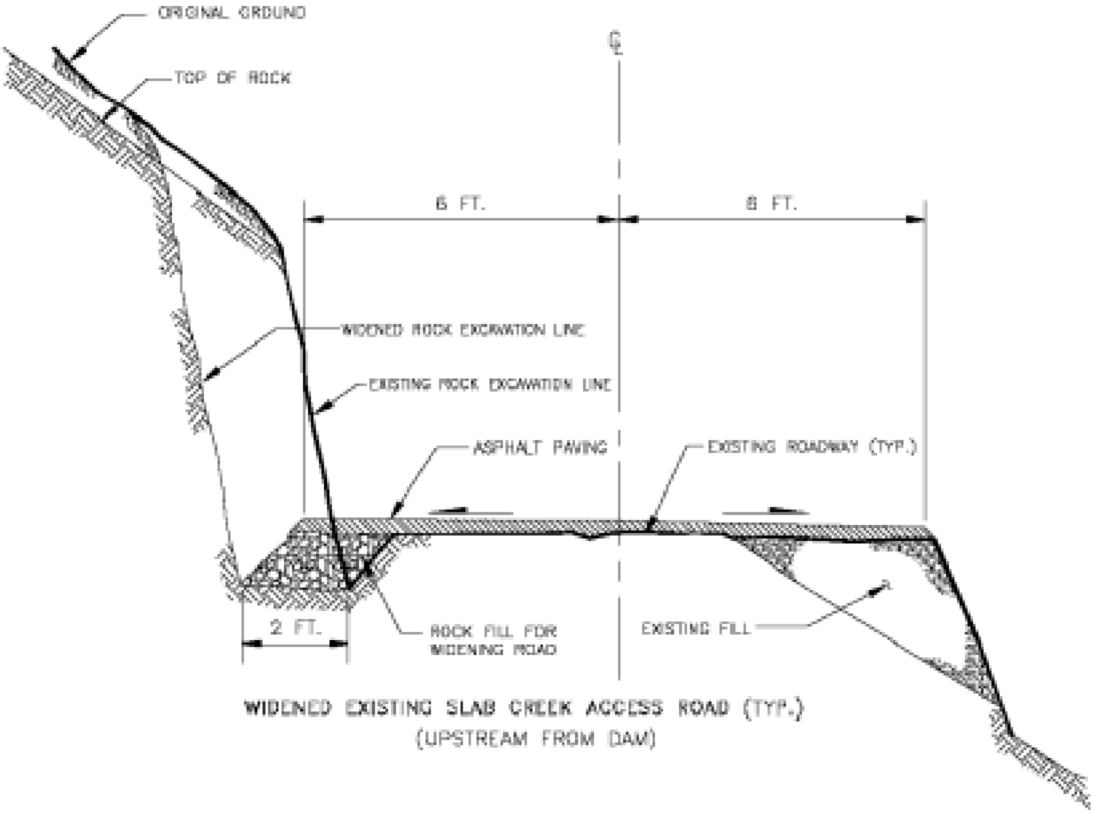

Figure 13. Typical Improvements for the last portion of the Slab Creek Reservoir Access Road

Transporting Rock to the Upper Reservoir Site

During construction SMUD would transport the excavated rock and soil from the powerhouse, tunnel, and shaft to the upper reservoir site to be used for berm construction of the upper reservoir. The difference in elevation from the lower access area to the upper reservoir site is about 1,000 feet.

SMUD would use large dump trucks to transport the excavated rock from the main access tunnel for the powerhouse to the upper reservoir site. The transportation route would likely follow the following route starting from the main access tunnel site: Slab Creek Reservoir access road, North Canyon Road, Larson Drive, Carson Road, Cable Road, concluding at the upper reservoir site at Iowa Hill. This route is approximately 16 miles one-way, and includes going through the central district of the Camino community. This transportation route may change between the time of production of this IIP and final construction planning in the 2007-2010 time period.

During construction, the Slab Creek Reservoir access road would be closed to the public and the contractor would establish a staging area along the road some distance from the tunneling operations. There would be daily construction traffic from the staging area to the tunnel portals and spoils would be hauled to the upper reservoir daily. During shotcreting, grouting, or other concrete work, there would be heavy use of the Slab Creek Reservoir access road.

SMUD would develop a Traffic and Transportation Plan prior to the commencement of construction that describes the level of planned road use and identifies measures to control impacts to social and environmental resources. SMUD would also consult with the relicensing participants and representatives of Apple Hill tourism industry concerning the effects this construction traffic would have on the community and Apple Hill tourism. Measures necessary to mitigate or minimize the effects will be included in SMUD's application for new license.