VOLUME 3, GEOLOGY AND TUNNELING OF THE MARICOPA SUPERCONDUCTING SUPER COLLIDER SITE PROPOSAL*

by

John Welty

Arizona Geological Survey
Open-File Report 88-7

Submitted to the U.S. Department of Energy
September 2, 1987

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

**Prepared by The Arizona SSC Project*
1317 E. Speedway Blvd.
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This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

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PREFACE

In 1983 the State of Arizona began a statewide search for a site for tl Superconducting Super Collider (SSC). By 1984 a site selection working grou at the University of Arizona had identified 31 sites along a northwest trendin band from New Mexico to California as possible locations for the SSC. Whe the U.S. Department of Energy (DOE) issued the Invitation for Site Proposal in April, 1987, the State under the auspices of the Arizona Department o Commerce in collaboration with the University of Arizona, Arizona Stat University, the Arizona Geological Survey, and many other state agencie proceeded to develop full proposals for the Maricopa Site 35 miles southwes of Phoenix and the Sierrita Site 25 miles southwest of Tucson. The followin report is a copy of the Geology and Tunneling chapter filed with the DOE i compliance with the Invitation for Site Proposals. The other volumes tha comprise the full site proposal are available for inspection at the Arizon Geological Survey library and at the Special Collections library of th University of Arizona Main Library.

Figures 3-1 and 3-2 are not included in this report because of their great size however they are available for inspection in the copy of the full proposal a the above locations. Figures 3-4 through 3-8 and 3-12 have been provided as photographically reduced versions in this report; full-size copies are available from the Arizona SSC Project.

Many people beyond those listed as contributors helped ease the difficult task of proposal writing and preparation. In particular, Nita Haddock and Margaret Schmidt typed, formatted, and produced this volume. A special thanks goes to Ms. Haddock for her tireless efforts to assure the production of Volume 3 in time for submission to the DOE. Mr. Ian Macpherson, Arizona SSC Project Coordinator, Dr. Peter Carruthers, Chairman of the Arizona SSC Technical Committee, Dr. Richard Jacob, Deputy Chairman of the Technical Committee, and Mr. Donald Morris, Project Manager all provide valuable insight and support to see this effort to completion. Finally, a special thanks goes to Dr. Larry Fellows, State Geologist, who allowed the senior author to participate in this program.

John W. Welty

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VOLUME 3. GEOLOGY AND TUNNELING

3.1 GENERAL

3.1.0 SUMMARY

The geologic setting of the Maricopa Site is very favorable for rapid and cost-effective construction of the SSC facility. To correlate geology with tunneling construction methods, the collider ring was divided into ten Construction Units (Table 3-1). A Construction Unit may include several different rock types with varying support requirements but uses a <u>single</u> tunneling construction method. In some units tunnel excavation and lining will be accomplished exclusively by tunnel-boring machine (TBM) systems (see Section 3.5.4.2). In other units either proven cut-and-fill methods or TBM may be used depending upon the depth of the ring below ground surface (see Section 3.5.4.1). The ideal geologic conditions not only allow construction of the collider ring in a near surface plane tilted 0.3° from the horizontal, but also provide considerable flexibility for relocation of the proposed ring alignment or for location of future additions to the facility if desired by DOE. The injector complex, experimental chambers, and future facility additions can be built with cut-and-fill methods. Construction problems are not anticipated from geotechnical factors such as collapse-susceptible soils, seismic events (natural or man made), ground water, regional subsidence, expansive clays, or naturally-occurring gases (see Section 3.2.4).

The Maricopa Site area has been studied extensively by the Arizona SSC Project team. The proposed ring alignment passes through approximately 18 miles of bedrock in the Maricopa Mountains and 35 miles of indurated alluvium (fanglomerate) on the pediments and in the basins surrounding the mountains. The bedrock consists of a Precambrian granitic basement and Tertiary sedimentary and volcanic rocks (see Section 3.2.3). Fanglomerate is a unique material that has uniform engineering properties similar to those of a sandstone. It is ideal for rapid construction of tunnels using TBM or cut-and-fill excavations (see Sections 3.5.2.1, 3.5.4.1, and 3.5.4.2). The geologic setting is simple, predictable, and none of the geologic materials identified at the site are expected to pose construction problems for the ring tunnels, injector complex, shafts, experimental chambers, or conventional structures. The Maricopa Site has rock or fanglomerate as foundation materials throughout and offers ideal foundation conditions for all SSC structures. There is no uncertainty associated with the prediction of time-dependent settlements for sensitive instruments or differential settlements between various structural elements (see Section 3.2.4.1).

All of the proposed SSC ring path lies in unsaturated materials; therefore construction problems related to water inflow will not exist. The geohydrologic setting of the Maricopa Site consists of a dense impermeable bedrock that forms shallow pediments shouldering the basin margins and more permeable basin-fill deposits (see Section 3.3.1). Although ground-water data are sparse over the tunnel extent, experience with other southwest alluvial aquifers and available data suggest that the aquifers surrounding the Maricopa Site have a predictable and

TABLE 3-1
SUMMARY OF MARICOPA SITE CONSTRUCTION UNITS

CONSTRUCTION UNIT	GEOLOGY [1]	CONSTRUCTION [2] METHOD	GEOTECHNICAL CONTINGENCY
1 (Mile 52.2 to 5.0)	Fanglomerate	Weak Rock TBM	10%
2 (Mile 5.0 to 12.8)	Fanglomerate	Cut-and-Fill	5%
3 (Mile 12.8 to 15.3)	Granite and Fanglomerate	Mixed Rock TBM	15%
4 (Mile 15.3 to 21.3)	Granite and Fanglomerate	Mixed Rock TBM	15%
5 (Mile 21.3 to 28.3)	Volcanic and Sedimentary Rocks	Mixed Rock TBM	20%
6 (Mile 28.3 to 37.4)	Fanglomerate	Weak Rock TBM	5%
7 (Mile 37.4 to 41.5)	Fanglomerate	Cut-and-Fill	5%
8 (Mile 41.5 to 45.0)	Granite and Fanglomerate	Mixed Rock TBM	15%
9 (Mile 45.0 to 42.2)	Granite	Hard Rock TBM	10%
10 (Mile 35.5 to 43.5)	Fanglomerate	Weak Rock TBM	5%

[1] Geologic descriptions are qualitative only, detailed descriptions are provided in Section 3.2.3.

[2] Construction methods are described further in Section 3.5.4, TBM = tunnel-boring machine.

consistent water-table gradient in areas of little or consistent pumping. Seasonally, ground-water levels remain fairly constant because of low aquifer recharge rates. On-site ground water is not being considered for use in supplying SSC needs. The Vekol Valley, approximately 11 miles south of the campus area, is the optimal ground water source in the region, with an estimated reserve of 3.1 million acre-feet (one acre-foot equals 325,800 gallons) of recoverable water.

The Maricopa Site is not affected by the principal western seismic belts (see Section 3.4). Arizona has not experienced a seismic event of magnitude 5.0 or greater since 1910, when instrumental monitoring of seismic events commenced. None of the known faults at the site has surface ruptured within the past five million years, nor are the shear zones of any of the faults that intersect the ring alignment expected to pose construction problems.

The rock types identified at the Maricopa Site are all amenable to efficient and cost-effective tunneling by a conventional TBM (see Section 3.5.4). TBM advance rates in these rock types have been estimated to be between 120 and 205 feet of completed tunnel per day at costs ranging from $560 to $810 per foot. Construction of the ring in the fanglomerate may be accomplished either by TBM at depths greater than 80 feet or by proven cut-and-fill techniques at depths shallower than 80 feet. Cut-and-fill advance rates in the fanglomerate will be approximately 100 feet of completed tunnel per day at a cost of $450 per foot.

A heavy construction cost and scheduling model based on site specific data was used to estimate costs and to develop construction schedules. This model considered all major construction elements (collider ring, injector complex, shafts, and experimental chambers). Site estimates encompass about 81% of construction costs. Furthermore, the model demonstrated that construction of the SSC facility at the Maricopa Site, when contrasted to DOE generic models, will provide DOE with sufficient cash flow and schedule flexibility to realize a 22% savings in project costs. In addition, the model predicted that SSC construction, when contrasted to DOE generic model "C", can be shortened by two years if built at the Maricopa Site (see Section 3.5.4.6). The Maricopa Site can meet or exceed all major "Beneficial Occupancy" goals as defined in the Conventional Facilities Report.

In addition to the tunneling and underground construction advantages offered by the geologic setting, the Maricopa Site has other site-specific advantages. For example, a copper mine in the region has existing waste dumps on which the SSC spoils material may be disposed of without degrading the environment (see Section 3.5.5). All of the proposed SSC ring path lies in unsaturated materials; therefore construction problems related to water inflow will not occur. Near-surface construction with cut-and-fill methods for experimental facilities will allow future construction to take place without interfering with on-going operations at the completed Maricopa SSC Site.

The Maricopa Site thus possesses the following excellent characteristics for efficient and cost-effective construction of all components of the SSC project:

- A nearly horizontal collider ring with both the experimental chambers and injector complex close to the ground surface.
- A simple geologic setting that will allow for the maximum flexibility in construction techniques and scheduling, and a low geotechnical contingency.
- An estimated two-year savings in construction schedule and a 22% cost savings, when contrasted with DOE generic model "C."
- Construction in unsaturated materials entirely above the ground-water table.
- Low seismic risk and a very low probability of seismic disturbance during the lifetime of the project.
- Spoils disposal sites that will not disturb the local environment.
- A broad local base of construction resources and the infrastructure needed to complete a project the size of the SSC.
- An available labor force trained and experienced in the proposed construction methods.
- A superb climate that allows construction 365 days a year.

3.1.1 LOCATION OF THE MARICOPA SSC FACILITY

The Maricopa SSC Site circles the Maricopa Mountains in Maricopa County, 35 miles southwest of Phoenix. The proposed alignment (Figure 3-1) encircles the southern Maricopa Mountains and passes through the northern Maricopa Mountains. The center of the SSC facility is located at 32° 58' 14"N latitude and 112° 23' 53"W longitude. The major axis of the collider trends N4°W. The proposed locations for the injector complex and campus area are on the east side of the collider ring with the injector complex lying north of the campus area, in order as to take maximum advantage of proximity to Phoenix and to the infrastructure needed for efficient construction and operation. The highest elevations in the Maricopa Mountains are approximately 3,100 feet falling to 1,150 feet in the adjacent intermontane valleys. Surface elevations along the proposed SSC path range from 1,170 to 2,300 feet.

The topography of the current alignment allows for the greatest ease of access and most cost-effective construction for all SSC facilities. It also permits considerable flexibility for future changes in final design. The site can potentially accommodate a larger or smaller ring, a ring with a different orientation, a ring with a different center elevation, or a ring with different tilt attitudes. Moderate lateral displacements, up to 0.5 miles to the south, and up to one mile in all other directions, can be accommodated with little sacrifice of the site's advantages. Modification of the tilt of the SSC plane also can be accommodated with negligible changes in the site's construction qualities.

Figure 3-1 is a collection of eight 7.5' quadrangles with the proposed Maricopa SSC site plotted on them. They are not included with this report. Please refer to the original proposal to examine them.

3.1.2 PROFILE OF THE MARICOPA SSC ALIGNMENT

Figure 3-2 shows a profile of the Maricopa SSC alignment. The SSC plane has been positioned with a 0.30 degree tilt to the southwest. It passes close to the surface in the eastern and western sections of the ring path and passes at greater depths beneath the surface in the northern and southern sections of the ring. The plane is within 100 feet of ground surface at the east campus area and injector complex; whereas it is within 80 feet of ground surface at the west experimental campus. For this reason the Maricopa Site allows the use of conventional and low-cost construction techniques in both the eastern and western campus locations (see Section 3.5.4).

3.2 GEOLOGY

3.2.1 MARICOPA SSC SITE GEOLOGIC OVERVIEW

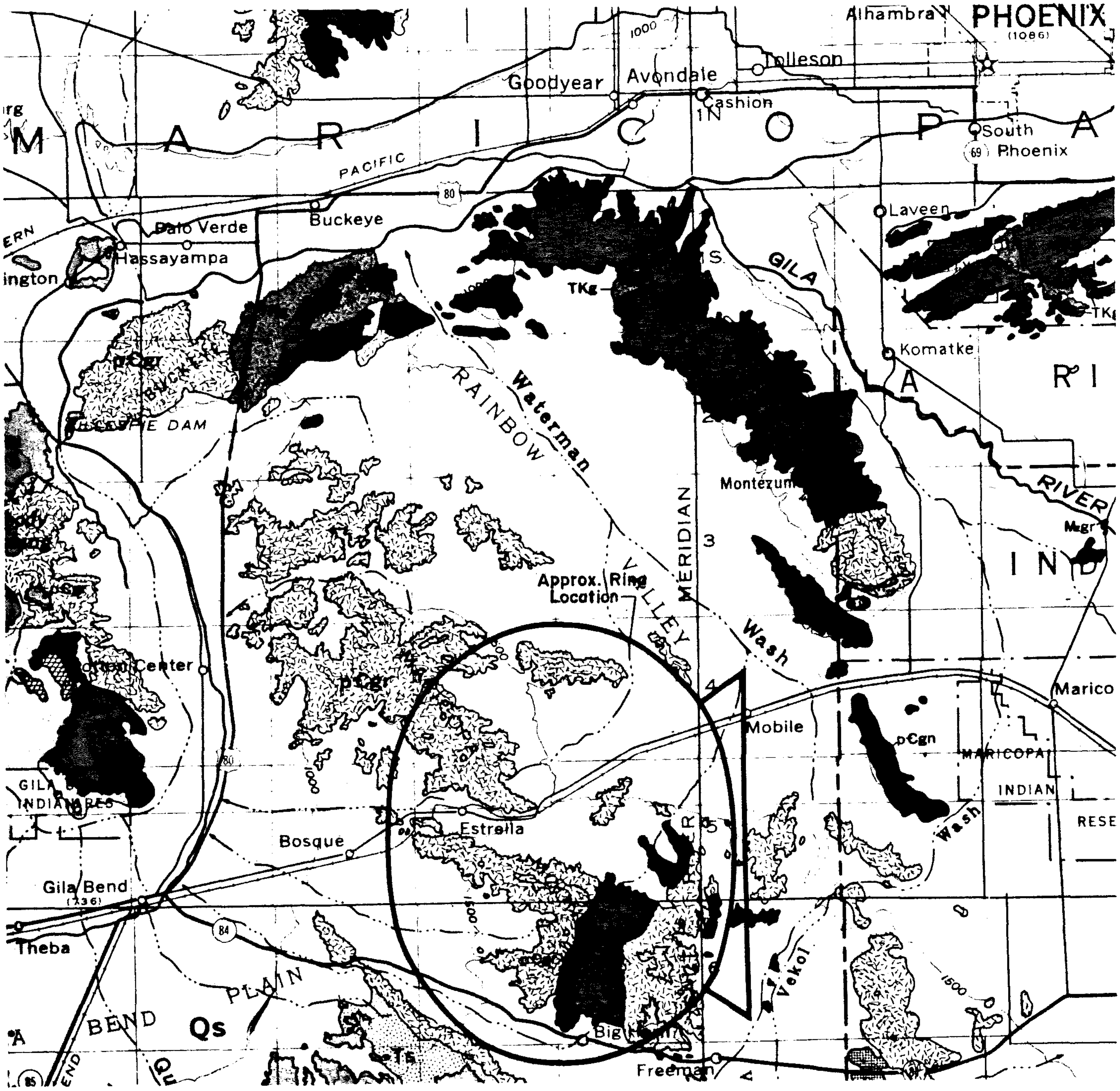
Previous geologic studies of the Maricopa Mountain region are rare. The first reconnaissance geologic map of the area was completed in 1987 at the request of the Arizona SSC Project (Cunningham et al., 1987). Prior to this the Maricopa Mountains had been discussed only in a cursory fashion as part of regional efforts of the U. S. Geological Survey (Ross, 1923; Kahle et al., 1978; Hollett and Garrett, 1984; Peterson et al., 1985) and the Arizona Geological Survey (Wilson et al., 1957; Morrison, 1984). The following descriptions and conclusions are drawn from these sources as well as from independent studies carried out by Arizona SSC Project team members.

The Maricopa Mountains are composed predominantly of Proterozoic plutonic and metamorphic rocks (Figure 3-3). The oldest rock unit, Proterozoic Pinal Schist, occurs in the southern Maricopa Mountains. The schist has been intruded by Proterozoic granitic rocks, of which most of the range is composed. The plutonic rocks consist of two separate granitic plutons and a dioritic pluton. A sequence of Tertiary sedimentary and volcanic rocks overlies the Proterozoic basement in the southeastern corner of the range. No Paleozoic or Mesozoic lithologies are recognized in the Maricopa Mountains.

The Pinal Schist occurs as a northeast-trending strike belt and as isolated pendants of higher metamorphic-grade schists which are in fault contact or intrusive contact with the younger Proterozoic plutons. The Pinal Schist generally consists of fine- to medium-grained biotite-muscovite quartzo-feldspathic schist. Within the Pinal Schist are concordantly intruded pegmatite dikes of Precambrian(?) age.

The Proterozoic granites consist of an older medium- to coarse-grained porphyritic granite which is intruded by dikes and irregular masses of leucocratic medium-grained granite. The dioritic pluton is generally a mesocratic biotite-hornblende tonalite to quartz diorite. All three Proterozoic plutonic rock types range from undeformed to well foliated. Within the central region of the range several small Proterozoic gabbroic bodies occur within the porphyritic granite.

Figure 3-2 is a seven-foot long topographic profile of the SSC site and has not been reproduced for this report. Please refer to the original proposal to examine this figure.



ROCK UNITS

Symbol	Description
Qs	Fanglomerate and surficial deposits (Quaternary – Tertiary)
Qb	Basalt (Quaternary)
Qi	Basaltic dikes and plugs (Quaternary)
Ts	Sedimentary rocks (Tertiary)
TKs	Sedimentary rocks (Upper Cretaceous?)
TKg	Granitic rocks (Upper Cretaceous?)
pЄgr	Granitic rocks (Precambrian)
pЄgn	Gneiss (Precambrian)
pЄsc	Pinal Schist (Precambrian)

SYMBOLS

—— Contact

Geology from Wilson et al. (1969).

NORTH

0 3 6 MILES 12

FIGURE 3-3
REGIONAL GEOLOGIC MAP
MARICOPA SITE
STATE OF ARIZONA SSC PROJECT

The Tertiary sequence consists of a gently southwest-dipping stack of sedimentary and volcanic rocks that form an asymmetric southeasterly plunging trough that disappears beneath younger sediments. The lowermost unit consists of a poorly sorted dominantly granite-clast conglomerate that was derived from Proterozoic basement. Field relations suggest that the basal conglomerate is in depositional contact with the basement. Above the lower conglomerate lies a sequence of dense to highly vesicular basalt flows. Above the basalt occurs a granite- and schist-clast conglomerate unit that contains smaller clasts than the basal conglomerate. This middle conglomerate unit locally contains a basal sandstone and is intercalated with locally great thicknesses of vesicular basalt. A welded tuff overlays the middle conglomerate along an angular unconformity and is probably unconformably overlain by an upper conglomeratic unit that is polylithologic and contains local interbeds of tuffaceous sandstone and basalt. The thickness of each unit has not been measured, and may vary considerably. The total thickness of the Tertiary section is in excess of 1,250 feet.

Structures recognized in the Maricopa Mountains include brittle faults, mylonitic and/or cataclastic shear zones, metamorphic foliations and lineations, and bedding in the Tertiary units. More specifically, northwest- or northeast-trending mylonitic and/or cataclastic shear zones are locally common within the two Proterozoic granites, especially near their mutual contacts; however, only a few of these zones are wider than 10 feet. In the southern Maricopa Mountains brittle faults containing up to 10 feet of breccia and gouge occur along two separate fault systems. The western fault is a Precambrian mylonite zone that contains gouge evidencing Tertiary reactivation and places Proterozoic porphyritic granite against Pinal Schist. The eastern fault system consists of multiple splays that juxtapose Tertiary conglomerates against Pinal Schist.

Foliation attitudes within the Proterozoic basement, although not systematically studied, generally strike northeast and dip steeply (>60°). In the center of the range northwest-striking attitudes associated with northwest-trending mylonitic shear zones also are found. Lineations in the plane of foliation generally trend north-northwest and sense of shear, where determined, indicates southeast side up. No major folds occur in the range, but small-scale folds are common in the Pinal Schist.

The Proterozoic plutonic units are believed to have intruded approximately 1.7 Ga (billion years) ago and were subjected to a Proterozoic deformational event which imparted a metamorphic foliation and mylonitic shear zones into the plutons sometime between 1.7 and 1.4 Ga ago (Reynolds, 1987).

In much of Arizona, the Paleozoic Era was characterized by transgression of broad epicontinental seas that covered the region and deposited thick sequences of marine sediments. No record of this event is preserved at the surface in the Maricopa SSC region, but it is remotely possible that Paleozoic sedimentary rocks may be buried deeply in the basins beneath alluvial cover (Peirce et al., 1970). Similarly, Mesozoic plutonic, volcanic, and sedimentary rocks, which occur commonly throughout Arizona and represent Jurassic and Laramide orogenic events, are not found on the surface or in the subsurface in the site region, but may occur deeply buried beneath basin-fill (Peirce et al., 1970).

In southern Arizona, crustal extension occurred in the middle Tertiary at both deep and shallow crustal levels. In late Tertiary time, extension formed block faults during the Basin and Range disturbance. This event, which is responsible for the present physiographic character of the area, was characterized by mostly east-west extension occurring along north-south-trending normal faults. Accompanying regional extension was widespread silicic and basaltic volcanism. In addition, thousands of feet of clastic sediments were deposited in the basins between the fault-bounded ranges (Scarborough and Peirce, 1978). Basin and Range extension ceased in the Maricopa region in the Late Tertiary probably prior to 5 Ma (million years) ago. Since then, the region has undergone very little tectonic activity (see Section 3.4). The Maricopa Site area is now characterized by eroding mountain fronts, extensive pediment development, and an integrated drainage system, all signs of a tectonically quiescent region.

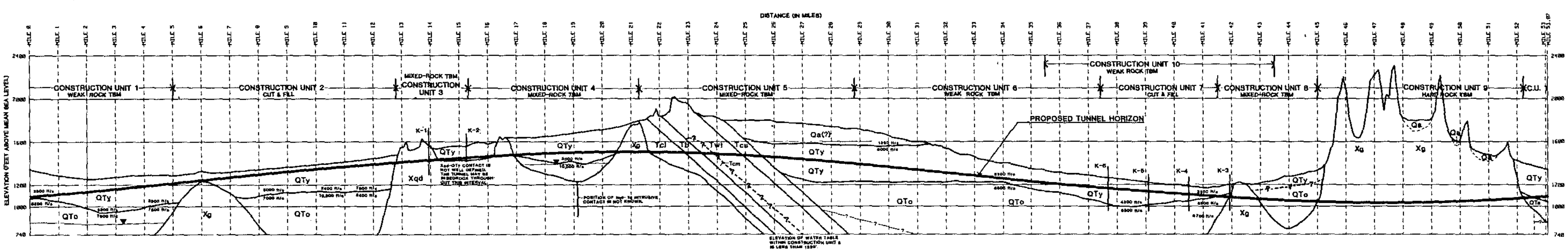
3.2.2 GEOLOGIC PROFILE OF THE MARICOPA SSC SITE

Geologic mapping of the Maricopa Mountains is available at the scales of 1:62,500 (Cunningham et al., 1987) and 1:375,000 (Wilson et al., 1957). Figure 3-4 is presented at a scale of 1:62,500. Figure 3-5 is a geologic cross-section derived from Figure 3-4. The geologic features portrayed in Figures 3-4 and 3-5 are discussed in Section 3.2.3.

3.2.3 SITE-SPECIFIC GEOLOGY OF THE MARICOPA SSC SITE

The geologic setting of the Maricopa SSC Site consists of approximately 18 miles of bedrock and 35 miles of indurated alluvium along the ring alignment. The bedrock consists of 10 miles of Precambrian granite and quartz diorite and eight miles of Tertiary sedimentary and volcanic rocks. The alluvium contains chiefly fanglomerate, with near-surface, thin deposits of sand and silt. Fanglomerate describes locally conglomeratic alluvial fan deposits cemented by calcium carbonate. The ring alignment does not cross any known faults, and the few mylonitic shear zones in the granite that the ring intersects do not pose any reactivation hazards or construction problems.

For purposes of this proposal, the site-specific geology of the Maricopa SSC alignment is most usefully described in terms of Construction Units (CUs). Lithology, structure, geotechnical characteristics, topography, and construction method alternatives serve to define the length and number of CUs (Miller et al., 1987). Table 3-2 summarizes the geographic extent of individual CUs, the geologic conditions anticipated within each CU, a compilation of known seismic velocities, and the SSC facilities present within each CU. (See also Figures 3-4 and 3-5). Compressional wave velocities from seismic refraction profiles provide an accurate and rapid means of characterizing cemented basin-fill sediments. This method was used to investigate fanglomerate along the ring alignment (see Section 3.5.2.1). Sections 3.2.3.1 through 3.2.3.8 provide detailed geologic descriptions for each CU derived from the regional geologic relations discussed in Section 3.2.2 and field examinations.



Qa	QUATERNARY ALLUVIUM
QTy	QUATERNARY - TERTIARY YOUNGER FANGLOMERATE LOWER SEISMIC VELOCITIES THAN QTo
QTo	QUATERNARY - TERTIARY OLDER FANGLOMERATE
Tcu	TERTIARY, POLYLITHOLOGIC UPPER CONGLOMERATE
Twt	TERTIARY, WELDED ASH-FLOW TUFF
Tcm	TERTIARY, BASEMENT-CLAST MIDDLE CONGLOMERATE
Tb	TERTIARY, BASALT FLOWS
Tcl	TERTIARY, GRANITIC-CLAST LOWER CONGLOMERATE
Xqd	PROTEROZOIC, BOOTH HILLS QUARTZ DIORITE
Xg	PROTEROZOIC, PORPHYRITIC GRANITE

NOTE: SEISMIC VELOCITY MEASURED IN FEET PER SECOND.

CONTACT
INFERRED CONTACT
WATER TABLE
INFERRED WATER TABLE

VERTICAL EXAGGERATION IS 20X
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET
SEPT 2 1987

FIGURE 3-5
GEOLOGIC PROFILE
MARICOPA SITE
STATE OF ARIZONA SSC PROJECT

TABLE 3-2
GEOLOGIC SUMMARY OF MARICOPA SITE CONSTRUCTION UNITS

CONSTRUCTION UNIT	MILEAGE FROM	MILEAGE TO	EXPECTED GEOLOGIC FEATURES	APPROXIMATE SEISMIC VELOCITY IN FEET/SEC.	SSC FACILITIES
1	52.2	52.8	"Older" Fanglomerate	6,900 - 11,000	Shafts E2, E3, and F2
Section 3.2.3.1)	0(52.8)	5.0	Variably cemented clayey to gravelly sands and silts, ("younger" fanglomerate).	2,800 - 4,000	
2 (Section 3.2.3.1)	5.0	6.0	Variably cemented clayey to gravelly sands and silts, ("younger" fanglomerate).	2,800 - 4,000	Shafts E1, F1 and F10
	6.0	12.8	Gravelly sands grading to silty sands ("younger" fanglomerate).	~ 3,000	
			Basement imaged at 2,150 ft.	~ 13,000	
3 (Section 3.2.3.2)	12.8	14.2	Booth Hills quartz diorite	~ 12,000	Experimental Chambers K1 and K2, and the Injection Complex.
	14.2	15.3	Variably cemented silty sands ("younger" fanglomerate).	2,000 - 3,000	
4 (Section 3.2.3.3)	15.3	16.3	Variably cemented silty sands ("younger" fanglomerate).	2,000 - 3,000	Shafts F10 and F9
	16.3	16.9	Booth Hills quartz diorite.		
	16.9	20.5	Variably cemented silty sands ("younger" fanglomerate).	2,500 - 3,000	
	20.5	21.3	Porphyritic granite.		

TABLE 3-2
GEOLOGIC SUMMARY OF MARICOPA SITE CONSTRUCTION UNITS

CONSTRUCTION UNIT	MILEAGE FROM	TO	EXPECTED GEOLOGIC FEATURES	APPROXIMATE SEISMIC VELOCITY IN FEET/SEC.	SSC FACILITIES
5 (Section 3.2.3.4)	21.3	25.5	Granite-clast and polylithologic conglomerates; flow-foliated basalts; limestone; expect rapid lateral lithologic changes.		Shafts E8, E9, and F8
	25.5	28.8	"Older" Fanglomerate	~ 6,000	
6 (Section 3.2.3.5)	28.8	37.4	"Younger" and "Older" Fanglomerate	3,700 - 8,500	Shafts E6, E7, F6, and F7
7 (Section 3.2.3.5)	37.4	39.0	"Younger" and "Older" Fanglomerate	3,700 - 8,500	Experimental Chambers K3, K4, K5, and K6, and Shaft F5.
	39.0	41.5	"Younger" Fanglomerate	2,500 - 4,000	
8	41.9	42.9	Porphyritic granite.		Shaft E5
(Section 3.2.3.6)	42.9	45	"Older" Fanglomerate	~ 7,700	
9 (3.2.3.7)	45.0	52.25	Porphyritic granite		Shafts E4, F3 and F4

3.2.3.1 Construction Units 1 and 2 (Mile 52.2 to 5; mile 5 to 12.8). The ring passes through fanglomerate in most of these two CUs. Six separate seismic refraction profiles along this length indicate that the upper 655 feet of fanglomerate consists of a two-layer system with the upper 250-300 feet consisting of indurated fine sandy or locally clay-rich silts with compressional wave velocities between 2,800-4,000 ft/s. The lower unit consists of indurated, poorly sorted sandy gravel with compressional wave velocities between 6,900 and 11,000 ft/s. Near mile 4.5 a 6.5-inch hollow stem auger hole was drilled to sample the upper silts. The hole, borehole MA-3, was drilled to a depth of 32 feet, where it bottomed in cobbles or a boulder. Therefore, borehole MA-3A was drilled to a depth of 60 feet, 100 yards to the southwest of MA-3. The composite section derived from logs of both holes shows the profile to consist of 12% silty clay, 5% sandy silt, and 83% clayey to gravelly sand (visual classification). The predominance of sandy lithologies and the nearly ubiquitous presence of fine gravel is probably due to the proximity of MA-3 and MA-3A to bedrock. Thin interbedding and textural characteristics of the sediment suggest an alluvial fan.

At mile 8.25 a 42-inch large-diameter auger hole, MA-2, was drilled to a depth of 70 feet. Visually classified sediments consist of 9% clay, 34% silt, 43% silty-sand and 14% sand. The generally finer grained character of this sediment compared to that encountered in boreholes MA-3 and MA-3A, the presence of abundant mica, and the paucity of gravel suggest a lower energy deposition overall and greater distance from bedrock. General fining of sediments basinward has been observed in many basins throughout Arizona (Scarborough and Peirce, 1978). These sediments probably represent distal alluvial fan and intermittent stream overbank deposits.

Near mile 6 the ring passes 500 feet south of a Proterozoic porphyritic granite ridge. The granite might intersect the ring alignment although the subsurface geometry of the granite-fanglomerate contact is not well known. The granite is a gray to brownish-tan, medium- to very coarse-grained porphyritic biotite granite. Potassium feldspar phenocrysts in the coarsest phases average one to two inches in length. The granite ranges from undeformed to well-foliated although the vast majority of outcrop exposures are weakly to moderately foliated. Foliation is commonly best developed along zones where the porphyritic granite is intruded by a younger leucocratic muscovite-biotite granite. A mylonitic fabric is locally well developed.

3.2.3.2 Construction Unit 3 (Mile 12.8 to 15.3). At mile 12.8 the ring alignment passes into the Booth Hills which consist of mesocratic, fine- to medium-grained biotite-hornblende quartz diorite. Locally, epidote is present along fractures and replaces biotite and hornblende. Conspicuous 0.5- to 0.75-inch quartz eyes are characteristic of this unit.

At mile 14.2 the ring leaves the Booth Hills and enters a zone of fanglomerate and shallow bedrock. The bedrock is expected to be a subsurface projection of the Booth Hills quartz diorite. This was verified by Borehole MD-3R which was diamond-drilled through 120 feet of homogeneous Booth Hills quartz diorite near mile 14. The fanglomerate consists of cemented sands, silts and gravels.

Seismic refraction surveys indicate compressional wave velocities of 2,000-3,000 ft/s.

In order to obtain data on the stratigraphy of the fanglomerate adjacent to bedrock outcrops, a 6.5 inch hollow-stem auger hole, MA-1, was drilled near mile 15 to a depth of 76 feet. Refusal was encountered in cemented gravel or cobbles. Visual classification of the sediments show that they consist of 34% sandy clay, and 66% clayey or silty sand. Interbedded clayey sands and sandy clays, with few silty units, suggest the possibility of a succession of buried paleosols. This type of sequence is what might be expected in thin, pediment-mantling deposits where a long stable period of basin-fill is represented by only a few feet of sediment. Thicknesses above the pediment range from 150 to 0 feet, and probably vary abruptly over buried topographic features developed on the pediment.

3.2.3.3 Construction Unit 4 (Mile 15.3 to 21.3). The ring continues to traverse fanglomerate, probably shallowly floored by Booth Hills quartz diorite until mile 16.3. From mile 16.3 to 16.9 it reenters Booth Hills quartz diorite. To mile 20.5 the ring passes largely through fanglomerate. Depth to bedrock is poorly defined for this segment of the ring path, however, and the ring could pass into bedrock. Basement in this area may be Pinal Schist, porphyritic granite, or Booth Hills quartz diorite. The fanglomerate here consists of cemented sand and silts derived from eroded porphyritic granite, Booth Hills quartz diorite, and Pinal Schist. A seismic line 0.8 miles west of mile 17.6 indicates that the fanglomerate has compressional wave velocities of approximately 2,500 ft/s. At mile 20.5 the ring enters porphyritic granite and remains in granite until the end of the CU.

Porphyritic granite is described in CUs 1 and 2 (Section 3.2.3.1), and Booth Hills quartz diorite is described in CU 3 (Section 3.2.3.2). The Pinal Schist is a fine- to medium-grained biotite-muscovite quartzo-feldspathic schist with a generally strong foliation coincident with lithologic layering and a penetrative lineation in the plane of foliation. The rock unit is medium gray to brownish-gray, and muscovite up to 0.5 inches in size is common. Pinal Schist is concordantly intruded by abundant muscovite pegmatites. Locally, the pegmatites are so common that the rock appears migmatitic. Deformation within the Pinal Schist is easily observed at the outcrop scale; minor folds, fold boudins, intrafolial folds, and sheared-out chevron folds occur locally.

3.2.3.4 Construction Unit 5 (Mile 21.3 to 28.8). The ring passes from the porphyritic granite of CU 4 into a Tertiary sequence of volcanic and sedimentary rocks. It will first enter into a poorly sorted granite-clast conglomerate. This unit lies depositionally upon basement and varies laterally in thickness. Clasts are typically one inch in diameter, but can be as large as three feet. Clasts are subangular to subrounded, and cemented by a dark red, locally arkosic, quartzose cement. Tuffaceous sandstone subunits occur locally within the lower sections of the basal conglomerate. Lying depositionally above the basal conglomerate is a thick sequence of dense to vesicular black to medium-gray olivine basalts. Flow foliation is common in the basalts. Above the basalt is the middle conglomerate unit which is predominantly composed of clasts of all Precambrian basement lithologies in a quartzose cement. Within the middle conglomerate are intercalated basalt flows and a thin, very fine-grained, thinly laminated, lacustrine(?) limestone. The middle conglomerate is unconformably overlain by a reddish-gray massive welded tuff that is horizontally and vertically fractured. Above the welded tuff is the upper conglomerate that is polylithologic and also contains subunits of basalt flows and tuffaceous sandstone. Clasts in the upper conglomerate are generally two to five inches in diameter with a few clasts up to 20 inches. The clasts are matrix supported in a dark red quartzose to calcareous cement.

Core from diamond drillhole MD-1R, located one mile southeast of mile 23.5, suggests that thickness and facies variations are expected within the Tertiary rock sequence. This hole penetrated 1,250 feet of volcanic and sedimentary rocks and did not reach basement. According to drillhole information, the upper conglomerate is 250 feet thick and underlain by 350 feet of basalt flows. Two hundred fifty feet of middle conglomerate lie beneath the basalts. Separating the middle and basal(?) conglomerates is 200 feet of basalt. Drilling ceased after 200 feet of basal(?) conglomerate was sampled.

The entire Tertiary sequence strikes approximately N45°W and dips gently to the southwest. The Tertiary basin is an asymmetric trough that plunges gently to the southeast. No faults are known to occur within the Tertiary section, but the basin is, locally, in fault contact with the Pinal Schist to the west.

At mile 25.5 the ring passes from the Tertiary rock sequence into the fanglomerates of the Bosque Valley. The fanglomerate there is composed primarily of eroded granite and is expected to consist of cemented sands, silts, and fine-grained conglomerates.

3.2.3.5 Construction Units 6 and 7 (Mile 28.8 to 37.4; mile 37.4 to 41.5). For the entire length of CUs 6 and 7 the ring passes through fanglomerates of the Bosque Valley. Three separate seismic refraction profiles along this length indicate that the fanglomerate has compressional wave velocities varying from 3,700 to 8,500 ft/s. The fanglomerate is expected to consist of sands, silts, and fine gravels. Northeast of mile 31 a reverse circulation rotary borehole, MD-6, penetrated 258 feet of material identified visually as sandy clay and silty sand. No groundwater was encountered. Approximately 39% of the sediments were classified as fine sandy clays and 60% as silty fine sands. A trace of gravel is found as thin lenses. All sediments in Borehole MD-6 are weakly to moderately lime cemented. This overall fine-grained character shows that sediments of the upper basin-fill become finer to the southeast in the Bosque Basin and to the west, toward Gila Bend. The fine-grained character of these sediments, coupled with the presence of thin lenses of gravel, suggest that they were deposited as overbank flood sediments or as playa or playa-edge sediments. The lateral extent of these fine-grained sediments is currently unknown.

At mile 39.5, Borehole MA-6 penetrated 70 feet of indurated sediment, consisting of 4% silt, 66% silty or clayey sand, and 30% sandy gravel (visual classification). The ubiquitous presence of varying amounts of gravel in all units of Borehole MA-6, the extremely poor sorting of sediments, and the vertical variability of sediment textures suggest that Borehole MA-6 penetrated intermittent channel, sheetflood, and overbank deposits in the medial portion of an alluvial fan. Sand and gravel deposits between 12 and 33 feet in thickness probably represent intermittent channel deposits. Clayey sands probably represent mixed sheetflood and overbank sediments, possibly with some accumulation of paleosol clays.

At mile 41, a 42-inch large-diameter auger hole (MA-5) penetrated 70 feet of cemented silty to gravelly sand. The extremely poor sorting of these deposits, which range in grain size from clays to cobbles, the apparently local derivation from granitic source rock, and the general lack of vertical variability suggest that Borehole MA-5 penetrated intermittent channel and sheetflood deposits on the proximal portion of a small alluvial fan. The lower percentages of gravel here may be accounted for by provenance. The granitic bedrock appears to weather more readily than the metamorphic source rocks of Borehole MA-6 because of the granite's mineralogical composition and larger grain size.

3.2.3.6 Construction Unit 8 (Mile 41.5 to 45.0). At mile 41.5 the ring enters porphyritic granite and returns to fanglomerate at mile 42.3. The fanglomerate in this area is derived from granite and is expected to consist of lime-cemented, fine-grained sands, silts, and gravels. One seismic refraction profile from this area indicates that the fanglomerate has compressional wave velocities of 4,200 ft/s in the upper 90 feet and 7,700 ft/s below 90 feet.

At mile 42.5, a 6.5-inch hollow stem auger hole (MA-4) penetrated 100 feet of texturally diverse sediments. One four-foot thick unit of sandy clay makes up 4% of the section. Beds of silty, clayey and gravelly sand from five feet to 27 feet thick make up 84% of the section. A 12-foot-thick silty sandy gravel makes up the final 12% of the section. All identifications were made visually in the field. The extremely poor sorting, rapid vertical variability in sediment texture, unit thicknesses, and grain size range suggest deposits from intermittent streams, sheetflood, and overbank flooding on the medial part of a moderate-sized alluvial fan.

The ring enters porphyritic granite near mile 45, where 450 feet of weakly foliated porphyritic granite were sampled in Borehole MD-5. This granite is described in Section 3.2.3.1.

3.2.3.7 Construction Unit 9 (Mile 45.0 to 52.2). From mile 45 to mile 51.25, the ring passes through porphyritic granite. Seismic refraction profiles indicate that only thin veneers of fanglomerate (no thicker than 100 feet) are present from mile 47.5 to 48.75 and mile 50.25 to 51.25. At mile 51.25 the ring may pass through a leucocratic, tan to cream, fine to medium-grained muscovite-biotite granite. This granite is not porphyritic and intrudes the porphyritic granite as both concordant and discordant masses. From mile 51.25 to the junction with CU 1, the ring passes through fanglomerates as described in CU 1 (Section 3.2.3.1).

3.2.3.8 Construction Unit 10 (Mile 35.5 to 43.5). From mile 35.5 to 43.5 a by-pass tunnel will be constructed. This facility is treated as a separate CU because the geologic and topographic characteristics of this length are most efficiently and cost-effectively constructed by a single TBM designed for weak-rock applications (see Section 3.5.4.2) separate from CUs 6, 7, and 8. Geologic descriptions for the materials that will be penetrated are presented in Sections 3.2.3.5 (CUs 6 and 7), and 3.2.3.6 (CU 8).

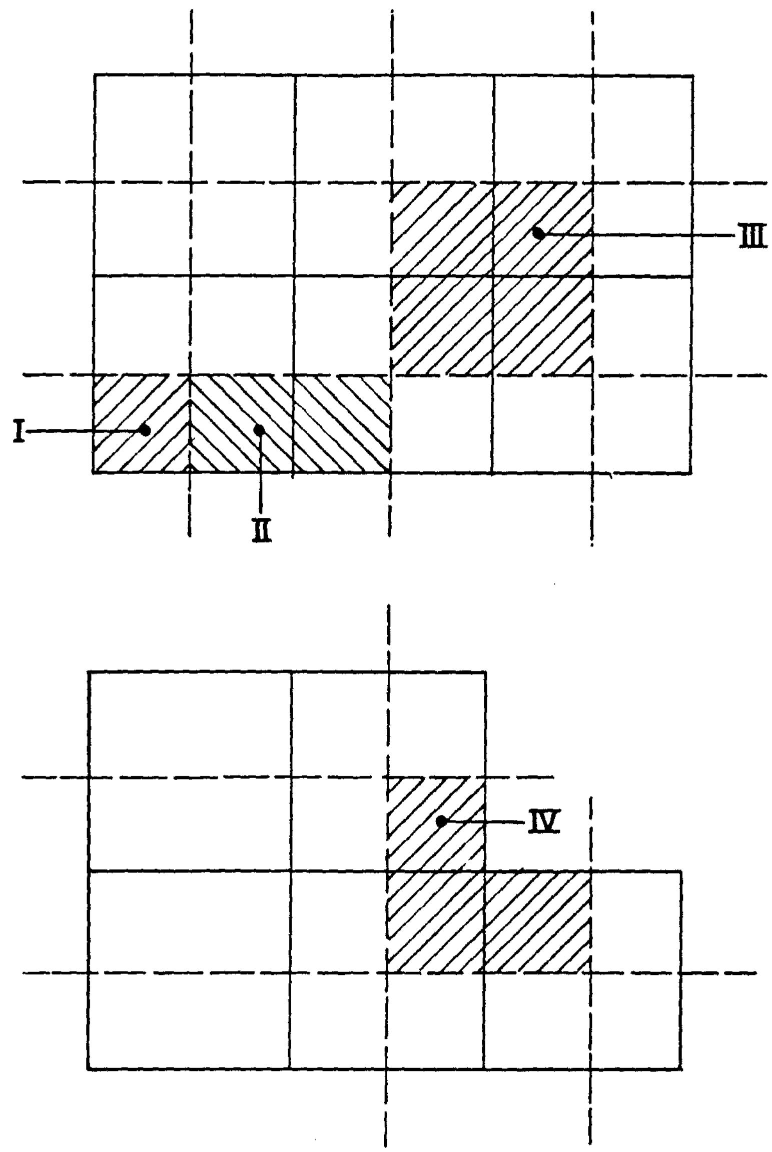
3.2.4 GEOLOGIC CONCERNS IN CONSTRUCTION OR OPERATION

3.2.4.1 Structural Settlements. Structural settlements, either short-term or long-term, are not expected to pose a problem at the Maricopa Site. As indicated in Section 3.2.1, approximately 18 miles of the ring will pass through bedrock and 35 miles, including the campus facilities and six collision halls, will be founded on fanglomerate. The bedrock along the tunnel alignment is competent and is not expected to deform under the magnitude of the anticipated applied loads. As indicated in Section 3.5.2.1, the fanglomerate has geotechnical engineering properties similar to those of a weak sandstone. Therefore, although some settlement can be expected, it will take place during construction and be of relatively small magnitude under the anticipated design loads. Since all settlements in the fanglomerate will be "immediate," the site offers the advantage of allowing compensation during construction for even minute differential settlements. In addition, since soft clays are not known to exist at depths of foundation influence (see Section 3.2.5.1) it is unnecessary to predict time-dependent consolidation settlement of clay materials. Finally, since the water table is below the foundation elevations of any SSC facility (see Section 3.3.1.1), the site is free of potential settlement problems caused by excavation dewatering.

In order to estimate the potential for settlement of structures founded at various depths within the fanglomerate, the following assumptions were made with regard to loading:

- Office buildings $p = (15 \text{ pcf})(12 \text{ ft/story}) = 180 \text{ lb/ft}^2$ - story
- Heavy buildings $p = (20 \text{ pcf})(12 \text{ ft/story}) = 240 \text{ lb/ft}^2$ - story

Column loads for the three different types of areas shown in Figure 3-6 were computed using these expressions. In order to estimate footing size for these column loads, an allowable bearing pressure based on the ultimate bearing capacity of the fanglomerate and acceptable settlements had to be estimated. If the effect of friction angle is neglected, and the cohesion parameter of 3200 psf given in Table 3-12 of Section 3.5.2.1 is used, the bearing capacity of a footing founded on the surface of the fanglomerate may be conservatively estimated by the Terzaghi Equation to be q(ult) = 20,000 psf = 10 tsf. If the friction angle of 37° is taken into account, then the bearing capacity of a footing founded on the surface of the fanglomerate becomes q(ult) = 178000 psf = 89 tsf. Although these conservatively computed capacities are high, they do not control the foundation design. Therefore, in order to keep settlements within an acceptable range, the more conservative value of q(ult) = 20000 psf was used for this evaluation. An allowable bearing pressure of q(all) = 10000 psf yields a factor of safety of 2 with respect to bearing capacity failure. On this basis the most



AREA TYPE	FOOTING TYPE
TYPE I	SPREAD OR CONTINUOUS
TYPE II	SPREAD OR CONTINUOUS
TYPE III	SPREAD
TYPE IV	SPREAD OR CONTINUOUS

FIGURE 3-6
TYPES OF FOOTINGS AND LOADED AREAS

critical foundation conditions occur in the Campus Laboratory Building (CA-1) where the following maximum footing sizes were computed:

- Spread footing (square) B = L = 11.5 ft.
- Continuous footing B = 7 ft.

An elastic analysis was used to estimate settlements (Schmertmann, 1970;1978) because the fanglomerate is unsaturated and does not exhibit time-dependent load-deformation behavior. The results of the analysis for both the spread footing and continuous footing are shown in Table 3-3. The settlements shown are total settlements and they will occur during construction. Conservative values of soil modulus were used; therefore the reported settlements represent maxima. Refinements will be made as more building-specific data are provided.

Our preliminary analysis and design of the mat foundation envisaged for the collision halls indicates that it will be approximately nine feet thick. Conservative assumptions were made regarding the magnitude of the loads and the distribution of contact stresses. A more sophisticated finite element (FEM) analysis is required to determine settlements and mat deformations. The FEM analysis was not performed as part of this proposal pending issue of more detailed loading data. In any case, settlements and deformations will occur within a very short time, before the end of construction.

3.2.4.2 Slope Stability. Visual observation of natural slopes at the Maricopa Site and construction experience with cut slopes in virgin soils at the site and in surrounding areas suggests that such slopes are extremely stable even over long periods of time. Typically, roadway cuts made in the fanglomerate throughout Maricopa County remain extremely stable at angles shallower than 45° although long-term erosion generally becomes a problem for unprotected slopes. Experience with cut slopes in similar materials at the Twin Buttes Mine, approximately 100 miles south-southeast of the Maricopa Site, and the Sacaton Mine, approximately 30 miles southeast of the site, indicates that near-vertical slopes have been standing to heights of 50 to 60 feet for more than ten years (refer to Figures 3-12 through 3-16). In some areas the Twin Buttes pit has been "double benched." This suggests that near-vertical slopes could be stable at heights of 100 to 120 feet. Therefore the slope angle (60°) and depth (80 feet) proposed in Section 3.5.4.1 for cut-and-fill CUs are conservative. As indicated in Section 3.5.2.1, the results of laboratory tests and seismic refraction studies indicate that the fanglomerate at the Maricopa Site has geotechnical engineering properties very similar to those measured at the Twin Buttes Mine. Construction experience with similar materials in the greater Phoenix area indicates that three- to four-story basement excavations can be made easily at near-vertical slope angles (Hansen, 1985a). Therefore, there is every reason to believe that slope instability will not pose construction problems or long-term operational problems at the Maricopa Site.

To verify the observational experience analytically, slope stability analyses using Bishop's Modified Method (Bishop, 1955) were performed for a number of different slope angles and heights. Shear strength parameters of $c = 3200$ psf and $\phi = 37°$, as determined in the laboratory and inferred from field tests at the Twin

TABLE 3-3

Settlement Estimates for Critical Footing Sizes[1]

Spread Footing (L = B = 11.5 ft.)		Continuous Footing (L/B > 10, B = 7 ft.)	
Depth (ft)	Settlement[2] (inches)	Depth (ft)	Settlement[3] (Inches)
0	$\leq$ 1	0	$\leq$ 1/2
10	$\leq$ 3/4	10	$\leq$ 1/3
20	$\leq$ 1/2	20	$\leq$ 1/4
30	$\leq$ 1/3	30	$\leq$ 1/6
40	$\leq$ 3/16	40	$\leq$ 1/12
50	$\leq$ 1/8	50	$\leq$ 1/16
60	$\leq$ 1/16	60	Negligible
70	Negligible	70	Negligible

[1] All settlements are immediate and are inversely proportional to E.

[2] Based on elastic analysis with constant E = 600 tsf.

[3] Based on elastic analysis with constant E = 840 tsf.

Buttes mine (see Section 3.5.2.1), were used in all of the analyses. The total unit weight was taken as 130 pcf based on measurements performed on core samples. A ground-water table was not considered. The results of the analyses for slope angles (B) = 60° and 45° are summarized in Table 3-4. For vertical slopes the maximum slope height (H) is related to in-service safety factor (F) as H = 213/F (feet). It is clear from this expression and from Table 3-4 that cuts made into the fanglomerate will be stable with a factor of safety of at least 2 at angles up to 90° and to depths of 100 feet. It should also be kept in mind that these results are based on a value of cohesion that is conservatively low.

3.2.4.3 Natural Gas. Gases related to the presence of hydrocarbons, coal-bearing or carbonaceous materials are not known or suspected to be present at the Maricopa SSC site. The geology of the area is fundamentally a Precambrian basement terrane with no record of Paleozoic or Mesozoic rocks, thought to be permissible source materials for these gases. The Tertiary stratigraphic section, consisting of volcanic rocks and basement-derived conglomerate, is not believed to be a viable source of natural gases. Construction problems related to the presence of natural gas are not expected at the Maricopa SSC site.

3.2.4.4 Subsidence. Geologic materials prone to the formation of solution cavities are not present at the Maricopa Site.

The Maricopa Mountains consist almost wholly of a 1.7 Ga granitic basement terrane and for that reason may be considered metallogenically barren. As a result, the Maricopa Mountains have not been the site of any of Arizona's enormous mining activity. Fewer than 10 pre World War II prospect pits and very short adits are found scattered about the Maricopa Mountains, but no extensive surface or underground workings of the type associated with modern mining techniques are present. Therefore, the Maricopa SSC alignment will not suffer from construction problems related to the presence of mining excavations.

The ring at the Maricopa Site has been located in an area with no measured or suspected subsidence from ground-water withdrawal. The physical characteristics of the aquifer, the lack of previous water-table decline, and the ability to control future pumping indicate that future subsidence from this source will not be a problem.

Land surface subsidence has commonly been associated with ground-water withdrawal in the alluvial basins of the Southwest. Where subsidence has occurred in Arizona, relationships have been found between water-level decline and subsidence. This relationship is dependent on three major parameters: (1) the thickness of the alluvium, (2) the percentage of fine sediments, and (3) the degree of cementation or competency of the material. Thus, most of the recorded subsidence in the State has occurred in heavily pumped alluvial basins filled with thick deposits of fine, uncompacted material.

Land surface subsidence caused by ground-water withdrawal has been observed in adjacent, but hydrologically separate, areas of the Salt River Valley and

TABLE 3-4

SUMMARY OF SLOPE STABILITY ANALYSES
MARICOPA FANGLOMERATE

Slope Angle B (deg)	Height H (ft)	Safety Factor F (min)
60	40	4.31
	50	3.65
	60	3.21
	70	2.89
	80	2.65
	90	2.46
	100	2.31
45	40	5.20
	50	4.45
	60	3.93
	70	3.56
	80	3.28
	90	3.06
	100	2.88

[1] Parameters used in the calculation - c = 3200 psf; ϕ = 37°; γ = 130 pcf.

Stanfield. This subsidence is not of the sinkhole variety found in other parts of the nation, but is usually a general lowering of the land surface with differential subsidence near pediments, that can form earth cracks and earth fissures. Areas in which subsidence has occurred normally have had cumulative water-table declines of well over 100 feet. Although data are lacking, because of the scarcity of wells, the Maricopa Site probably has not experienced any significant water-table decline. At the village of Mobile, 1.5 miles east of the site, the ground water has been drawn down only 10 feet since 1950. The interior of the ring site, except for five square miles of private land, is managed by the Bureau of Land Management. As a result, the only pumping that has occurred is from low-capacity livestock and domestic wells that withdraw less than 10 acre-feet per year, per well. Currently no producing wells exist inside the site circumference.

A National Geodetic Survey level line follows the Southern Pacific Railroad through Mobile and across the northern third of the site. Comparison of the elevations from 1949, 1967, and observed elevations in 1980 reveals no subsidence at the site or northeasterly along the railroad in Mobile Valley.

Only the northeastern section of the ring, mile 0 to mile 10, can be affected by pumping, since it lies within the Waterman Wash basin. The rest of the land surrounding the site is owned by the State or Federal Government; thus when land for the project is acquired a buffer zone will be included that will permit control of near-site ground-water pumping. Extensive drawdown calculations were performed for the northeastern section under various pumping scenarios. The results indicate that, even under pumping conditions more severe than currently occur or are anticipated to occur, drawdown will not be of a magnitude sufficient to cause subsidence. The results and description of methods used in these calculations can be found in Appendix 3-A. As local land use in the area changes from irrigated agriculture to urban or suburban development, pumping rates will be reduced still further. The Arizona Ground Water Management Act, passed in 1980, prohibits any new development of irrigated agricultural acreage.

Another key consideration is the character of the sediments. Strange (1982) states that "the most important mechanism in subsidence is the compaction of the clay and silt layers in the sediments, brought about by the expulsion of water from the clay minerals into the void spaces in adjoining sands and gravels created by removal of water." Available data, which include nearby U.S. Geological Survey test wells (Wilson, 1979) and SSC test holes, describe the physical characteristics of any aquifer materials that could be dewatered as slightly to moderately consolidated gravelly sand. These materials are not prone to compaction. Any clay present is dispersed throughout the sediments and not as extensive clay beds. In the Waterman Wash agricultural area, 10 miles to the north of the ring, drill holes penetrate alluvial deposits similar to those at the Maricopa Site (ADWR well log data base). At that location, water table declines of over 150 feet have produced no evidence of subsidence.

The lack of previous ground-water withdrawal on or near the site, the absence of compactible material in the aquifer, and the ability to control future ground-water pumping thus indicate no potential for subsidence at the Maricopa Site.

3.2.5 SOIL CONDITIONS THAT MAY POSE CONSTRUCTION PROBLEMS

3.2.5.1 Soft Clay. Several thick, laterally extensive, clay-rich lacustrine deposits are found at considerable depths in south-central Arizona. These occur at the Arizona Hazardous Waste Site west of Mobile, at the site of the Palo Verde Nuclear Generating Station northwest of Buckeye, in the Gila Bend area, and in some of the deep basins in the vicinity of Phoenix, including the Luke, Paradise, and Higley Basins. Elevations and thicknesses of these deposits are shown in Table 3-5. Many of these deposits are related to a period of internally directed drainage or sluggish external drainage prior to the establishment of the modern throughflowing Salt/Gila/Colorado River system (Eberly and Stanley, 1978; Scarborough and Peirce, 1978). The differing structural positions of these clays may reflect the different levels of basin filling and different geologic histories of the basins in which they are found.

Four boreholes were drilled at the Arizona Hazardous Waste Site (refer to Figure 3-7) as part of the investigations for that facility. In each of these boreholes a thick bed of soil containing as much as 60% by weight of silt and clay was encountered below 200 feet of poorly sorted, clayey sand. The lateral extent of this deposit is unknown. X-ray diffraction analyses performed on the clay-fraction of soils sampled at shallower depths indicate the presence of smectite or an expansive type of chlorite, and illitic clays.

Nine bore holes were drilled into the fanglomerate in the various basins at the Maricopa Site as part of the Arizona SSC proposal preparation. The borehole locations are shown in Figure 3-7. Descriptions of the materials encountered are given in Section 3.2.3.

X-ray diffraction analyses were performed on specimens prepared from the clay fraction of selected samples taken from borings MA-2, MA-5, MD-6, and MD-7. Table 3-6 presents a summary of the results of these analyses. As indicated in the table, an expansive clay mineral (smectite) was identified in Boring MD-6 at each of the depths sampled. Therefore, it is likely that the clayey sands encountered in that boring are expansive. Such soils may either be chemically stabilized prior to construction, or, for near-surface construction, removed and replaced by non-expansive materials (Nowatzki, 1981a). A number of proven techniques are available for stabilizing such soils (Sowers, 1979; Winterkorn and Fang, 1975).

3.2.5.2 Unconsolidated Sand. Because of the alluvial geomorphology of the desert basins, pockets of unconsolidated sands are sometimes encountered during conventional geotechnical field investigations (Beckwith, 1968; Tweet, 1984). The occurrence of such deposits is generally limited to areas within the flood-plains of major water courses. The SSC ring alignment has been purposely located away from such features; therefore, these deposits are not expected to pose problems during construction of any of the facilities.

TABLE 3-5

CLAY DEPOSITS IN SOUTH-CENTRAL ARIZONA

Location	Elevation	Thickness	Distance From Maricopa Site
Gila Bend (Ross, 1923, Heindl & Armstrong, 1963)	600-700 ft.	300-500 ft.	25 mi.
Luke Basin (Eaton et al, 1972)	1000 ft.	55 ft.	25 mi.
Palo Verde Nuclear Plant (Fugro, 1974)	1150 ft.	120 ft.	30 mi.
Adjacent to Maricopa Mts. (Jones, 1987)	1212 ft.	844 ft.	5 mi.
Paradise, Higley Basins (Scarborough & Peirce, 1978)	300-400 ft.	>300 ft.	50 mi.

TABLE 3-6
RESULTS OF X-RAY DIFFRACTION[1] ANALYSIS

Sample	Air Dried[2] 2θ (deg)	Air Dried[2] d (A)	Glycolated[3] 2θ (deg)	Glycolated[3] d (A)	Heated[4] 2θ (deg)	Heated[4] d (A)	Mineral Identification
MA 2 50-55	8.5	10.4	Not run		--	--	Attapulgite
	12.5?	7.1			--	--	Chlorite?
MA 5 60-65	7.2	12.27	Not run		--	--	Vermiculite
	8.9	9.93			8.9	9.93	Mica
	12.5	7.08			--	--	Chlorite?
	23.2	3.83			--	--	K-feldspar?
	26.9	3.31			--	--	Quartz
	29.5	3.03			--	--	Calcite
MD 6 25-30	6.0	14.72	5.2	17.00	--	--	Smectite
	8.9	9.93	8.9	9.93	8.9	9.93	Mica
	9.9	8.93	9.9	8.98	10.0	8.84	?
	17.8	4.98	Run stopped		Run stopped		Mica
	26.9	3.31					Mica
MD 6 50-55	6.1	14.48	5.2	17.00	--	--	Smectite
	8.9	9.93	8.9	9.93	8.9	9.93	Mica
	9.9	8.93	9.9	8.93	10.0	8.84	?
	17.8	4.98	Run stopped		Run stopped		Mica
	21.7	4.09					
MD 6 248-253							
	6.1	14.48	5.2	17.00	--	--	Smectite
	8.9	9.93	8.9	9.93	8.9	9.93	Mica
	9.9	8.93	9.8	9.02			?
MD 7 75-80	8.9	9.93	Not run		9.0	9.82	Mica
	12.5	7.08			Run stopped		Chlorite

[1] All tests were performed on a general Electric XRD-5 instrument with copper K_{α_1} radiation (λ= 1.54050 A).

[2] All specimens were prepared on glass slides from extract taken from soil-water slurry.

[3] Ethylene glycol treatment was performed only on air-dried specimens that exhibited a well-defined 14 A peak.

[4] Air-dried specimen left in 400°C furnace for minimum of three hours prior to x-ray analysis. A dash (--) indicates that a peak observed in test on air-dried specimen disappeared.

3.2.5.3 Collapse-Susceptible Soils. Near surface collapse-susceptible soils are generally found in arid or semi-arid regions where high evaporation rates cause smaller sized particles of silt/clay to be drawn to the contact points between larger particles in recently deposited sediments. As the sediments dry, strong bonds are formed at the contact points by surface tension. These bonds cause the soil mass to be quite stable as long as it remains dry. Failure of such soil masses generally occurs as a rapid change of volume or "collapse" that takes place under either of two conditions. First, applied loads exceed the dry strength of the silt/clay bonds at contact points. Second, the soil is wetted to near saturation while carrying a load less than the dry strength failure load. In either case the failure is usually rapid.

The phenomenon of collapse-susceptible soils in southern Arizona has been studied extensively (Abdullatif, 1969; Alfi, 1984; Anderson, 1968; Beckwith and Hansen, 1982; Crossley, 1969; Nowatzki, 1981b; Sabbagh, 1982). Most recently Ali (1987) has shown statistically that the probability of occurrence of such soils is greatest in the flood plains of major water courses, at least in the Tucson vicinity. Since the ring alignment was purposely located as much as possible in the pediments away from rivers and streams, collapse-susceptible soils are not expected to pose significant problems for construction or structural stability. Ali (1987) has also shown statistically that the severity of collapse susceptibility decreases with depth with the most collapse susceptible soils found within the top five to six feet of the surface. Since the foundations of most of the structures associated with the SSC project will be founded at depths greater than these, collapse-susceptible soils are not expected to pose difficulties even in areas where they may be encountered closer to the surface. Finally, geotechnical engineers in the Southwest have wide experience dealing with stabilization of such soils (Hansen, 1985b; Nowatzki, 1981b; Schwindt, 1982, 1984).

3.2.5.4 Perched Ground Water. Perched water is known to exist in numerous areas in southern Arizona, but it is most common in heavily irrigated areas where a constant source of recharge is available. There is no agriculture within the Maricopa Site boundaries. Although the presence of clays at the site suggest a possibility for perched water, the available information shows no indication of it. Eight alluvial drill-holes ranging in depth from 70 to 655 feet were spaced around the site perimeter. No saturated or even near-saturated zones were detected other than the regional unconfined water table. This conclusion was confirmed with borehole geophysics. Analysis of aerial photographs of the site show no abnormally vegetated areas that would indicate near-surface perching of water. These findings, along with low precipitation, high evapotranspiration, and the generally impermeable nature of the surface soils indicate that perched water is extremely rare if not absent entirely at the Maricopa Site.

3.2.6 LOCATIONS AND SOURCES OF DATA

Adequate data are available for the site to define the character of rock, fanglomerate, and unconsolidated alluvium expected to be involved in construction. Previous geologic investigations by Wilson et al. (1957) and Cunningham et al. (1987) provide the baseline for information. The Arizona SSC Project augmented these and other studies mentioned in Section 3.2.1 with geophysical exploration and geotechnical drilling programs. Geophysical exploration included seismic refraction, gravity, magnetic, and resistivity and induced-polarization surveys along segments of the ring path lacking bedrock outcrops (Bryan et al., 1987; Sternberg and Esher, 1987; Sternberg et al., 1987; Sternberg and Sutter, 1987). The geotechnical drilling program consisted of three diamond-drill core holes, six augered holes, and two reverse-circulation rotary holes (Cummings et al., 1987; Sergent, Hauskins, and Beckwith Inc., 1987). Joy Manufacturing Company was contracted to complete the diamond-drill core holes under the supervision of the Arizona SSC Project geologist and geological engineer. Joy has extensive experience in southern Arizona. The auger and reverse-circulation rotary drilling was contracted to and supervised by Sergent, Hauskins, and Beckwith Inc., a geotechnical consulting firm with offices in Phoenix and vast experience in the evaluation of construction sites in Arizona. Further geotechnical characterization of the geologic materials present at the site were conducted by Cummings and Glynn (1987), DeNatale and Nowatzki (1987), and Glynn (1987). Hydrogeological data was compiled from the Arizona Department of Water Resources computer data base and the U.S. Geological Survey's WATSTORE water well data base.

The areal extent of the reports listed above is shown in Figure 3-7. Full bibliographic information is provided in the references cited at the end of volume.

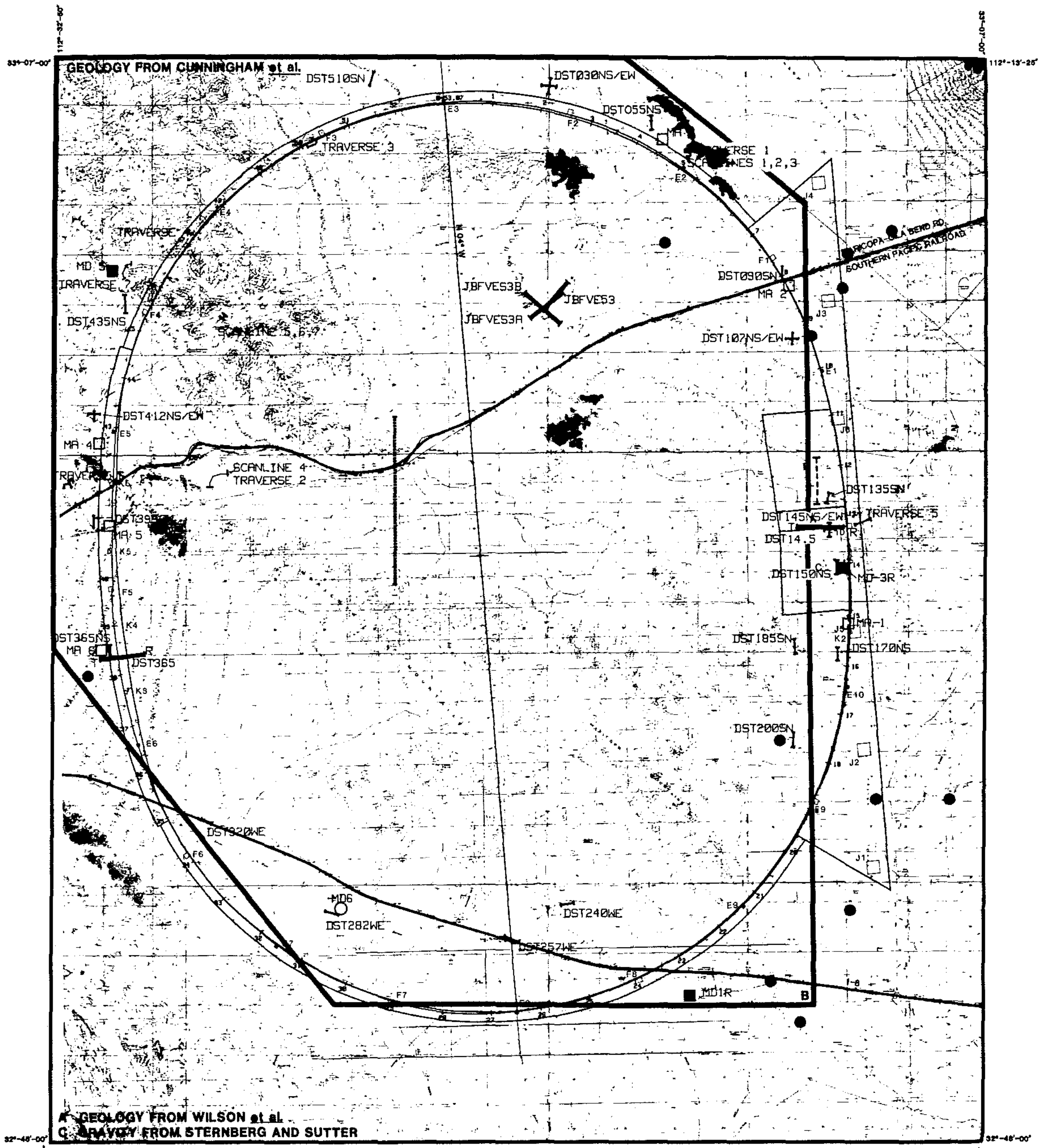
3.3 GEOHYDROLOGY

3.3.1 DETAILED CHARACTERISTICS

3.3.1.1 Geohydrological Regime. The Maricopa Site touches portions of the Vekol Valley, Waterman Wash, and Bosque geohydrological basins. These are structural depressions surrounded by mountains that are composed of intrusive rocks, mostly granite, with small areas of metamorphic and sedimentary rocks. Dense, impermeable bedrock forms the mountains that bound the valley floors. Pediment areas, in which the bedrock is at a shallow depth, extend valleyward for varying distances from the base of the mountains. The central portions of the valleys are underlain by great thicknesses of basin-fill sediments. The basins are filled with alluvial fan and alluvial plain deposits consisting of lenticular beds of poorly sorted gravel, sand, silt, and clay. These deposits generally exhibit some degree of calcium carbonate cementation.

Hydrologically, the most important aspect of the geologic setting around the site is the distribution of the bedrock and other impermeable materials and the more permeable basin-fill sediments. As Figure 3-5 shows, no interaction is expected between the construction of the SSC and the water table. For this reason detailed aquifer characteristics will not be presented here. In general, the site is underlain by unconfined aquifer systems. Permeabilities in the alluvial aquifers, as is expected in alluvial fan materials, are very site-specific. Brooks (1987) provides more detailed information.

Because of the lack of prior development in the area of the site, ground-water elevation data is sparse along and within the tunnel alignment. As a result,



A — GEOLOGY FROM WILSON et al. (1957)	RESISTIVITY SURVEYS - STERNBERG et al. (1987)
B — GEOLOGY FROM CUNNINGHAM et al. (1987)	ARIZONA SSC PROJECT GEOTECH TRAVERSES - CUMMINGS AND GLYNN (1987)
● WATER WELLS	GRAVITY / MAGNETIC SURVEY - BRYAN et al. (1987)
○ ARIZONA SSC PROJECT ROTARY DRILL HOLES	SEISMIC REFRACTION PROFILES - STERNBERG (1987)
■ ARIZONA SSC PROJECT DIAMOND DRILL HOLES	SEISMIC REFRACTION PROFILES - BRYAN et al. (1987)
□ ARIZONA SSC PROJECT AUGER DRILL HOLES	C — GRAVITY MEASUREMENTS - STERNBERG AND SUTTER (1987)

FIGURE 3-7

GEOLOGIC & GEOTECHNICAL DATA SOURCES

MARICOPA SITE

STATE OF ARIZONA SSC PROJECT

SCALE 1:62500

1 .5 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 FEET

NORTH

SEPT 2 1987

the ground-water table has been estimated over much of the site by using linear interpolation and extrapolation techniques combined with geologic and hydrologic knowledge of the area. The site's simple geology combined with experience from similar basins and the available data suggest that the aquifers have a predictable and consistent water-table gradient in areas of little or no pumping. High confidence in the estimated values along with the site's overall great depth to water in relation to the tunnel elevation strengthens the statement that no part of the tunnel will be in saturated material. The depth to water appears to be 300 feet or greater around the entire site.

As discussed in Section 3.2.5.3, perched ground water is not expected to be a problem at the Maricopa Site.

Interaction with streams is an important aspect of southwestern alluvial geohydrology. As much as 70% of the natural aquifer recharge in the Southwest typically occurs in the permeable stream sediments (Burkham, 1970). But the low precipitation (about 7 in/yr), high evapotranspiration rates, and the great depths to the water table at the Maricopa Site suggest that this interaction is of minimal concern. Typically, streams in the area are dry for more than 95% of the year. Therefore, with proper planning, disturbance of the natural recharge environment can be minimized.

3.3.1.2 Ground Water Levels and Fluctuations. Seasonally, ground-water levels at the Maricopa Site remain very consistent because of the absence of pumping and the negligible aquifer recharge. Large fluctuations, in southern Arizona, are seen only in areas of agricultural irrigation where heavy pumping occurs. There is no agriculture within the site area. No operating wells are currently within the site area. Outside of the site area large-scale irrigation is taking place approximately 10 miles north of the Maricopa Site. A smaller area of irrigation, about 1,800 acres, is three to five miles northeast of the site. Available water level and pumpage data indicate little or no ground water decline in the site area caused by pumping in these outside agricultural areas. Ninety percent of pumping in the region is agricultural, a figure that should decrease in the future as agriculture declines.

3.3.1.3 Permeability of Saturated Zones. As previously mentioned, no portion of the Maricopa SSC tunnel is expected to be in saturated material. The only saturated sediments that may be encountered will be below washes after a large runoff in a normally dry channel, when a pulse of recharged water can travel down through the alluvium. These infrequent pulses of recharge will be rare and should pose no trouble to the construction and operation of the SSC.

3.3.2 WATER RESOURCES

3.3.2.1 Local Water Quality. Because the site area is rural and undeveloped, water-quality data are scarce. Available data show ground-water quality as very good to fair in the basins within and surrounding the Maricopa Site. Water of lower quality usually means the presence of higher amounts of dissolved solids, usually sodium and chloride. Available ground-water quality generally meets the State of Arizona Water Quality Standards listed in Table 3-7. Occasional violations are usually in the form of excessive nitrates or fluorides. Brooks (1987) presents site-specific data.

3.3.2.2 Local Water Resources. Ground water is the largest and most reliable water resource in Arizona; it is also the most misunderstood. Investigations show large reserves of ground water in storage in the four ground-water basins near the site (Figure 3-8). A report by the Arizona Water Commission (1975) estimated reserves to a depth of 1200 feet at two of the neighboring basins as follows:

- Waterman Wash Basin - 9 million acre-feet
- Gila Bend Basin - 60 million acre-feet

Additional reports by the U.S. Geological Survey give:

- Bosque Basin - 3.6 million acre-feet
- N. Vekol Valley - 3.1 million acre-feet

The northern Vekol Valley has been determined to be the optimal source of water for the SSC project.

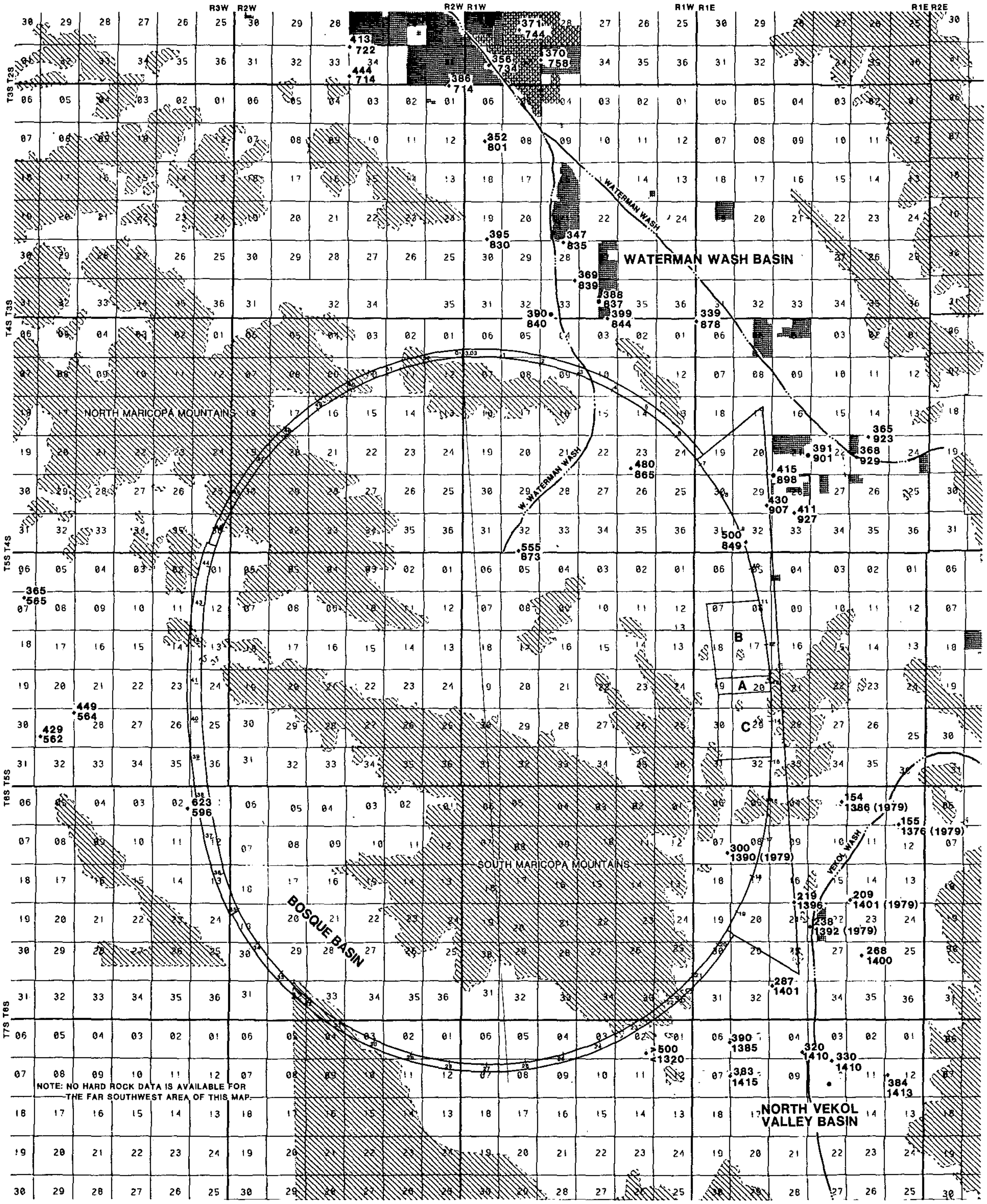
Comprehensive hydrogeologic investigations and subsequent reports on northern Vekol Valley were completed by the U.S. Geological Survey (Wilson, 1979; Hollett and Marie, 1987). These reports identified Vekol Valley as the optimal ground-water source in the region to provide approximately 174,000 acre-feet of water over a 25-year period to the Ak-Chin Indians. This is 75% more water than the SSC will require for the same length of time. The Indians subsequently refused this source of water and the valley has remained essentially unpumped.

Northern Vekol Valley is a north-trending basin approximately 12 miles long and six to eight miles wide. It is filled with as much as 1,900 feet of basin-fill deposits. Ground-water depths range from around 160 feet in the northeast part of the basin to 400 feet south of Interstate 8. Wilson (1979) estimated about 1.5 million acre-feet of recoverable water to a depth of 500 feet below the water table. Brooks (1987) presents detailed aquifer characteristics.

As Section 3.2.3.4 indicates, subsidence is not expected to occur in Waterman Wash. In northern Vekol Valley, the expected source of SSC water, the character of the aquifer and the amount of water to be withdrawn indicate that subsidence is not a concern. Also, the well field is far (~11 miles) from any portion of the tunnel that could be affected by subsidence.

3.3.3 POTENTIAL GROUND WATER IMPACTS ON SUBSURFACE CONSTRUCTION

3.3.3.1 Ground Water Inflows and Pressures. One reason the Maricopa Site is an excellent site for the SSC is that water-related construction problems are



LEGEND

300 / 1390 (1975) - WATER LEVEL DATA POINTS: DEPTH TO WATER; ELEVATION OF WATER TABLE (YEAR MEASURED*)

• - WATER QUALITY DATA

*DATA YEAR IS 1986 UNLESS NOTED OTHERWISE.

IRRIGATED GROUNDWATER RIGHTS

TYPE-1 GROUNDWATER RIGHTS

HARD ROCK AREAS

SECTION LINES

TOWNSHIP RANGE LINES

BASE MAPPING PRODUCED BY ARIZONA DEPARTMENT OF WATER RESOURCES GEOGRAPHIC INFORMATION SYSTEMS

SCALE 1:62500

1 .5 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 FEET

NORTH

SEPT 2 1987

FIGURE 3-8

WELL DATA AND GROUNDWATER RIGHTS

MARICOPA SITE

STATE OF ARIZONA SSC PROJECT

TABLE 3-7

PUBLIC DRINKING WATER QUALITY GUIDELINES--STATE OF ARIZONA

Community water systems within Maricopa County are required to comply with the maximum contaminant level standards set by the State of Arizona. These are grouped into five major categories; inorganic chemicals, organic chemicals, radiochemicals, turbidity and microbiological. The following table summarizes these regulations.

A. Inorganic chemicals (MCL)

Contaminant	Community Water* Systems (mg/l)	Non-Community** water systems (mg/l)
Arsenic	0.05	0.10
Barium	1.0	2.0
Cadmium	0.010	0.020
Chromium (total)	0.05	0.50
Lead	0.05	0.10
Mercury	0.002	0.004
Nitrate (as N)	10.	10.
Selenium	0.01	0.02
Silver	0.05	0.10

B. Organic chemicals (MCL)

1. Chlorinated hydrocarbons:

a. Endrin	0.0002 mg/l
b. Lindane	0.004 mg/l
c. Methoxychlor	0.1 mg/l
d. Toxaphene	0.005 mg/l

2. Chlorophenoxys:

a. 2,4-D	0.1 mg/l
b. 2,4,5-TP Silvex	0.1 mg/l

3. Total Trihalomethanes (TTHM) 0.10 mg/l

C. Radiochemicals (MCL)***

1. Radium-226, radium-228 and gross alpha particle radioactivity

a. Combined radium-226 and radium-228	5 pCi/l#
b. Gross alpha particle activity (including radium-226 but excluding radon and uranium)	15 pCi/l#

2. Average annual concentration of beta particle and photon emitters from man made radionuclides shall not produce an annual dose equivalent to total body or any internal organ greater than 4 millirem/year.

TABLE 3-7 (Continued)

3. Radionuclide concentrations assumed to produce a total body or organ organ dose of 4 millirem/year are:

Radionuclide	Critical Organ	pCi/l#
Tritium	Total Body	20,000
Strontium-90	Bone Marrow	8

D. Turbidity (MCL)

Basis	Maximum turbidity NTU (turbidity units)
Monthly average	1
Average of two consecutive days	5

E. Microbiological (MCL)

1. Membrane filter technique

Basis	Coliform bacteria
a. Monthly average	1 per 100 ml
b. 1 sample (<20 samples/month) or 5% of samples (>20 samples/month)	4 per 100 ml

2. Multiple tube fermentation technique and 10 milliliter standard portions.

No coliform bacteria shall be present in any of the following:

a. More than 10% of the portions in any month
b. Three or more portions in more than one sample (<20 samples per month) or 5% of the samples (>20 samples/month).

3. Multiple tube fermentation technique and 100 milliliter standard portions.

No coliform bacteria shall be present in any of the following:

a. More than 60% of the portions in any month
b. One sample (<5 samples/month) or 20% of the samples (>5 samples/month).

TABLE 3-7 (Continued)

NOTES:

*A public water system serving at least 15 service connections used by year-round residents, or regularly serving 25 year-round residents.

**A public water system that is not a community water system.

***Maximum Contaminant Levels

#pCi/l = pico (10^{-12}) Curies per liter.

extremely unlikely. As discussed in Section 3.3.1 and shown in Figures 3-2 and 3-5, water-table elevations are expected to be well below the proposed tunnel elevations. The only potential for inflows, therefore, is from perched water or from temporary seasonal pulses of recharge from the normally dry stream channels. As Section 3.2.5.3 states, perched water has not been found nor is it expected to be found in the site area. The proposed Maricopa tunnel alignment intersects only two large watercourses, Bender Wash (twice) and the West Prong of Waterman Wash. At these locations the depth of the tunnel suggests that no problems will be encountered.

3.3.3.2 Swelling Clays. No thick deposits of swelling clay are known or expected. As described in Section 3.2.5.1 and as indicated in Table 3-6, expansive clay minerals have been identified in soil samples retrieved from certain locations at the Maricopa Site. The clay fraction of these soils, however, represents less than 8% by weight of the total sample. Therefore, swelling clay minerals are not expected to pose construction problems.

3.3.3.3 Effect of Chemical Constituents. As Section 3.3.3.1 shows, ground water will have no effect on SSC structures; therefore, chemical constituents of ground water are not relevant to construction.

3.4 SEISMICITY AND FAULTING

3.4.1 HISTORICAL SEISMICITY OF THE MARICOPA SSC SITE

Most of Arizona is in one of the lowest historical seismicity and earthquake hazard regions on the North American continent (Ryall et al., 1966; Wong et al., 1982; Zoback and Zoback, 1980). South-central Arizona in particular is far removed from the principal western seismic belts. The San Andreas fault system of California crosses the extreme southwest corner of the state and the Intermountain Seismic Belt apparently terminates in northwestern Arizona. Large magnitude earthquakes originating along the San Andreas system are rarely felt in south-central Arizona and those originating in northwest Arizona, Utah, or Nevada have never been felt in south-central Arizona (Dubois et al., 1982). Although Arizona has had a continuously operational seismic station since 1910, there were not enough high gain stations until about 1960 to locate seismic events accurately (Wallace, 1987). Since monitoring began in 1910, there have been no earthquakes of Richter magnitude M=5.0 or greater in Arizona. Figure 3-9 shows the locations of all historically felt reports and earthquake epicenters within 100 miles of the Maricopa Site.

Earth shaking in the region around the Maricopa Site has been infrequent and generally of low intensity. Between 1875 and 1980, eleven earthquakes were reported felt in the Maricopa Site area, all with Modified Mercalli (MM) intensities $\leq$ V. Four of the events were centered 200 or more miles west of the Maricopa Site on the San Andreas fault system (Dubois et al., 1982). Isoseismal maps (Dubois et al., 1982) indicate that the Maricopa Site has experienced no

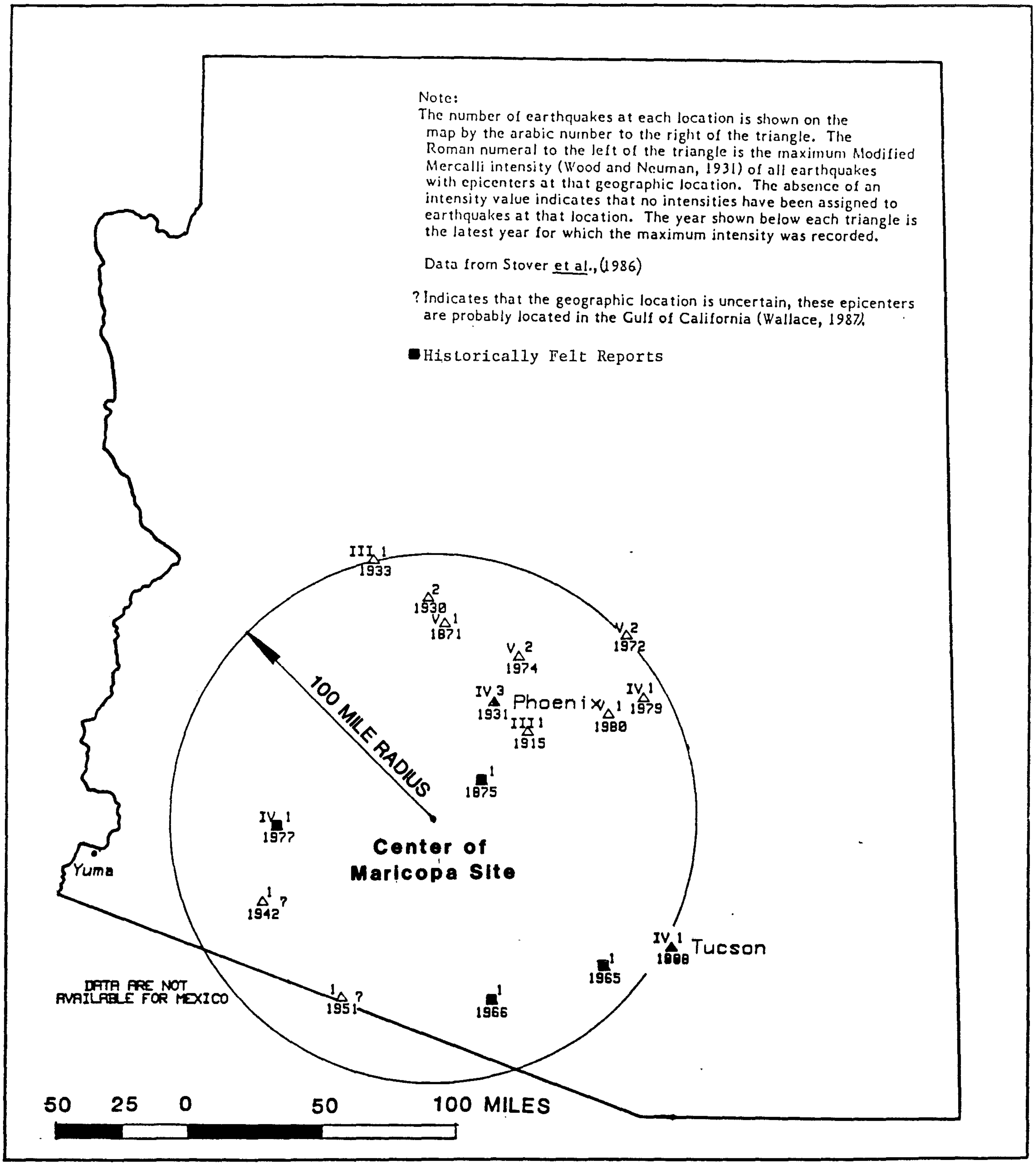


FIGURE 3-9
HISTORICALLY FELT REPORTS AND EARTHQUAKE EPICENTERS WITHIN 100 MILES OF THE MARICOPA SITE

earthquakes with MM intensities equal to or greater than VI (the lower limit for structural damage).

Microearthquakes ($M < 3.0$) have been experienced in the region. Wallace (1987) reports that there is no systematic pattern to the microearthquake seismicity and it does not appear to be related to any obvious structural feature. On the basis of recurrence of these events it is reasonable to assume that there will be about one microearthquake per year in the region (Wallace, 1987). Microearthquakes do not influence construction in the Phoenix area, nor are they expected to cause operational problems. Motion-sensitive operations performed in many hospitals in Phoenix have not been affected by microearthquakes.

3.4.2 GROUND ACCELERATION AT THE MARICOPA SSC SITE

The Maricopa Site is located in a region of low seismic risk (Algermissen and Perkins, 1973; 1976). Seismic hazard maps prepared by Algermissen et al., (1982; 1983; Figures 3-10 and 3-11) suggest the following effective peak horizontal ground acceleration values (A_a):

- $A_a < 0.04g$ for an estimated recurrence interval of 100 years
- $A_a < 0.06g$ for an estimated recurrence interval of 475 years
- $A_a < 0.14g$ for an estimated recurrence interval of 2,200 years

The accelerations have a 90% probability of not being exceeded in 50 years. The value of 0.06g is recommended for the design of ordinary structures by the Applied Technology Council (1978), the American National Standards Institute (1982), the American Association of State Highway and Transportation Officials (1983), and the Federal Emergency Planning Agency (1986).

The maximum credible earthquake for south-central Arizona is the 1887 Pitaycachi event with M=7.25 (Dubois and Sbar, 1981; Wallace, 1987). The maximum credible earthquakes for active and suspected active faults closer to the Site are discussed in Section 3.4.3 and presented in Table 3-8. The magnitudes in the table were estimated by methods described by Bonilla et al. (1984). The maximum ground acceleration values at the Maricopa Site that could be expected from these faults were estimated from the attenuation relationships presented by Campbell (1981). As indicated by the table, an M=5.8 earthquake along the Sand Tank fault would constitute the maximum credible earthquake for the Maricopa Site. It could produce an $A_a = 0.09g$ at the site with a recurrence interval of at least 30,000 years (Pearthree et al., 1983). However, the definition of an "active" fault established for the SSC is one which has experienced offsets in the past 10,000 years. Therefore, the Sand Tank fault is not considered as critical to the SSC project.

As indicated in Table 3-8, peak effective horizontal ground accelerations at the Maricopa Site resulting from movements along other faults, including the Pitaycachi, all fall below the recommended design value for the region of 0.06g. Since 0.1g is the level of acceleration generally considered strong enough to

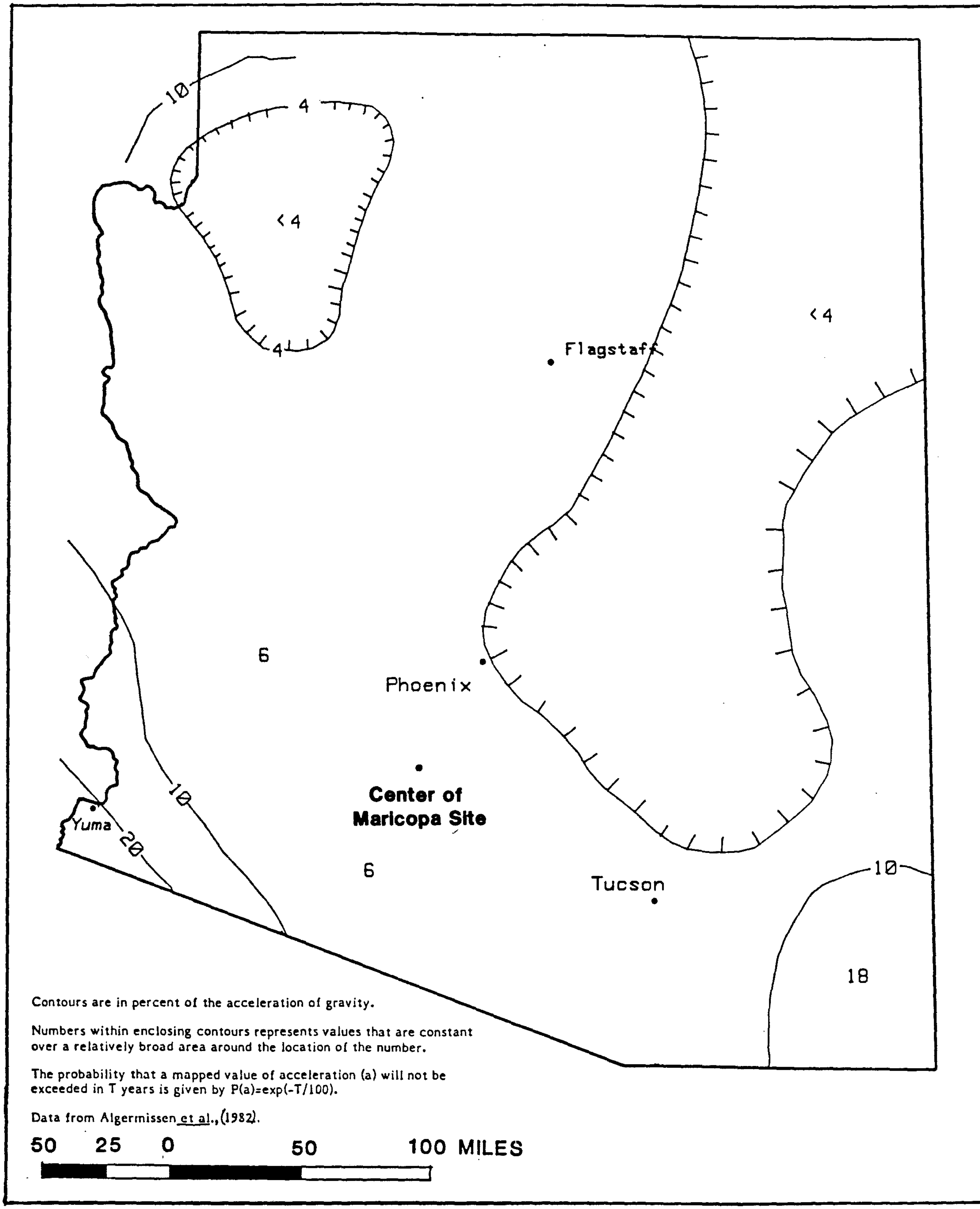
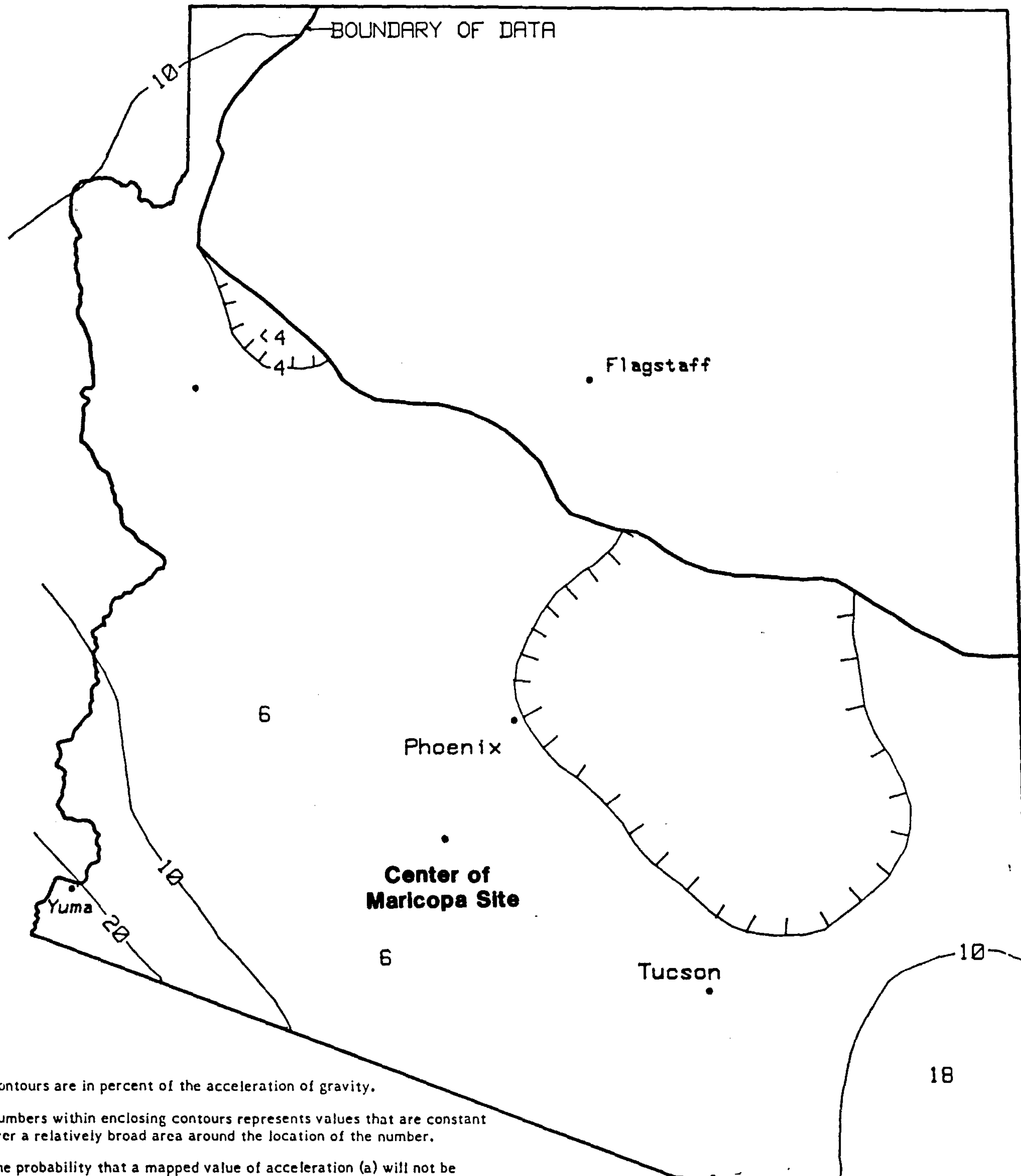


FIGURE 3-10
HORIZONTAL GROUND ACCELERATION MAP OF ARIZONA



Contours are in percent of the acceleration of gravity.

Numbers within enclosing contours represents values that are constant over a relatively broad area around the location of the number.

The probability that a mapped value of acceleration (a) will not be exceeded in T years is given by P(a)=exp(-T/100).

Data from Algermissen et al. (1983).

50 25 0 50 100 MILES

FIGURE 3-11
HORIZONTAL GROUND ACCELERATION MAP OF THE BASIN AND RANGE PROVINCE IN ARIZONA

TABLE 3-8
ESTIMATED PEAK GROUND ACCELERATION AT MARICOPA SITE, FROM MAXIMUM CREDIBLE EARTHQUAKES CREATED BY POTENTIALLY ACTIVE FAULTS WITHIN 250 MILES OF THE SITE

FAULT NAME [1]	APPROXIMATE LENGTH (mi) [2]	ESTIMATED MAGNITUDE (M) [3]	APPROXIMATE DISTANCE (mi) [4]	PEAK GROUND ACCELERATION (g) [5]	RECURRENCE INTERVAL (yrs)
Big Chino	28	7.0	145	0.02	<30000
Chiricahua	12	6.6	220	0.01	<30000
Pitaycachi	43	7.3	250	0.01	<30000
Safford	18	6.8	170	0.01	<30000
Sand Tank	3	5.8	11	0.09	<30000
Santa Rita	32	7.1	130	0.02	3000 < RI< 150000
Sugarloaf	4	6.0	80	0.01	<30000
San Andreas [6]	- -	8.0	150	0.04	150

[1] Refer to Figure 3-12 (Scarborough et al., 1986).
[2] Measured from Figure 3-12.
[3] Measured from Bonilla et al. (1984); US 7 data.
[4] Measured from mid-fault to injector complex on Figure 3-12.
[5] Campbell (1981).
[6] Historical.

produce some degree of damage to "weak" construction," the possibility of a damaging earthquake occurring in the site area is very remote.

It should be noted that the value of M=7.3 estimated for the 1887 Pitaycachi event by using the method proposed by Bonilla et al. (1984) corresponds almost exactly to the value of M=7.25 proposed independently by Dubois and Sbar (1981).

3.4.3 ACTIVE FAULTS IN THE MARICOPA SSC REGION

The definition of an "active" fault established for this project is one which has experienced offsets in the last 10,000 years. No active faults have been identified in the vicinity of the Maricopa SSC site. Figure 3-12 shows all Late Pliocene-Quaternary (post-4 m.y.) faults within Arizona. Table 3-8 lists all potentially active faults within 250 miles of the Maricopa Site including the San Andreas Fault in California. The table also contains estimates of Richter magnitudes based on relationships proposed by Bonilla et al. (1984) that relate earthquake magnitude to the associated length of surface rupture and amount of maximum offset. These parameters can be determined quite well in Arizona, where fault scarps are preserved for periods of tens of thousands to hundreds of thousands of years because of the desert environment.

Reactivation of older inactive faults which the Maricopa SSC ring might cross is an extremely unlikely prospect for several reasons:

- These older faults are the result of different regional stress fields which are not the present stress condition.
- Seismic events which occurred in the region during the last five million years, including the 1887 Pitaycachi event, failed to trigger slip along these older faults.
- Faults in the Maricopa Mountains show no evidence of Quaternary activity.

3.4.4 POTENTIAL FOR LIQUEFACTION

There is no known record of seismically induced liquefaction of geologic materials in southern Arizona (Dubois et al., 1982). The fact that construction will be conducted in materials with cohesion values in excess of 1100 psf above the water table eliminates liquefaction as a potential problem at the site. Additionally, the dense cemented desert alluvium at the Maricopa Site is well outside the limits of liquefiable soils given by Seed and Idriss (1982). With no historical precedent, and with stable geology, the Maricopa Site is not at risk from liquefaction.

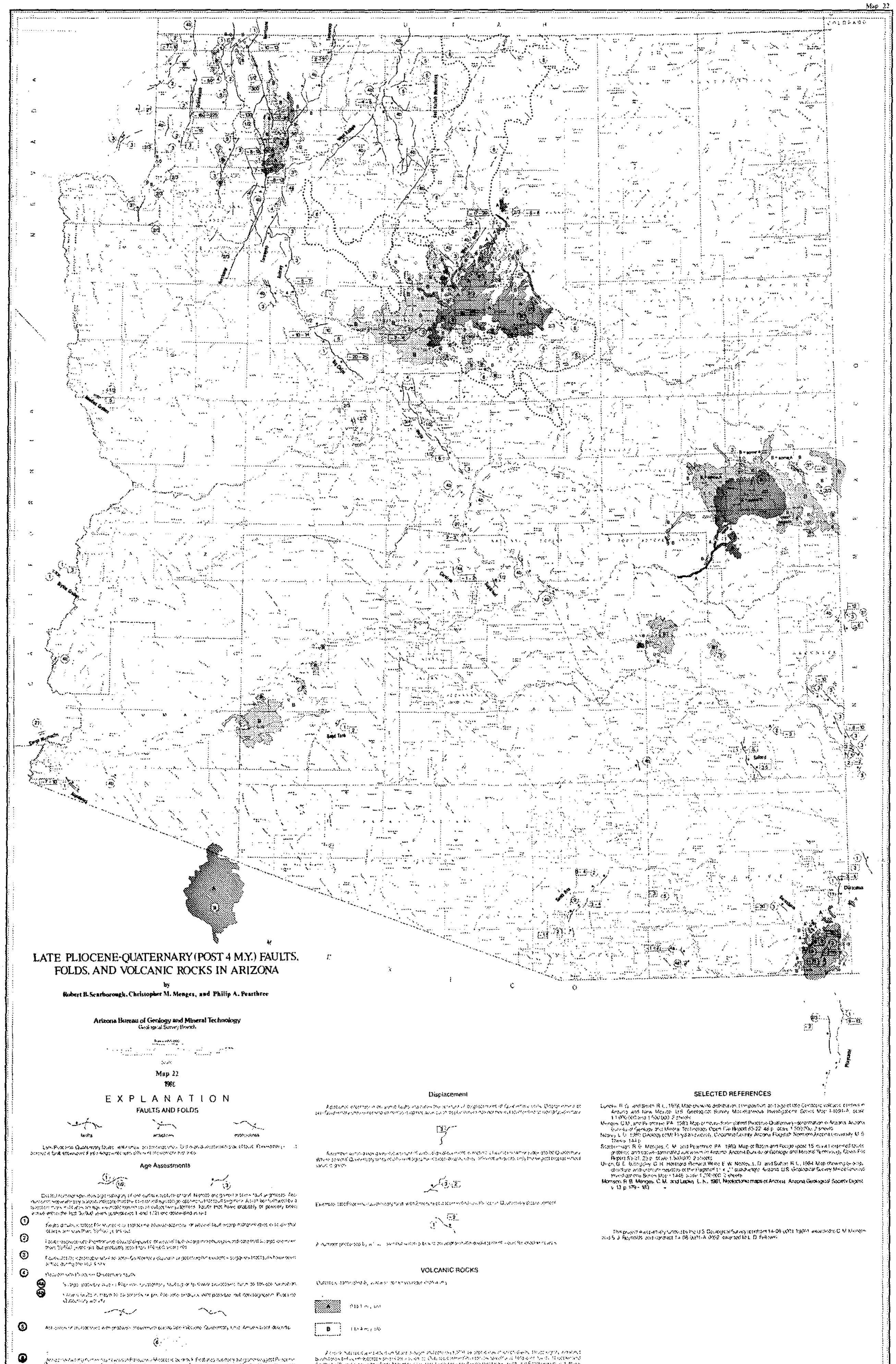

Map 22
U T A H
COLORADO
N E V A D A
M E X I C O
LATE PLIOCENE-QUATERNARY (POST 4 M.Y.) FAULTS, FOLDS, AND VOLCANIC ROCKS IN ARIZONA
by
Robert B. Scarborough, Christopher M. Menges, and Philip A. Pearthree
Arizona Bureau of Geology and Mineral Technology
Geological Survey Branch
Map 22
EXPLANATION
FAULTS AND FOLDS
Age Assessments
Displacement
VOLCANIC ROCKS
SELECTED REFERENCES
Morrison, R. B., Menges, C. M., and Lepley, L. K., 1981, Neotectonic maps of Arizona: Arizona Geological Society Digest, v. 13, p. 179–183

Figure 3-12

3.5 TUNNELING AND UNDERGROUND CONSTRUCTION

3.5.1 ENGINEERING DESCRIPTION OF RELEVANT SOIL AND ROCK UNITS

The geologic assemblages involved in the construction are easily characterized, for engineering purposes. The site involves three general assemblages. The 10.35-mile segments comprising CUs 4 and 9 cross a granitic intrusive terrane. In CU 5, ring segments totalling approximately 7.5 miles cross a sequence of volcanic and interbedded sedimentary rocks, with short sections in fanglomerate. Fanglomerate hosts the remaining 35.45 total miles of ring segments in CUs 1, 2, 3, 6, 7, and 8. A description of each of the assemblages follows.

3.5.1.1 Fanglomerate Assemblage. The ring at the Maricopa Site will pass through three basins containing fanglomerate. These are the Rainbow Valley Basin, the North Vekol Valley Basin, and the Bosque Basin. Eight SSC project boreholes were drilled close to the ring alignment as shown in Figure 3-7. The fanglomerate assemblage consists of two components, alluvium and fanglomerate. The term "alluvium" refers to the unconsolidated and non-indurated sediments typically found as surface soils in the desert basins of the Southwest. The term "fanglomerate" refers to locally conglomeratic alluvial fan deposits cemented to various degrees, generally by calcium carbonate.

Rainbow Valley Basin Fanglomerate (Boreholes MA-2, MA-3, MA-3A, wells Waterman 1, Waterman 2) has been divided into two units based on the results of two deep exploratory wells and numerous water wells (Wilson, 1979). The upper unit is up to 400 feet thick and consists of lime cemented sandy clay to sand and gravel, and generally contains more gravel in the northwestern part, and more clay and silt in the central part. The lower unit is as thick as 1,000 feet and consists of coarse sandy gravel to sand and gravel that contains small amounts of silt and clay cemented by calcium carbonate (Wilson, 1979).

North Vekol Valley Basin Fanglomerate (no boreholes drilled). Basin-fill in the North Vekol Valley Basin can be divided into three units (Wilson, 1979, USGS unpub. well log data). The upper unit adjacent to Interstate Highway 8 is up to 200 feet thick and consists of gravelly sand, or gravelly silt further north in the basin. The middle unit is 700 feet thick and consists of silty gravelly sand. The lowermost unit is more than 875 feet thick and consists of Tertiary tuff, silty to clayey sand and gravel, and andesite. The two upper units are cemented by calcium carbonate.

Bosque Basin Fanglomerate (Boreholes MA-4, MA-5, MA-6; wells Bosque 1 and Bosque 2). As much as 3,000 feet of basin-filling sediments in the Bosque Basin were laid down in lenses and discontinuous sheets. These sediments have been divided into three units (Wilson, 1979). The upper unit is from 700 to 900 feet thick and is composed of coarse to fine gravel and sand, silt, and clay. Reddish silty and clayey layers are common and increase to the southwest to comprise 65% of the upper unit in the vicinity of Gila Bend, 25 miles from the Maricopa Site (Wilson, 1979). The middle unit thickens from 800 feet to 1,450 feet in the Bosque 2 Well, and is composed mainly of sand and gravel with a few reddish-brown silty and clayey layers. The top of the lower unit is an erosion surface.

The lower unit consists of volcanic rocks interbedded with and underlain by moderately to weakly cemented conglomerate that are similar to the tilted Tertiary rocks of the volcanic assemblage, and to those present in the Sand Tank Mountains (Sell, 1968). Cementation in the upper two units is usually by calcium carbonate and varies from weak to strong with disseminated lime and coatings on individual clasts. Some cementation by clays also occurs.

In summary, the fanglomerate in each of the basins consists of a wide range of materials from clays to gravels. In all cases the fanglomerate is moderately to strongly cemented within construction depths. Gravel occurs only in scattered layers and cobbles are rare. All evidence suggests that the fanglomerate offers two options for construction of the SSC tunnel:

- Machine tunneling. This method seems best suited for depths greater than 80 feet. A double shield TBM pushing off a segmented concrete liner can achieve advance rates of 200 feet of completed tunnel per day in the fanglomerate. The concrete liner will provide a clean environment for the 23.5 miles of tunnel constructed in this material.

- Cut-and-fill construction. This method is best suited for depths less than 80 feet. As is documented in Section 3.5.2.1, the fanglomerate possesses properties that allow it to stand stable for several years, unsupported, at heights up to 80 feet with 60° slope. Advance rates are expected to be 100 feet of completed tunnel per day for the 11.9 miles of tunnel to be constructed by this method.

3.5.1.2 Granitic Assemblage. The granitic assemblage has been found to be consistently strong and predictable in its rock mass properties (see Table 3-9). For rock support and penetration, geomechanics classifications rate these rock masses as "very good to excellent." These are favorable materials for machine tunneling, offering high advance rates and requiring very little or no support.

For segments in the granitic assemblage constructed by tunneling through harder rock, strength assessments show that sidewalls will permit the high gripper thrusts needed to maintain high advance rates, yet the material strengths are not so high as to indicate low cutter penetrability and high cutter wear rates. Fracturing densities, condition of fractures, and a low incidence of significant faulting indicate that only localized pattern- or spot-bolting will be required for support.

Granitic assemblage materials are ideally suited for the application of hard rock TBM methods. The rock types to be encountered are expected to be self-supporting with local zones possibly requiring rock bolts. For the ten miles of granitic assemblage, tunnel advances rates are expected to be 120 feet of completed tunnel per day (see Table 3-18).

3.5.1.3 Volcanic Assemblage. The segment traversing the volcanic assemblage will pass through massive, dense basalts, welded tuffs, and interbedded sandy conglomerates. The conglomerates are weakly cemented, containing lithic fragments of metamorphic, plutonic, and volcanic rock types in a sandy matrix. Fracturing is rare in the basalts, and almost nonexistent in the conglomerates; welded tuffs are moderately fractured, but of local extent.

The measured compressive strength of the basalt is high, but conventional TBMs are not expected to encounter difficulties. The conglomerates have low to moderate strengths and will permit excellent tunneling advance rates. The strength of the welded tuff is high, but it is sufficiently fractured so as to permit rapid tunneling advance rates.

The basalts are expected to stand without support, but locally they may require rockbolts. The conglomerate will require a segmental lining to permit rapid advance rates. The welded tuff may require pattern-bolting or a reinforced shotcrete lining. Overall advance rates in the volcanic assemblage are predicted to be 180 feet of completed tunnel per day (see Table 3-18) over the entire 7.5 mile length of tunnel.

3.5.2 PHYSICAL AND MECHANICAL PROPERTIES OF ROCK AND SOIL MASS

As indicated earlier, details of rock mass characteristics (strength, fracturing, and groundwater) were classified by means of rock mass classification systems to simplify construction estimating. The classification schemes used were the Geomechanics System of Bieniawski (1973), the "Q" System of Barton et al. (1974), and the RQD system of Deere (1968). Table 3-9 lists the values obtained and Figure 3-5A displays the constructability profile for the Maricopa Site. Fanglomerates were classified according to the Unified Soil Classification System (U.S. Army Corps of Engineers, 1960).

3.5.2.1 Fanglomerate Assemblage. Because the Maricopa Site is in a relatively remote and undeveloped area, very little geotechnical data is available to characterize the engineering properties of the fanglomerate at the site. Instead of embarking on a costly drilling and laboratory/field testing program, it was decided first to characterize the seismic properties of the fanglomerate and compare them to those of other fanglomerates in the region for which geotechnical data were available. Then, if the materials compared well seismically, a modest field and laboratory testing program including borehole drilling could be carried out to confirm the thickness and composition of the materials and to verify the existing engineering properties data. In this way the wealth of geotechnical data on fanglomerate properties accumulated over the past 20 to 25 years could be used to characterize the Maricopa Site. Most of the existing data on fanglomerate properties were obtained as part of the planning, development and operation of the Twin Buttes Mine located approximately 100 miles southeast of the Maricopa Site (Golder Associates, 1975, 1977, 1979; Omnes, 1976; Seegmiller, 1971).

Table 3-10 presents the results of seismic surveys conducted at the Twin Buttes Mine and at the Maricopa Site (Sternberg, 1986; 1987). The results suggest that the fanglomerates along the entire ring alignment are similar to those found at the Twin Buttes Mine and may even have more beneficial engineering properties. Table 3-10 also contains an estimate of unconfined compressive strength based on modulus of elasticity as proposed by Hobbs (1974). To charac-

TABLE 3-9
TUNNEL HORIZON
ROCK PROPERTIES

CONSTRUCTION UNIT	MILEAGE	TUNNEL DEPTH	DESCRIPTION	INTACT UNCONFINED COMPRESSIVE STRENGTH (KSI)	FRACTURE SETS[3]	FRACTURE ROUGHNESS[4]	AVERAGE FRACTURE FREQUENCY x/ft	RQD (%)	Q	RMR	COMMENTS
FANGLOMERATE ASSEMBLAGE											
1	1.0	170	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
1	2.0	90	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
1	3.0	105	Fanglomerate	0.4	--	--	--	--	--	--	See Note 1
1	4.0	90	Fanglomerate	0.4	--	--	--	--	--	--	See Note 1
1	5.0	65	Fanglomerate	0.6	--	--	--	--	--	--	See Note 1
1	53.0	260	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
2	6.0	80	Fanglomerate	0.6	--	--	--	--	--	--	See Note 1
2	7.0	40	Fanglomerate	0.4	--	--	--	--	--	--	See Note 1
2	8.0	40	Fanglomerate	0.4	--	--	--	--	--	--	See Note 1
2	9.0	30	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
2	10.0	40	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
2	11.0	40	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
2	12.0	50	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
3	14.5	105	Fanglomerate	0.1-0.3	--	--	--	--	--	--	See Notes 1, 2
4	17.0	160	Fanglomerate	0.2-0.4	--	--	--	--	--	--	See Note 1
5	25.7	340	Fanglomerate	2-3	--	--	--	--	--	--	See Note 1
5	27.0	310	Fanglomerate	1-2	--	--	--	--	--	--	See Note 1
5	28.0	310	Fanglomerate	1-2	--	--	--	--	--	--	See Note 1
6	29.0	310	Fanglomerate	1-1.5	--	--	--	--	--	--	See Note 1
6	30.0	290	Fanglomerate	1-1.5	--	--	--	--	--	--	See Note 1
6	31.0	260	Fanglomerate	1-1.2	--	--	--	--	--	--	See Note 1
6	32.0	220	Fanglomerate	1	--	--	--	--	--	--	See Note 1
6	33.0	160	Fanglomerate	0.8-1	--	--	--	--	--	--	See Note 1

TABLE 3-9
TUNNEL HORIZON
ROCK PROPERTIES

CONSTRUCTION UNIT	MILEAGE	TUNNEL DEPTH	DESCRIPTION	INTACT UNCONFINED COMPRESSIVE STRENGTH (KSI)	FRACTURE SETS[3]	FRACTURE ROUGHNESS[4]	AVERAGE FRACTURE FREQUENCY x/ft	RQD (%)	Q	RMR	COMMENTS
6	34.0	130	Fanglomerate	0.8-1	--	--	--	--	--	--	See Note 1
6	35.0	105	Fanglomerate	0.7-0.9	--	--	--	--	--	--	See Note 1
6	36.0	105	Fanglomerate	0.7	--	--	--	--	--	--	See Note 1
6	37.0	90	Fanglomerate	0.7	--	--	--	--	--	--	See Note 1
7	38.0	90	Fanglomerate	0.5-0.7	--	--	--	--	--	--	See Note 1
7	39.0	80	Fanglomerate	0.4-0.5	--	--	--	--	--	--	See Note 1
7	40.0	80	Fanglomerate	0.4	--	--	--	--	--	--	See Note 1
8	41.8	105	Fanglomerate	0.3-0.4	--	--	--	--	--	--	See Note 1
9	52.0	340	Fanglomerate	0.3	--	--	--	--	--	--	See Note 1
GRANITIC ASSEMBLAGE											
2	12.8	65	Quartz Diorite	28-32	80/250 60/340	Sm. (2-5) Sm. (2-4) CAL (1)	5	30-60	Very Good	Very Good	See Note 5
4	16.3	130	Quartz Diorite	28-32	80/250 60/340	Sm. (2-5) Sm. (2-4) CAL (1)	5	--	--	--	See Note 5
4	20.5	220	Porphyritic Granite	30-35	80/250 60/340	Sm. (2-4) Sm. (2-4)	1	80-100	Extr. Good	Very Good	
8	42.0	120	Porphyritic Granite	28-30	40/330 90/275 30/120	Sm. 4 Sm. 4 Sm. 1 CL (1)	1.5	70-90	Very Good	Very Good	See Note 1
8	45.0	290	Porphyritic Granite								See Note 2
9	46.0	1065	Porphyritic Granite								See Note 2
9	47.0	1170	Porphyritic Granite								See Note 2
9	48.0	780	Porphyritic Granite	14-30	40/330 90/275 30/120	Sm. 4 Sm. 4 Sm. 1 CL (1)	2	50-80	Good to very good	Good to very good	See Note 2

TABLE 3-9
TUNNEL HORIZON
ROCK PROPERTIES

CONSTRUCTION UNIT	MILEAGE	TUNNEL DEPTH	DESCRIPTION	INTACT UNCONFINED COMPRESSIVE STRENGTH (KSI)	FRACTURE SETS[3]	FRACTURE ROUGHNESS[4]	AVERAGE FRACTURE FREQUENCY x/ft	RQD (%)	Q	RMR	COMMENTS
9	49.0	780	Porphyritic Granite								See Note 2
9	50.0	550	Porphyritic Granite								See Note 2
9	51.0	420	Porphyritic Granite								See Note 2
VOLCANIC ASSEMBLAGE											
5	22.5	415	Basal Conglomerate	4-5	--	--	--	--	--	--	See Note 1
5	23.6	340	Middle Conglomerate	4-5	--	--	--	--	--	--	See Note 1
5	25.0	310	Upper Conglomerate	4-5	--	--	--	--	--	--	See Note 1
5	23.0	440	Basalt	10-15	30/250 30/340	CAL (2-8) Q (1)	2	90-100	Good	Good	
5	24.5	310	Welded Tuff	23-26	30/250 30/340	Sm.(2-4)	1	80	Very Good	Very Good	

TABLE 3-9
TUNNEL HORIZON
ROCK PROPERTIES

CONSTRUCTION UNIT	MILEAGE	TUNNEL DEPTH	DESCRIPTION	INTACT UNCONFINED COMPRESSIVE STRENGTH (KSI)	FRACTURE SETS	FRACTURE ROUGHNESS	AVERAGE FRACTURE FREQUENCY x/ft	RQD (%)	Q	RMR	COMMENTS

NOTES: (1) The fanglomerate has a texture and strength similar to weakly cemented sandstone. Strengths have been derived from empirical relations between modulus and strength using the data on sandstones collected by Deere, et al. (1974). Confirmatory data has been obtained from limited undisturbed specimens. No discontinuities occur in the fanglomerate or conglomerate.

(2) The data shown are the range of values representative of this rock unit. Some of the lower strengths may have been obtained from weathered samples. It is unlikely rock quality will ever be less than good.

(3) Fracture sets are quoted as dip/dip direction. Where there is more than one set all are listed. Joint set information was obtained from field measurement.

(4) Fracture roughness symbols:
Sm.1 - smooth
Sm.2 - slight roughness
Sm.3 - medium roughness
Sm.4 - rough
Sm.5 - very rough
PF (1) - partly filled (openness in mm)
Filling type: Give width of filled fracture and indicate filling, i.e., CAL - Calcite; CL - Clay.

(5) The fractures in this material were mainly healed with calcite. Many others have been induced by drilling. The very good quality is a subjective assessment of a strong rock.

See Figure 3-5A for Graphic Presentation of the Assemblage Distribution.

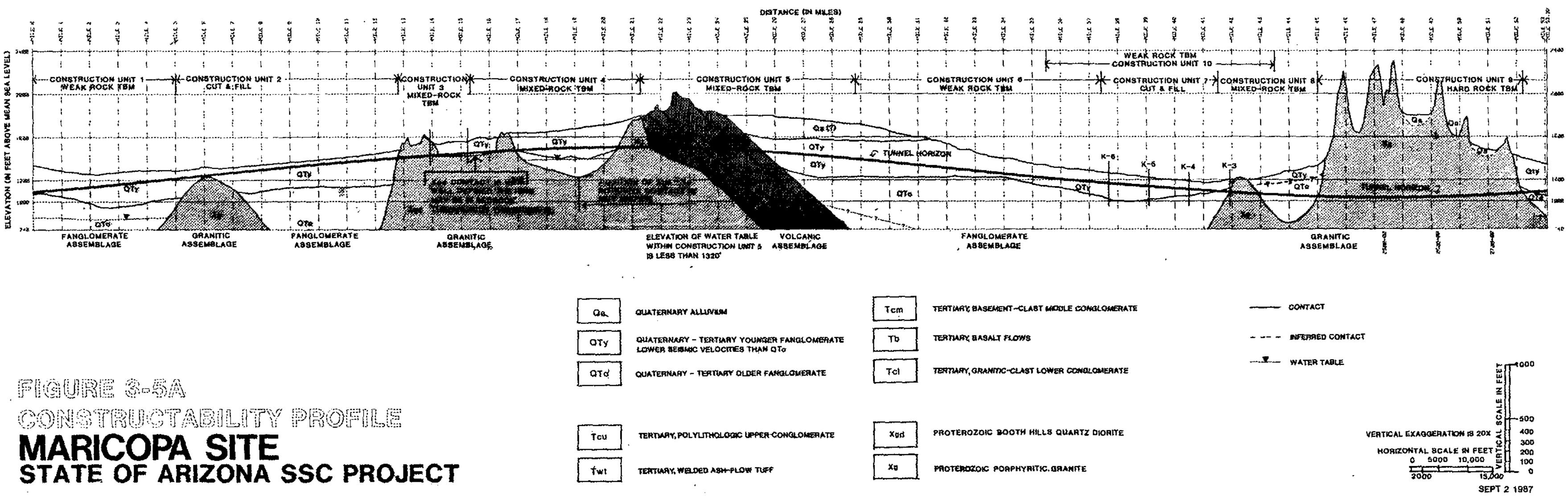


FIGURE 3-5A
CONSTRUCTABILITY PROFILE

MARICOPA SITE
STATE OF ARIZONA SSC PROJECT

TABLE 3-10

SUMMARY OF SEISMIC REFRACTION RUNS
INDURATED FANGLOMERATES - GEOTECHNICAL DATA[1]

Location Mileage	Average Thickness ft.	Seismic Velocity ft/s	E ksi	Estimated q_u psi
2.0N	250	3256	152	434
2.0E	300	3276	153	439
3.5	270	3958	224	641
8.0	240	3048	133	380
9.5	230	2899	120	344
12.0[2]	80	3897	215	615
12.0[2]	70	2500	89	256
12.0[2]	130	3768	203	581
12.7	160	2988	128	365
13.2	70	2643	103	297
15.6	110	3143	141	404
16.0	60	2085	62	178
17.5	70	2459	87	247
25.2[3]	260	7775	866	2476
34.4	70	5185	385	1101
38.2	270	4323	267	765
41.0	100	3185	145	415
51.2[4]	60	2741	107	308
Twin Buttes Pit[5]	250	3168	143	408
Twin Buttes Pit[5]	100	1912	52	150
Twin Buttes Pit[5]	60	1997	57	162
Twin Buttes Pit[6]	280	1800	46	132
Twin Buttes Pit[6]	80	3500	174	498

[1] Data from Sternberg and Esher (1987).

[2] These seismic refraction lines are located 0.5 miles west of mile 12.0.

[3] This seismic refraction line is located two miles north of mile 25.2.

[4] This seismic refraction line is located one mile north of mile 51.2.

[5] Data from Sternberg (1986).

[6] Data from Omnes (1976).

terize the geotechnical properties, a four-phase program was conducted. The first phase consisted of a literature review and a visual survey of the Twin Buttes pit; the second phase consisted of a comprehensive program of standard and specialized laboratory testing performed on samples retrieved from boreholes drilled at the Maricopa Site; the third phase involved a comparison of the results of the second phase with the results of similar tests run on materials retrieved from the Twin Buttes pit; the fourth phase involved supplemental field tests to verify the results of the laboratory strength tests.

The visual survey of the Twin Buttes pit confirmed the observations of Beckwith and Hansen (1982) that the fanglomerate is essentially continuous and is not appreciably affected by fissures or other discontinuities. As shown in Figure 3-13, the material is a mixture of coarse- and fine-grained particles with moderate to very strong calcareous cementation. The views of pit slopes shown in Figures 3-14 and 3-15 indicate that the fanglomerate is extremely strong and quite stable. Pit benches 50 to 60 feet high have near-vertical side walls. In some areas "double benching" has resulted in near-vertical slopes standing to twice those heights. Locally, the slopes exceed 90°. At several locations within the pit, massive circular crusher/conveyor foundations were built on the edge of the benches (Figure 3-16). The fanglomerate beneath these foundations has not deteriorated in over a decade despite having been subjected intermittently to significant static and dynamic loads. In addition, scraper marks can still be seen on the pit walls that are more than ten years old, as revealed in Figure 3-17. There are some occasional horizontal gravel lenses and localized pockets of uncemented silt, but even these resist extensive ravelling, as shown by Figure 3-18. These observations suggest that the fanglomerate is sufficiently strong to maintain slope stability over many years and yet will yield readily to standard, low-cost excavation techniques.

Classification Tests. The gradation curves shown in Figure 3-19 were established by standard sieve and hydrometer analyses (ASTM D-421, ASTM D-422, 1985) performed on deaggregated samples taken from various depths in two different boreholes. The curves appear to vary considerably; however this variation occurs only within the "sand" range of particles and is more indicative of differences in uniformity than in material type. The results of the grain-size distribution analyses for both the Maricopa Site and the Twin Buttes pit are summarized in Table 3-11.

Atterburg limits tests (ASTM D-4318, 1985) and x-ray diffraction analyses were also performed. These tests indicate that the fine-grained fraction is slightly plastic (PI = 3-30) and may contain some expansive clay minerals. The results of these tests are found in Tables 3-12 and 3-6, respectively.

On the basis of these tests, the deaggregated material is classified as an "SC" soil according to USCS, i.e. a well-graded sand with plastic fines.

Compaction Characteristics. Standard (ASTM D-698, 1985) and modified (ASTM D-1557, 1985) compaction tests were performed to establish the deaggregated materials compaction characteristics. The resulting compaction curves are shown in Figure 3-20. The standard test yielded a maximum dry density of 124 pcf and an optimum water content of 11.2%. The modified test produced a maximum

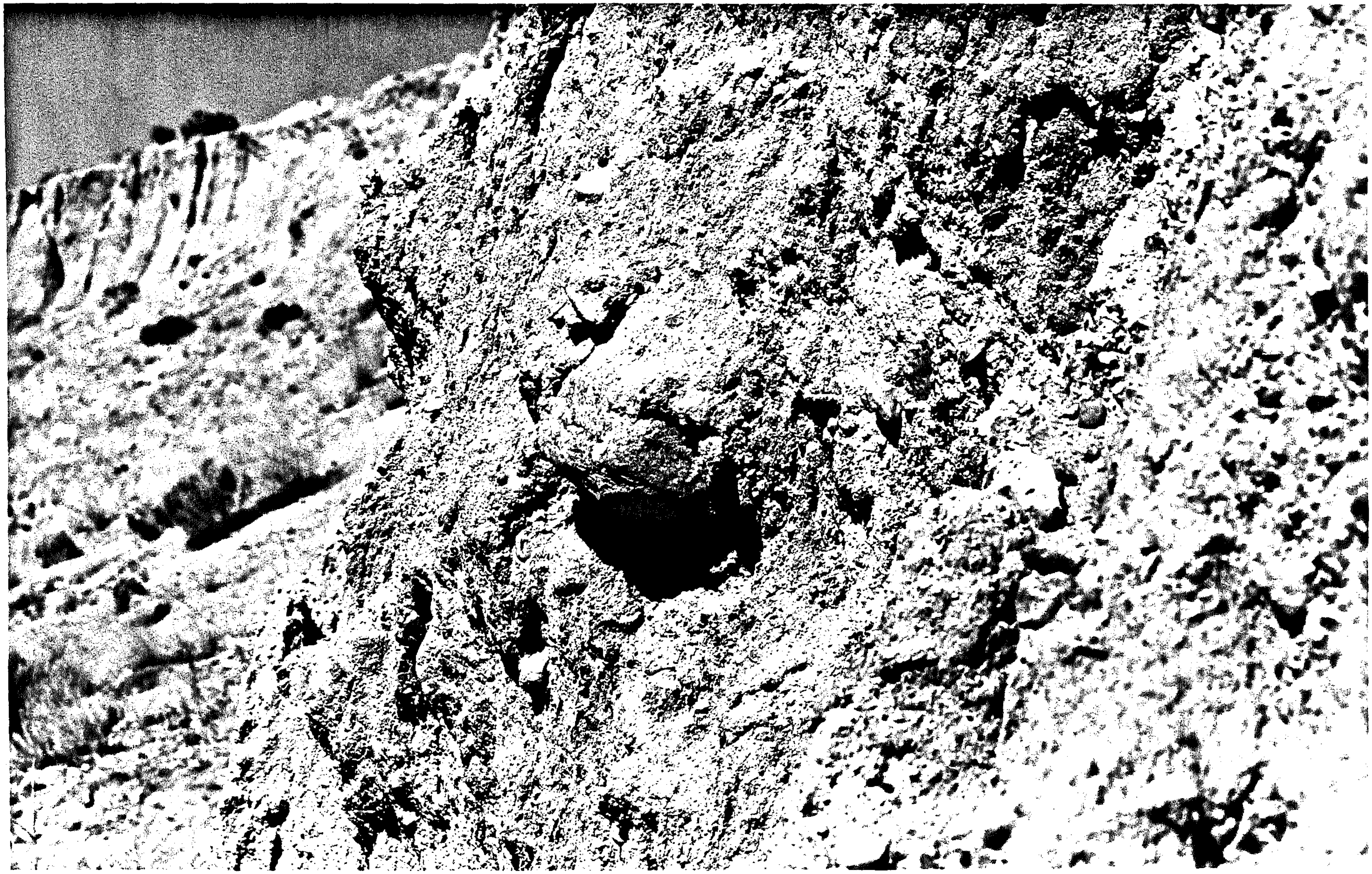


Figure 3-13
<u>In</u> <u>Situ</u> Appearance of the Fanglomerate
State of Arizona, Maricopa Site, September 2, 1987

Figure 3-14
An Overview of the Twin Buttes Open-Pit Mine
State of Arizona, Maricopa Site, September 2, 1987

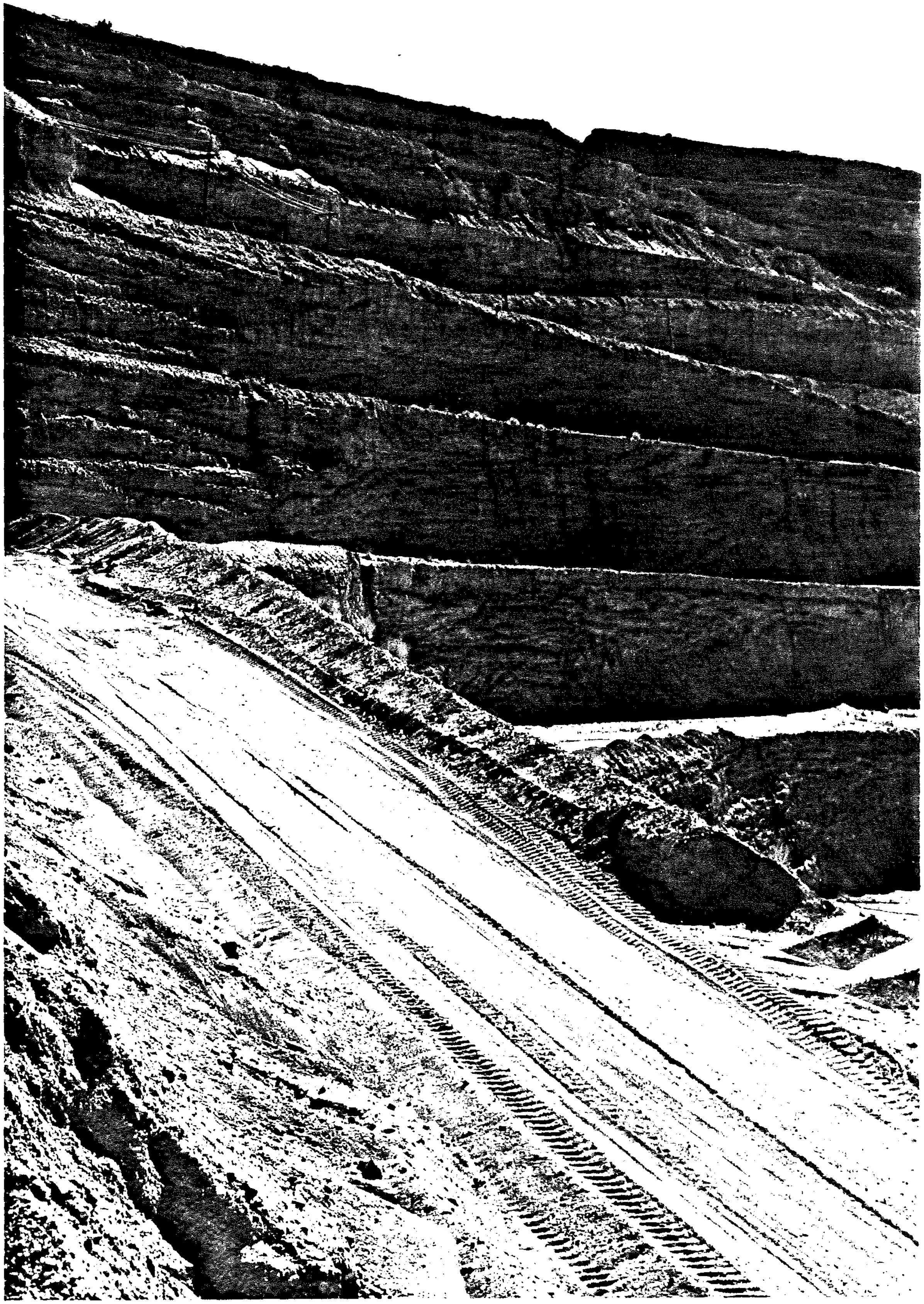


Figure 3-15
A Closer View of the Excavation Profile at Twin Buttes

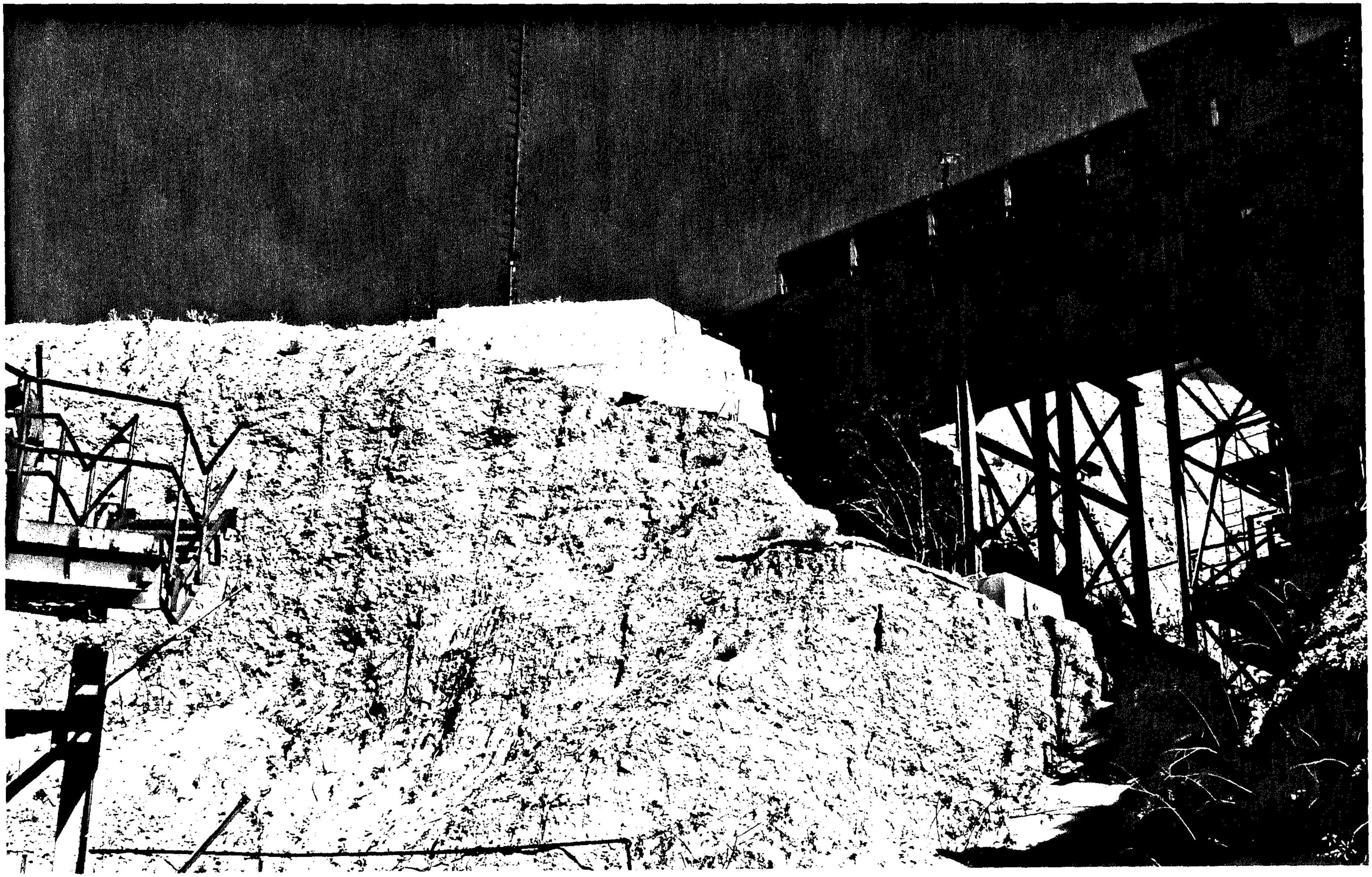


Figure 3-16
Conveyor Foundations Built on the Edge of Pit Benches at the Twin Buttes Mine

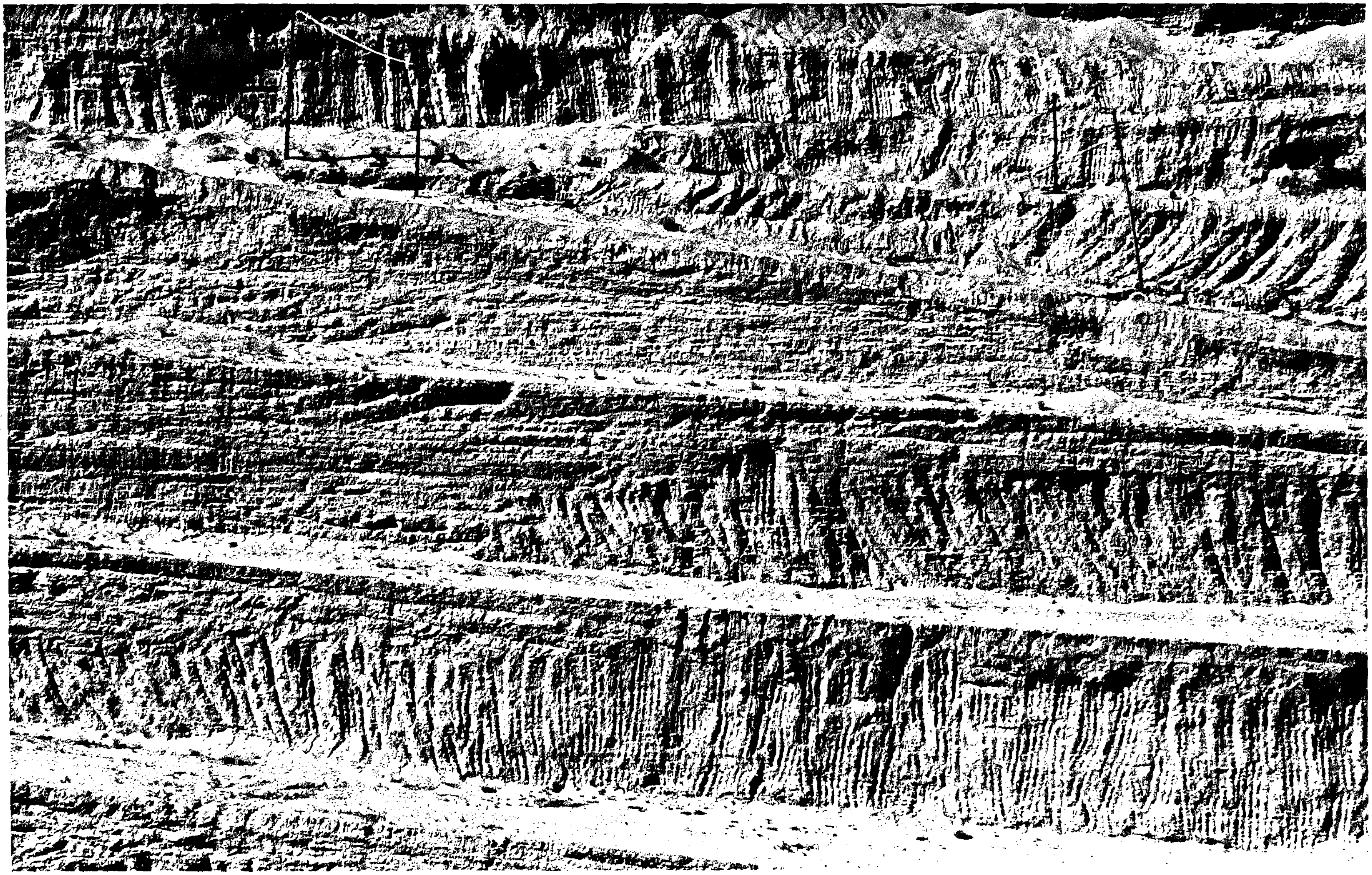


Figure 3-17
Scrapper Marks on a Ten-Year Old Slope Face
State of Arizona, Maricopa Site, September 2, 1987

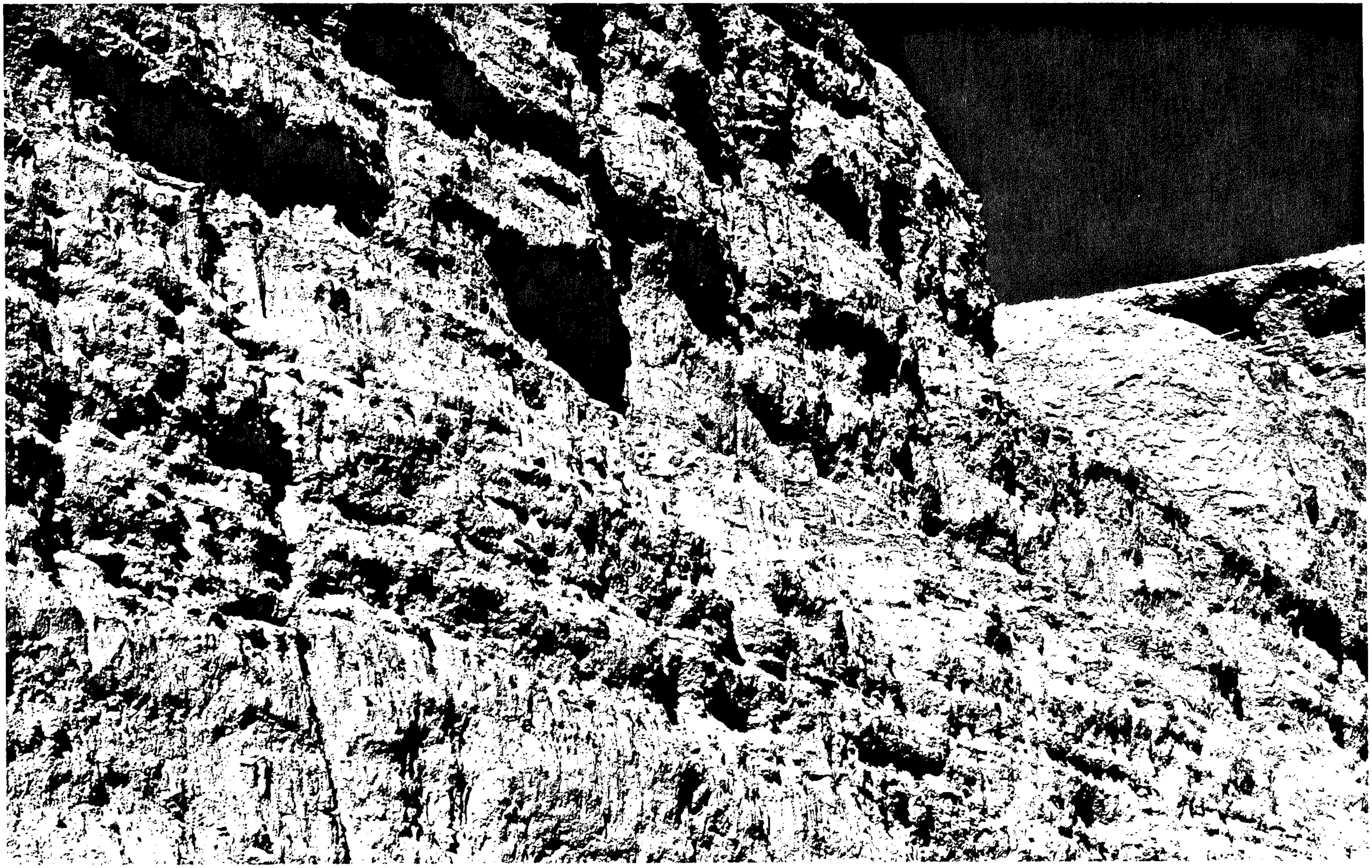


Figure 3-18
Gravel Lenses an Uncemented Pockets of Silt

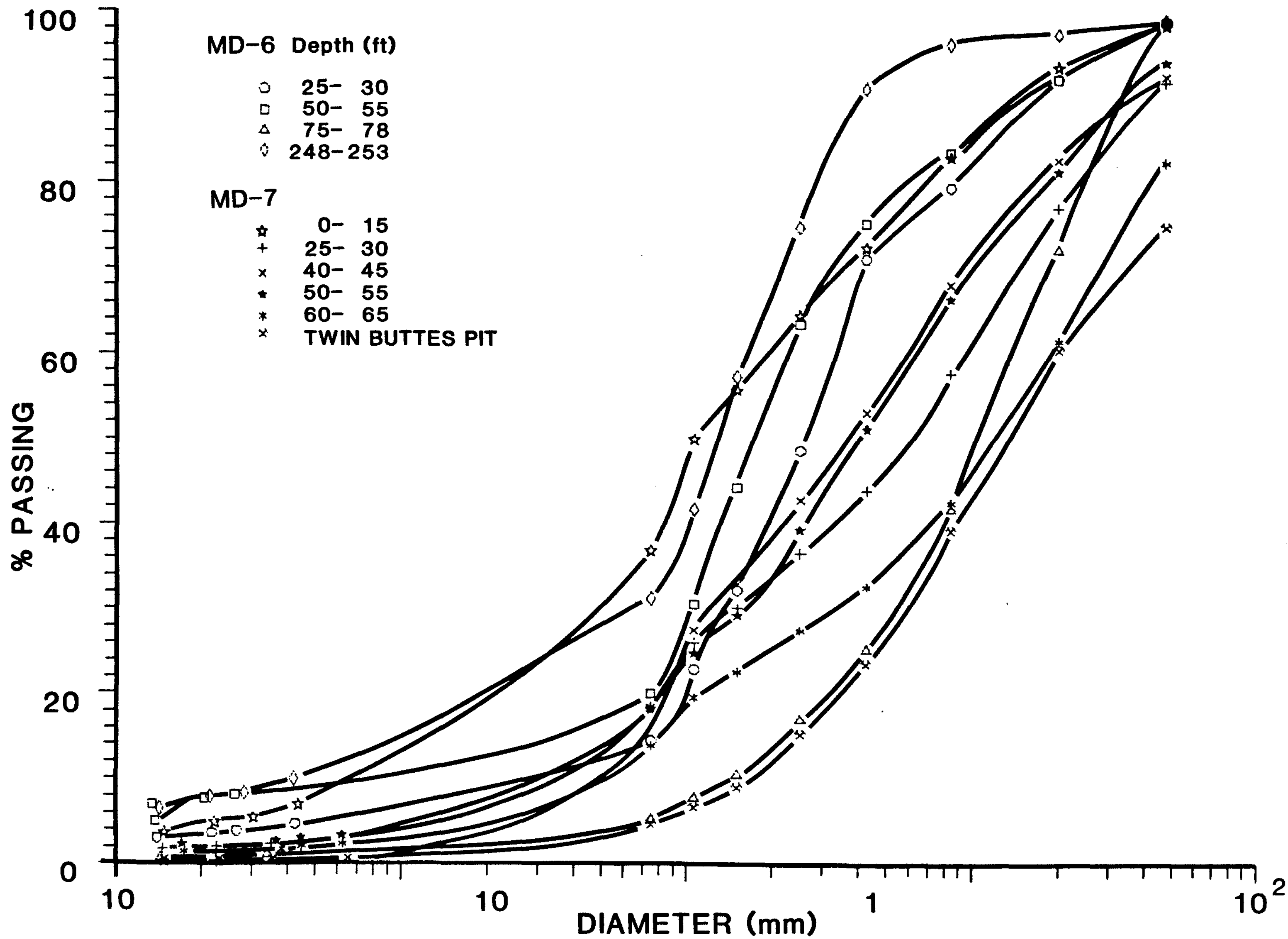


FIGURE 3-19
GRAIN-SIZE DISTRIBUTION CURVES FOR FANGLOMERATE ASSEMBLAGE MATERIALS

TABLE 3-11

SUMMARY OF CLASSIFICATION TESTS

Maricopa Site

Sample	% Gravel	% Sand	% Silt	% Clay	C_u[1]	C_{co}[2]	LL	PL	PI	USCS[3]
MA 2										
50-50	7	73	18	2	46	3		Not Run		
MA 5										
60-65	17	59	22	2	60	2	37	28	9	SM
MD 7										
0-15	2	60	34	4	50	3	34	22	12	SC
25-30	7	73	18	2	66	2	39	23	16	SC
40-45	7	73	18	2	41	2	32	24	8	SC
MD 6										
25-30	<1	84	13	2	7	1	42	21	21	SC
50-55	<1	79	12	8	42	7	44	20	24	SC
75-78	<1	94	4	1	10	1	51	22	29	SW-SC
248-253	<1	67	24	8	53	9	29	26	3	SM

Twin Buttes Pit

Sample	% Gravel	% Sand	% Silt	% Clay	C_u[1]	C_{co}[2]	LL	PL	PI	USCS[3]
Upper Adit										
Sample #1	19	76	5	Tr[4]	11	1	Not Run			SW
Sample #2	21	74	5	Tr	12	1	21	20	1	SW
Lower Adit										
Sample #1	25	68	7	<1	12	1	Not Run			SW
Sample #2	25	70	5	Tr	15	1	Not Run			SW

[1] Coefficient of Uniformity.
[2] Coefficient of Concavity.
[3] Classification according to the Unified Soil Classification System (U.S. Army Corps of Engineers, 1960).
[4] Tr = Trace.

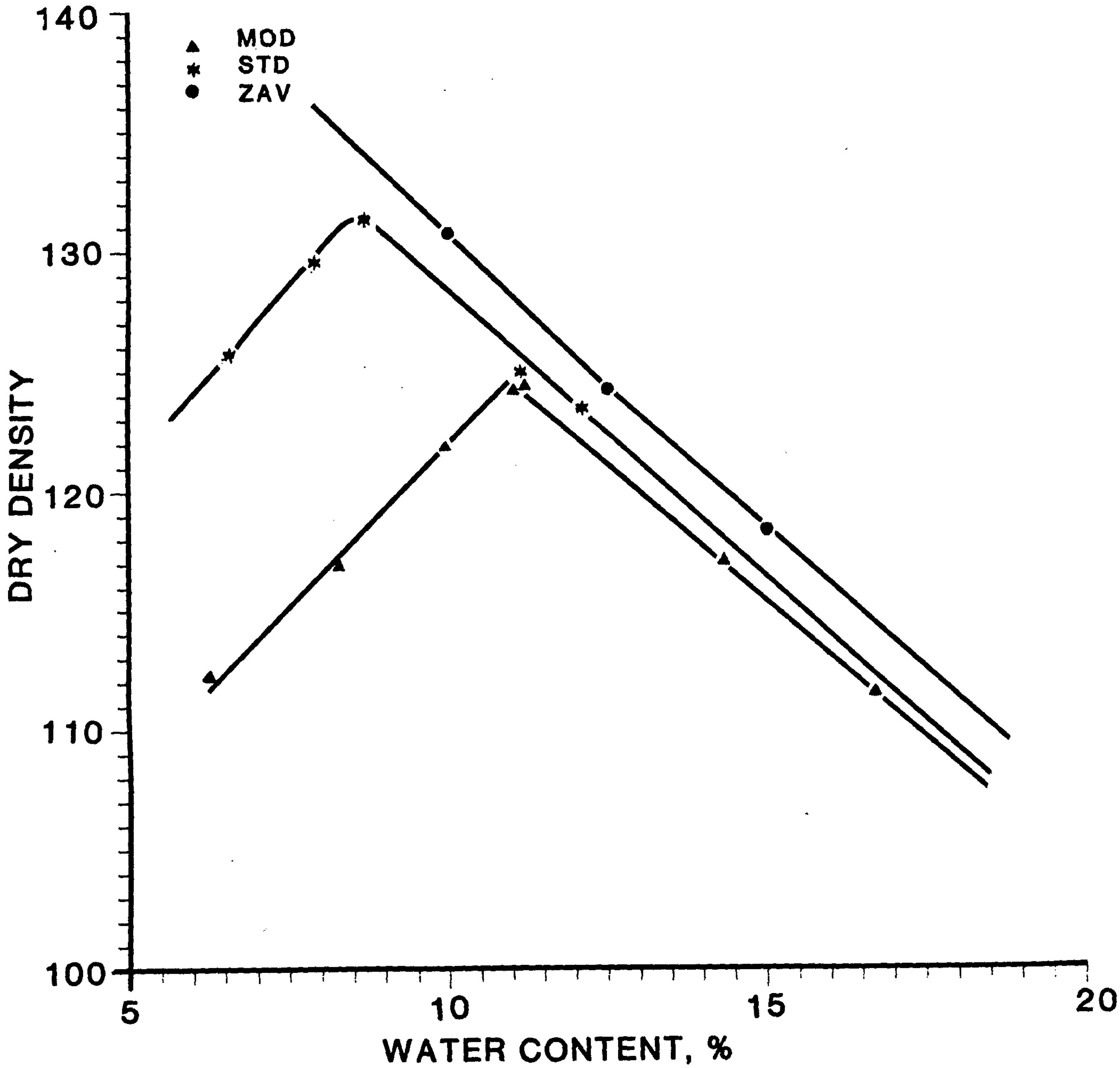


FIGURE 3-20
COMPACTION CURVES
FOR FANGLOMERATE ASSEMBLAGE MATERIALS

dry density of 132 pcf and an optimum water content of 8.3%. The in situ material was found to have a dry density of 125 pcf at an average moisture content of 4%. The solids were found to have a specific gravity of 2.65. The zero air voids (saturation) curve is included in Figure 3-20 for reference.

Permeability Tests. The falling head method was used to establish the material's permeability. Sample preparation and testing procedures are described by DeNatale and Nowatzki (1987). It was found that the relation between permeability, k, and void ratio, e, is essentially linear over the range $0.65 < e < 0.82$. A least-squares fit to the experimental data yielded the relation $k = (53e - 33.45)(10^{-3}$ cm/sec). Since the material has a field void ratio of $e = 0.35$, which falls below the range of void ratios used in the lab permeability testing, its in situ permeability is less than $k = 1 \times 10^{-4}$ cm/sec ($k = 0.3$ feet/day).

Consolidation Tests. The consolidation testing was done on a saturated specimen of the deaggregated material. The void ratio versus log effective stress curve is shown in Figure 3-21. As may be seen, the virgin compression curve is essentially linear over the entire range of applied pressures. As would be expected from a remolded sample, there is no observable maximum past pressure. A summary of the results is presented in Table 3-12.

Strength Tests (Laboratory). A program of laboratory testing was performed to identify the fanglomerate's cohesion and internal friction angle. The details of this program are described by DeNatale and Nowatzki (1987). Because of the cemented nature of the material and the presence of interspersed, large diameter grains, undisturbed specimens for direct shear tests and unconfined compression tests could not be obtained. Therefore, specimens for these tests were prepared by statically recompacting deaggregated material to densities corresponding to maximum "standard" and "modified" Proctor densities. The results of the direct shear tests shown in Figure 3-22 indicate that the friction angle varied slightly from 37° to 40°. This suggests that the friction angle is essentially independent of density and water content, at least within the ranges normally encountered in the field. In addition, the values obtained from these tests are probably a lower limit for the in situ value since coarser particles which would result in a greater degree of particle interlock were removed during specimen preparation. Since deaggregation during specimen preparation destroyed the cementation characteristics of the in situ material no significant cohesion was measured in either series of direct shear tests.

In order to obtain a conservative estimate of the material's in situ cohesion, unconfined compression tests were performed on two "undisturbed" cylindrical specimens that could be retrieved from boreholes. These specimens appeared to be intact and were very stiff to the touch. Surprisingly, when tested in unconfined compression, these specimens yielded strengths of $q_u = 2520$ psf and $q_u = 2180$ psf. Such anomalously low values are attributed to sample disturbance and the probable creation of microfractures within the specimens induced by the sampling procedure. These values yield a conservative value of cohesion $c = 1200$ psf. A summary of the laboratory test performed on the fanglomerate at the Maricopa Site is found in Table 3-12. For comparison, a summary of the results of similar tests performed on fanglomerate material obtained from

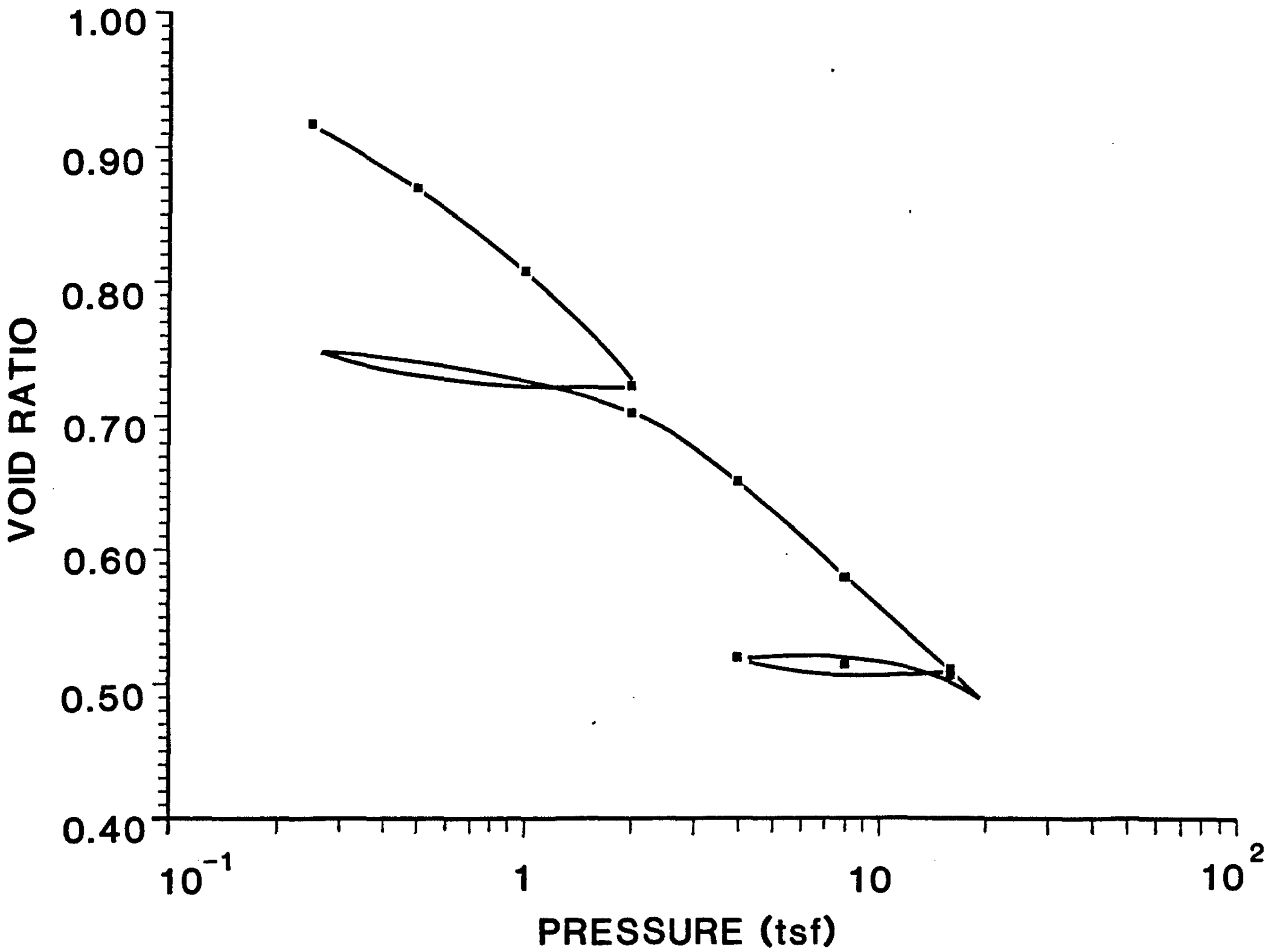


FIGURE 3-21
CONSOLIDATION CURVES
FOR FANGLOMERATE ASSEMBLAGE MATERIALS

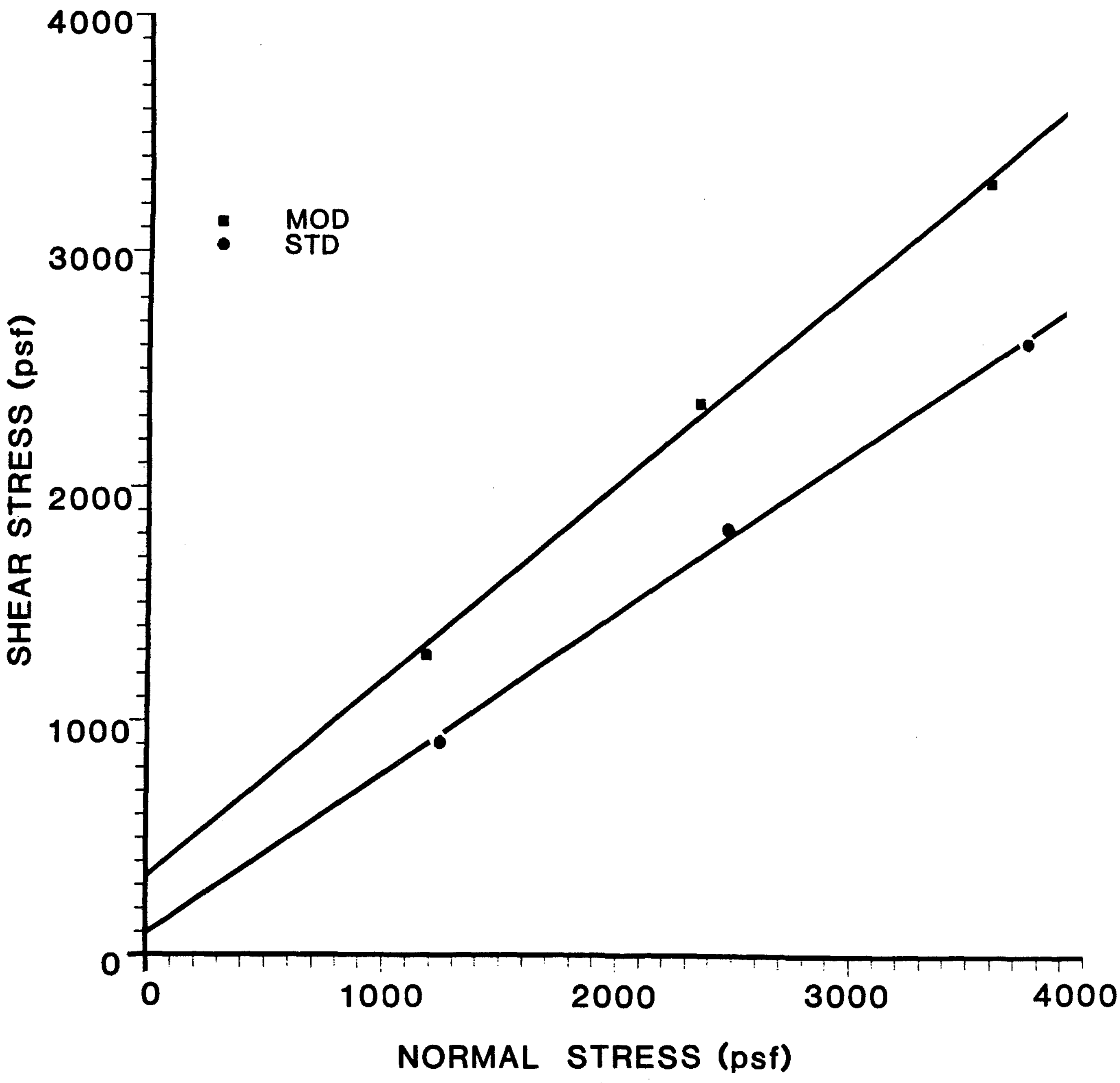


FIGURE 3-22
SHEAR STRENGTH ENVELOPES OBTAINED BY DIRECT SHEAR TESTING OF FANGLOMERATE ASSEMBLAGE MATERIALS

TABLE 3-12

Summary of Geotechnical Engineering Properties of Fanglomerate

Test and/or Parameter	Maricopa Site	Twin Buttes Pit
1. Compaction Characteristics		
a. Maximum Dry Density		
* Standard Proctor	124 pcf	127 pcf
* Modified Proctor	132 pcf	132 pcf
b. Optimum Moisture Content		
* Standard Proctor	11.2%	9.8%
* Modified Proctor	8.7%	8.3%
2. Specific Gravity of Solids	2.65	2.69
3. Consolidation Characteristics		
a. Compression Index (C_c)	0.229	0.130
b. Decompression Index (C_s)	0.015	0.007
c. Recompression Index (C_r)	0.013	0.017
d. Coefficient of Consolidation	Not significant	Not significant
4. Coefficient of Permeability		
a. Void ratio	e = 0.64; k=1 x 10^{-4} cm/sec	e = 0.48; k=1.4 x 10^{-5} cm/sec
b. Void ratio	e = 0.70; k=3 x 10^{-4} cm/sec	e = 0.52; k=7.8 x 10^{-4} cm/sec
c. Void ratio	e = 0.82; k=9.7 x 10^{-4} cm/sec	e = 0.86; k=43 x 10^{-4} cm/sec
d. In situ void ratio	e = 0.33; k<1 x 10^{-4} cm/sec	e = 0.35; k<1.5 x 10^{-5} cm/sec
5. Unconfined Compressive Strength		
a. Specimen #1	2520 psf	- -
b. Specimen #2	2180 psf	- -
c. Standard Proctor Specimen	- -	2000 psf
d. Modified Proctor Specimen	- -	2275 psf
6. Coulomb Shear Strength Parameters		
a. Angle of Internal Friction		
* Standard Proctor	36°	37°
* Modified Proctor	40°	37°
b. Cohesion		
* Standard Proctor Direct Shear	100 psf	- -
* Modified Proctor Direct Shear	300 psf	- -
* Specimen #1 Unconfined	>1260 psf	- -
* Specimen #2 Unconfined	>1090 psf	- -
* Standard Proctor Unconfined	- -	>1000 psf
* Modified Proctor Unconfined	- -	>1138 psf

TABLE 3-12 (Continued)

Summary of Geotechnical Engineering Properties of Fanglomerate

Test and/or Parameter	Maricopa Site	Twin Buttes Pit
6. Coulomb Shear Strength Parameters (Continued)		
b. Cohesion		
* Slope Stability Failure (Field Test)		>3200 psf
7. In Situ Moisture and Density Conditions		
a. In Situ Density		
* Specimen #1	123 pcf	- -
* Specimen #2	133 pcf	- -
b. In Situ Moisture Content (Average of 5 specimens)	5%	- -

various levels in the Twin Buttes pit is also shown in Table 3-12. The two sets of results suggest that the materials, although not identical, are similar and can be expected to exhibit similar engineering behavior.

Strength Tests (Field). Because of sampling difficulties, there were no suitable means of estimating the fanglomerate's in situ cohesion accurately by lab testing. Thus a simple field test was conducted at the Twin Buttes pit from which a value of cohesion could be back-calculated. The test involved inducing slope failures by applying a surface load to the top of several existing vertical slopes at the Twin Buttes pit. The details of the testing program are described by DeNatale and Nowatzki (1987). Figure 3-23 shows the test set-up and Figure 3-24 depicts a typical failed slope. Since failure implies a safety factor FS = 1, and since the material's internal friction angle was measured by lab tests to be 37° (conservatively), the material's cohesion could be back-calculated using any of the standard methods available for slope stability analysis. Bishop's Modified Method (Bishop, 1955) with a correction for three dimensional "end effects" developed by Azzouz et al. (1981) was used. The back-calculation yielded a cohesion of c = 3200 psf for the in situ fanglomerate. Because the cohesion of the fanglomerate is due to cementation and because the field tests were performed on bench slopes that have been exposed to weather and subject to surcharge from mining operations for at least ten years, factors that tend to destroy cementation, this value of cohesion should be regarded as a conservative estimate of the actual value that can be expected in situ.

In summary, the fanglomerate provides an excellent opportunity for flexibility in construction. It is uniquely suited for deep cut-and-fill operations and has excellent machine tunneling characteristics. Where encountered in CUs 1, 2, 6, and 7 (wholly) and 3, 4, 5, and 8 (partially), seismic velocity data suggest that it will tunnel like a soft rock. Ground water is not expected to be encountered in the fanglomerate in either cut-and-fill or machine-tunneling CUs; if it is, the in situ permeability of the material is low enough to allow for water control by conventional methods.

3.5.2.2 Granitic Assemblage. Approximately 19% of the tunnel alignment crosses the granitic assemblage in CUs 3, 4, 8, and 9. This assemblage consists primarily of Precambrian porphyritic granite, quartz diorite, and local xenoliths of gabbroic intrusive rocks and Pinal Schist. Sections 3.2.2 and 3.2.3 provide a discussion of the geology and composition of these rocks, and the current interpretation of their genesis.

As Section 3.2.2 shows, the granitic rocks present at the site are among the oldest rocks known in Arizona. Most have experienced multiple episodes of tectonic activity that are evidenced by mineral recrystallization and minor introduction of calcite, quartz, and epidote veinlets; development of weak to moderate foliation; and several different suites of fracturing. There is a noticeable absence of strong mineralization and alteration. Changes in rock composition and structural fabric that determine the strength and other engineering properties appear to be largely the result of near-surface weathering.

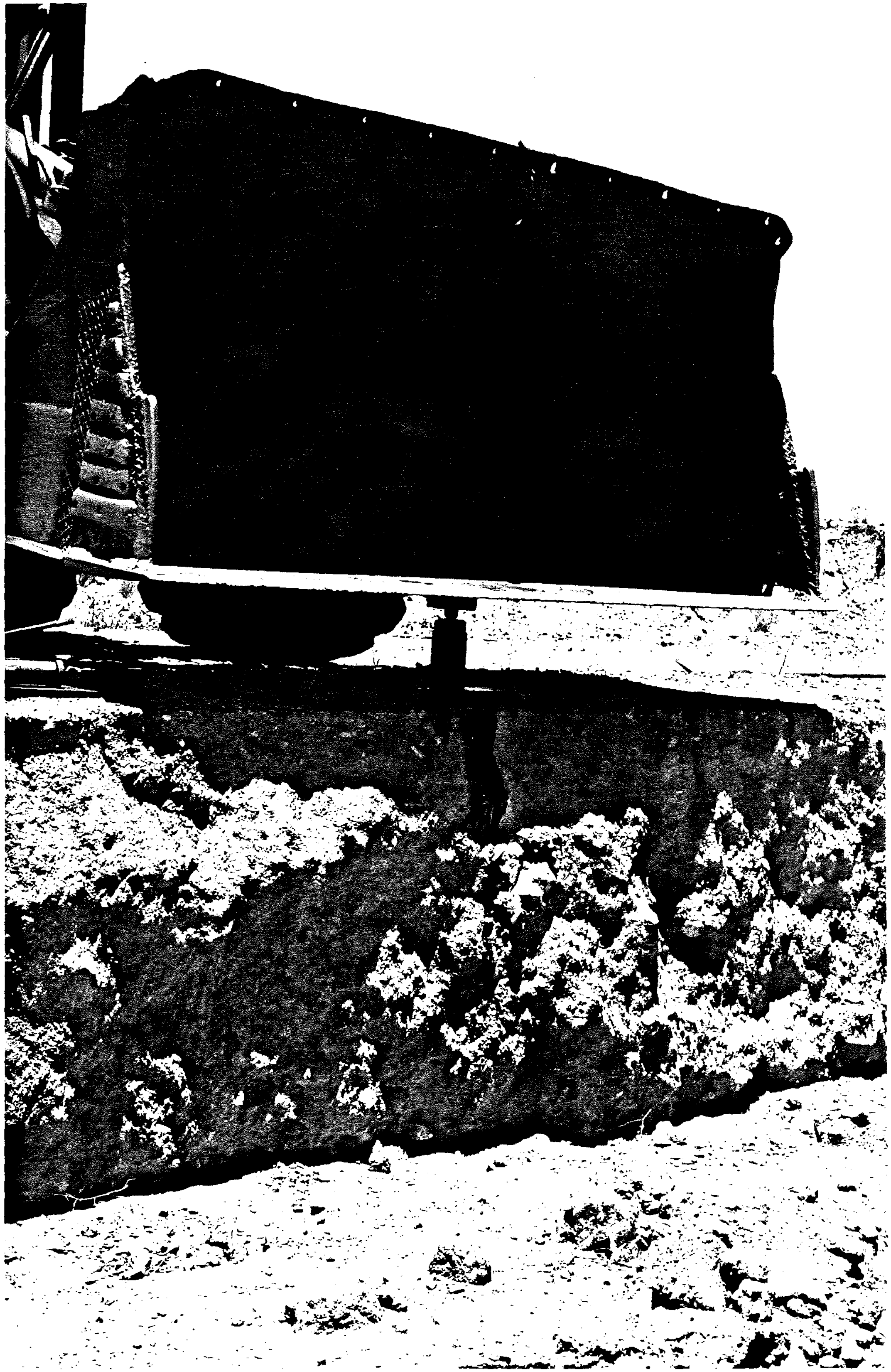


Figure 3-23
Typical Field Slope Loading Test

Figure 3-24
Typical Slope Failure in Fanglomerate Assemblage Materials

These rocks tend to be high in strength, except where the strength is lessened by fracturing, weathering, or weak hydrothermal alteration. Laboratory unconfined compressive strength in the porphyritic granite was found to be near 20,000 psi, and the strength of the Booth Hills quartz diorite was found to be near 25,000 psi. Locally, the unconfined compressive strength of either of these rocks can approach 30,000 psi. The consistency of these strength values throughout the rock mass is demonstrated by the results of point load testing that accompanied detailed geotechnical logging of recovered drill core. Rock compressive strengths estimated from point-load indices for the porphyritic granite average 19,280 psi with a standard deviation of 6,140 psi. For the Booth Hills quartz diorite, the average is 28,960 with a standard deviation of 3,680 psi.

Fracturing and jointing tend to occur in discrete zones. In the porphyritic granite, steeply-dipping joints are commonly found in groups separated by several feet of unfractured rock. The Booth Hills quartz diorite in the injector complex area appears to be more intensely fractured. In drill core, about half the joints logged are rough and relatively clean; most of the remainder contain clay or calcite, and are fairly smooth. Joints containing calcite may be partly open but all those seen that contain quartz or clay are completely filled. Overall fracture densities average 0.75 per linear foot of core for the porphyritic granite and 5.1 per foot for the Booth Hills quartz diorite. It is not uncommon to recognize at least six distinct joint orientations in a five-foot run of core. The net effect of the fracturing is to lessen the relatively high strength of these plutonic rocks. Fractures filled with clay may become softened and therefore weak if wet, although this is unlikely because the water table is considerably deeper than the tunnel horizon and because of the expected low permeabilities of the rock masses. The quality of the rock is likely to remain good for tunneling at the ring horizon, where many fractures are healed with calcite.

Exceptionally weak zones, such as wide faults filled with gouge, or wide zones of crushed and deaggregated granite, or great depths of weathering are not expected from the surface exploration and were not indicated in drill core. The true width of faults and deep weathered zones, as measured in core, were typically not more than a few inches, and were never found to exceed 0.5 feet. The maximum depth of substantial weathering appears to be less than 100 feet, with weathering below that depth limited to slight discoloration of feldspars and joint in-fillings, ordinarily in discrete zones associated with minor faulting or an increase in the density of fracturing. At shallow depths, 0-50 feet below the bedrock surface, weathering can be intense and result in nearly complete disaggregation of the rock. Should such weathered zones occur in surface excavations, they can be easily excavated by surface earthmoving equipment. Underground, the weathered material, should it be encountered, can be adequately restrained by the planned shield support system (see Section 3.5.4).

Results from drill-hole data were confirmed by surface geotechnical mapping. This mapping consisted of detail-line (scanlines) and detail-area surveys oriented wherever possible in three orthogonal directions. Figure 3-7 shows the locations within the site where these measurements were conducted. The surface mapping data were processed and analyzed according to accepted practices, namely, fracture spacings were computed from line intercepts as well as estimated in the field, and Schmidt equal-area plots of poles to planes were computer-generated.

Although the drill core was not oriented to provide absolute orientation measurements for all fractures logged, the generally excellent condition of the recovered core allowed determination of relationships between trends of fractures of various dip angles and therefore the number of fracture sets represented, according to amount of dip angle. When these data were compared with the data from the surface measurements, it was found that the numbers of joint sets and their respective prevalences did not differ substantially from place to place along the ring alignment, for each rock type studied (Cummings et al., 1987). It is therefore surmised that the tunneling conditions as interpreted from drill core will be broadly representative of all the granitic rock masses expected to be intercepted by the tunnel.

Rock stress conditions are unknown. No condition indicative of unusual stress conditions, such as core discing, was noted in drill core. In most cases, the shallow depth of tunneling and the intensity of the fracturing make encountering difficult stress conditions unlikely. Furthermore, major tectonic influences, such as regional thrust faults, that could suggest a potential for high residual stress fields, are unknown in the area.

In summary, the granitic assemblage may be characterized as uniformly strong but variably fractured, with little weathering or alteration occurring at tunnel depths. Because of the fracturing, excavation should not be difficult and excellent progress with a tunnel-boring machine is expected. Jointing intensity ranges from low to moderate and most fractures are moderately strong. The tunnel should be dry and complications arising from the influence of water should be absent. Rock stress is likely to be less than 20% of the compressive strength and therefore of little influence on stability. Such rock masses are almost always free of serious stability problems and are normally self-supporting at the tunnel diameters under consideration. It is possible, however, that localized blocks and wedges will be occasionally encountered that will require rock bolt support. Rock conditions are therefore considered to be "very good to excellent."

3.5.2.3 Volcanic Assemblage. The volcanic assemblage occurs in the southeastern portion of the ring alignment in CU 5 and constitutes 14% of the rock to be tunneled. As described in Sections 3.2.2 and 3.2.3.4, this assemblage consists of thick basalt flows interbedded with thick sequences of conglomerate. Locally, rhyolitic welded tuff might be encountered. These rocks have been carefully studied in drill hole MD-1R.

The basalt is strong and has low fracture frequency. It has a compressive strength of near 18,000 psi. Joints are commonly irregular, rough to wavy, with calcite fillings, and will provide little reduction in strength. Vesicularity is low to moderate and tends to reduce the material's strength. As represented in core, this thick unit is quite homogeneous. No recognizable flow stratigraphy was noted above tunnel depth, such as flow-top breccia or buried ash, regolith, or cinder layers.

The conglomerates are unjointed but may be fairly weak. Detailed logging indicates an average of 40% sandy matrix and 60% lithic fragments, which may range up to six inches in diameter. The matrix is poorly cemented but lithic fragments, which include a wide variety of igneous and metamorphic rock types, are generally quite strong. Laboratory testing of fresh, saturated conglomerate yielded a strength of only 3,900 psi. The moisture content was preserved for testing but probably was only due to drilling fluid. The material yielded a strength of 6,000 psi when dry.

There is a possibility that the tunnel will encounter thin layers of rhyolitic welded tuff. These rocks were not intercepted by the drilling completed to date. However, surface exposures and experience with similar rocks elsewhere in Arizona lead to expectations of low to moderate spacings of rough to irregular joints, and rock strengths in the range of 15,000-25,000 psi.

Attempts to measure depth to the water table in the volcanic assemblage in MD-1R were unsuccessful because the depth to water exceeded the 500-foot reach of the cable. This depth also exceeds the depth of the tunnel by about 150 feet at this location. Thus the volcanic rock units are expected to be dry when tunnelled. In particular, the moisture content of the conglomerate should be low, which will enhance strength.

In summary, the volcanic assemblage will be an excellent medium for tunneling. The contacts between various rock types are clear and should be easily locatable for tunnel design. The basalts should stand without any support except occasional rock bolts. Welded tuffs may require pattern-bolting at places or a light, reinforced shotcrete lining. The conglomerates may require a segmental liner, particularly if the transition to a more competent unit is to be made. Excellent excavation progress is expected in the conglomerates and welded tuffs. Basalt strengths are not high for modern TBMs and good progress can be expected.

3.5.3 SITE ADVANTAGES AND DIFFICULTIES

3.5.3.1 Advantages. The greatest advantage for construction of the Super Collider at the Arizona Maricopa Site is its flexibility. The geologic setting of the nearly flat and near surface collider ring allows both cut-and-fill and TBM techniques to be used (see Section 3.5.4). The fact that this site can make use of different construction techniques simultaneously permits the fullest use of local resources. These resources include:

- A superb climate offering virtually 365 days a year construction time (Volume 7, Section 7.3).
- Available labor trained in the proposed construction methodologies (Volume 4, Section 4.5).
- The infrastructure necessary to complete a construction project of this size (Volume 4, Section 4.4).
- No negative effects on the natural environment (see Section 3.5.5).
- Geologic simplicity and sufficient geotechnical information to permit low overall geotechnical contingencies (Sections 3.2.3, and 3.5.4.6).

Cut-and-Fill Construction. Approximately 20% of the ring at the Maricopa Site is less than 60 feet deep and ideally suited for construction using rapid, economical, and reliable cut-and-fill techniques. The ability to use cut-and-fill methods is a direct result of geologic setting and infrastructure. Cut-and-fill CUs are confined to stretches of fanglomerate. Central Arizona Project (CAP) construction, the operation of nearby open-pit mines, and geotechnical investigations all document that fanglomerate is an ideal material for the application of cut-and-fill technology (see Sections 3.5.1.1 and 3.5.2.1). The aforementioned construction projects have also provided an experienced labor force that will not require time-intensive training. In addition, the CAP has pioneered many techniques in high-production excavation for its canals and cut-and-fill construction for its siphons and other buried facilities. New technologies for construction of buried tunnels have been developed and proven in Arizona. This experience is documented in Section 3.5.4. These new technologies will result in substantial cost-savings and accelerated construction schedules for the Maricopa Site.

Geotechnical investigations at the Maricopa Site demonstrate that the cut-and-fill CUs will not be affected by ground swelling, liquefaction, or collapsing soil. Furthermore, land disturbances will be minimal because the fanglomerate's engineering properties allow a 60° profile for excavations. Section 3.5.2.1 and Table 3-4 document fanglomerate excavation stability to heights of 100 feet or greater at slope angles from 60° to 90°.

The water table is well below the tunnel depth at all locations of cut-and-fill construction. Therefore no problems are expected from ground water infiltration into surface excavations. Streams are dry more than 95% of the year. The seasonal nature of the surface flow events that do occur allow for a schedule that virtually assures no surface water disturbances during construction. Arizona's climate also permits virtually full-year construction with very few delays related to inclement weather. Since average total rainfall at the Maricopa Site is less than 12 inches, rainfall will not complicate spoil storage or cause road degradation.

In summary, the Maricopa SSC Site is ideally suited for the use of cost-saving cut-and-fill construction techniques. In addition, such construction allows future additions to the facility to be built in the fanglomerate at shallow depths rapidly and cost-effectively, without interrupting operations at the existing facility. When compared to DOE generic site models, the Maricopa Site offers an opportunity to construct substantial portions of the SSC collider ring, injector complex, experimental chambers, and future expansions using cut-and-fill at substantial savings (see Section 3.5.4.6 and Appendix 3-B).

Tunnel Construction. The tunnel alignment will also pass through rock and fanglomerate materials that are ideal for machine tunneling. Geotechnical evaluations indicate that rapid advances are possible and that no major problems are anticipated in CUs using TBM technology (see Sections 3.5.1 and 3.5.2). There also is no hazard from naturally occurring hydrocarbons (see Section 3.2.4.3), and the tunnel alignment will be entirely above the water table (see Section 3.3.1.3).

There is a history of successful TBM construction in the rock types characteristic of the geologic assemblages of the Maricopa Site. For example, the Papago

There is a history of successful TBM construction in the rock types characteristic of the geologic assemblages of the Maricopa Site. For example, the Papago Freeway Drainage Tunnels constructed in the metropolitan Phoenix area between 1984 and 1986 provide examples of local tunnels driven in the fanglomerate assemblage. In this case, the tunnels were driven through poorly cemented alluvium of less strength and stability than the fanglomerates present at the Maricopa Site. Despite the weaker character of the material in Phoenix, advance rates of up to 220 feet/day were achieved. This experience is discussed further in Section 3.5.4.2. Extrapolation to the Maricopa Site suggests equal or higher advance rates and reduced overall construction costs. Also, the CAP Buckskin Mountains Water Tunnel in western Arizona demonstrated that materials similar to the volcanic assemblage at the Maricopa Site can be TBM excavated with little difficulty. The Sandbar Tunnel in California is dramatic evidence of a successful high-speed machine-bored tunnel in granitic rocks similar to those present at the Maricopa Site.

In summary, in the last ten years, civil works projects in Arizona have made increasing use of machine tunneling. Additional tunnels are planned in several areas. The U.S. Bureau of Reclamation (USBR) plans to construct several diversion tunnels in connection with the New Waddell Dam construction in a volcanic terrane northwest of Phoenix. To complete the Central Arizona Project in the Tucson area the USBR has a design for nearly two miles of 10-foot diameter machine-bored water tunnel through volcanic rocks similar to those found at the Maricopa Site. These projects coupled with Arizona's extensive underground mining experience are evidence that a favorable technical, economic, and labor environment for large tunnel projects already exists and is growing in the area.

Reliability. The Maricopa Site's greatest asset is its geologic simplicity. Prior to work conducted for the Arizona SSC Project only regional geologic studies had been conducted in the area. A search of government, university, and industry files for data did not reveal any site-specific information. Site-specific geologic and geotechnical investigations were conducted by the Arizona SSC Project. These studies included 42,000 feet of seismic line data, 750 gravity measurements, 3,000 feet of drill-hole data, and extensive field and laboratory testing of materials (see Sections 3.2.3, 3.5.1, and 3.5.2). It is unlikely that conditions significantly different from those already identified will be encountered. This information allowed the Arizona SSC Project engineers to develop geotechnical contingencies based upon specific construction methods and ground conditions for each CU. The weighted average geotechnical contingency of 10% demonstrates the reliability of the Maricopa Site.

Several different rock types will be encountered by the SSC construction. Geologic diversity does not, however, imply construction problems. From an engineering perspective, the rock may be characterized as "hard," or "medium." The fanglomerate is best characterized as a "weak" rock. Contacts between rock units can be gradational or clean and predictable. Furthermore, the machine tunneling and liner placement techniques proposed are both economical and unaffected by geologic discontinuities or rock weakness when compared to conventional tunneling techniques. A 10-foot diameter, machine-excavated tunnel can be reliably driven and will remain stable under all conditions present at the Maricopa Site.

Rock Conditions. Two conditions might pose problems for construction in the fanglomerate. They are the presence of water in quantities sufficient to saturate the material, and a mixed face of fanglomerate and "hard rock." Although construction in the fanglomerate will be above the water table, perched water horizons can occur (see Section 3.3.3.1). Such occurrences are rare and limited in extent. The use of expanded pre-formed concrete segments for ground support and a full-face shield TBM will allow tunneling to continue without interruption. If similar conditions are encountered in cut-and-fill excavations, the water will be allowed to drain into the cut where it can be pumped out. Experience at the Twin Buttes Mine documented this approach successfully. An alternative approach is to install a local system of well points to intercept the water and not allow seepage into the excavation. This procedure is more desirable when considering possible slope stability problems.

The TBM design assumed for mixed-face conditions at the Maricopa Site is a double-shielded machine with a domed cutterhead. A similar machine is currently successfully driving an 18-foot-diameter tunnel in Melbourne, Australia, through mixed-face conditions of basalt and clay beneath the water table. Advance rates exceeded those projected by the design team after only 20% of the tunnel had been completed (Hunter, 1987). It is clear from this experience and from similar operations at the River Mountains Tunnel in Nevada (Sperry, 1987) that mixed-face conditions should not cause excavation problems.

If presently unknown structural features such as major faults or stratigraphic discontinuities are intercepted by the tunnels, the recommended tunneling methods for over 90% of the project will not be affected by such features. For the remaining 10%, drill-and-blast methods will be used to build machine staging areas and crosscuts to the shafts. A conservative view is that these areas may require steel sets or reinforced shotcrete for long-term support. Although such procedures are costly, they are not expected to have a major impact on the project.

3.5.4 RECOMMENDED CONSTRUCTION TECHNIQUES

The construction methods recommended for the Maricopa Site are basic high-production excavation and tunneling techniques that will:

- provide a safe working environment,
- be geotechnically correct for the site,
- allow immediate construction start-up,
- maximize flexibility,
- save time and money,
- make use of the well-established excavation and tunneling expertise of Arizona construction and mining firms,
- benefit from the skills of the locally available labor pool.

The two methods recommended for the Maricopa Site are (1) cut-and-fill for depths less than 80 feet, and (2) tunneling with a TBM in deeper areas. Occasionally, conventional drill-and-blast tunneling may be needed in short tunnel sections for driving crosscuts to shafts and for making portals or shaft-bottom staging areas.

sections for driving crosscuts to shafts and for making portals or shaft-bottom staging areas.

Cut-and-fill will be used extensively at the Maricopa Site. The geotechnical properties of the fanglomerate (Section 3.5.2.1) and the great depth to ground water (Section 3.3.1) permit safe and efficient uses of this technique to depths of 80 feet. Section 3.5.2.1 provides a thorough review of previous local construction experience in fanglomerate. The flexibility to use cut-and-fill methods guarantees low cost, high advance rates, and reliable construction.

Cut-and-fill is the best construction method for CUs 2 and 7, and the injector complex. For CUs 1 and 6, weak rock TBM is best, and for CU 9 hard rock TBM methods are recommended. Mixed-face TBM methods are needed for CUs 3, 4, 5, 8, and 10. Cut-and-fill methods may be used to excavate the injector complex tunnels in cuts less than 80 feet deep. Stacking the injector components can further reduce the depth of cut and improve construction efficiency. The LINAC would be constructed at the surface.

The following sections detail the recommended construction methods for the ring and injector tunnels, the experimental chambers, and the shafts. Where appropriate, unconventional techniques that may save time and money are introduced as alternatives.

3.5.4.1 Ring and Injector Complex Cut-and-Fill. The most economical way to construct a tunnel at shallow depths in fanglomerate is by cut-and-fill, using either precast cylindrical concrete tunnel segments or cast-in-place segments. The cut-and-fill method becomes more cost-effective as sideslopes become steeper because smaller volumes of material are handled. The feasible depth for cut-and-fill depends on equipment performance, material handling costs, and safety. Recent improvements in equipment, coupled with the strength and stability of the fanglomerate, suggest that excavation depths up to 80 feet are practical and safe.

As indicated in Section 3.5.2.1 and Table 3-4, theory and practice show that it is possible to excavate vertically to a depth of 100 feet and still have a safety factor greater than 2 against slope failure. However, a conservative depth cut-off of 60 feet with a 60° average slope angle was used for all cost and schedule estimates. Additional reductions in time and cost, using a cut-off depth of 80 feet, are discussed in Section 3.5.4.6. Approximately twelve miles of the ring alignment is amenable to construction by this method, using a 60-foot cut-off and 60° slope angle.

Several mass excavation systems are available for digging a trench in the fanglomerate. Two of these are discussed here in detail because they are ideally suited for the material handling needs of the Maricopa Site.

Scrapers. The mining industry has long used large volume scrapers for excavation in open-pit operations. Scrapers were used to remove the fanglomerate from the Twin Buttes and Sacaton mines, and were also used on the CAP canal. Major portions of all three projects were excavated in fanglomerate that had geotechnical properties similar to those present at the Maricopa Site.

that carries the muck out of the excavation. The Holland Loader is a modified scraper that fits into this category. For example, the Holland 700 Loader used on the Red Rock section of the CAP northwest of Tucson consisted of a bottom-cutting loader propelled by two large Caterpillar D10 tractors placed in tandem (see Figure 3-25). A large diesel engine mounted on the loader frame drove a belt conveyor which was also supported by the frame. For the 45° side slopes of the CAP canal, a bridge conveyor was suspended between the rear tractor and a third tractor at the top of the excavation. When weathered or fractured rock was encountered a ripper tooth, mounted on the front tractor, allowed the Holland Loader to excavate materials that would have been impossible for conventional scrapers to handle. Production levels using this system reached 3,400 tons/hour in fanglomerate similar to that found at the Maricopa Site. The modified Holland Loader used on the Red Rock section of the CAP proved so effective that the most recent section of the CAP was bid and won on the basis of projected production rates of 7,800 tons/hour (Cockran, 1987).

In general, Holland Loader systems are modified for specific applications. Components such as cutter teeth, the spacing between them, and conveyor belt widths are selected according to the rock and soil materials at the construction site. For example, the contractor of the Red Rock section of the CAP rigged the conveyor system described above specifically for that project. For steeper cuts the top of the bridge conveyor could be supported over the open cut at the end of a short stacker conveyor. With this system even vertical cuts could be made by adapting conventional conveyor systems to the Holland Loader. Another adaptation that has been proposed for steeper cuts in open-pit mines is to use the loader's feeder belt to load a sandwich belt high-angle conveyor system (Figure 3-26). Such systems allow shorter conveyor length and permit muck removal from excavations having steeper slopes, both of which result in construction savings. This system seems ideally suited for the 60° slopes proposed for the Maricopa SSC cut-and-fill construction segments.

In summary, since the Holland Loader was the most productive and least expensive of the excavation systems used in fanglomerate along the CAP route, it is an excellent candidate for use at the Maricopa Site where similar fanglomerates exist. Accordingly, the Arizona SSC Project prepared a contractor's estimate to document the cost and scheduling benefits that could be realized by using the Holland Loader for cut-and-fill sections of the ring. This estimate, as presented in Appendix 3-B and summarized in Section 3.5.4.6, is based on the following construction procedures: A Holland Loader will make successive passes along the trench line and dig a 20-foot wide trench graded to an angle of 60°. Muck spoils will be conveyed to one side of the excavation over the rear loader. Tunnel sections will be cast in place, and liner construction will proceed at a rate of 300 feet per day.

A small rotary separator will sort the excavated materials for select backfill that will be tamped into place around the tunnel sections with a sheepsfoot roller at 2,000 yd^3/hr. The Holland Loader will replace regular backfill at a rate of 6,000 yd^3/hr. Leftover materials will be spread over the disturbed area, contoured by a grader, and reclaimed by hydroseeding.

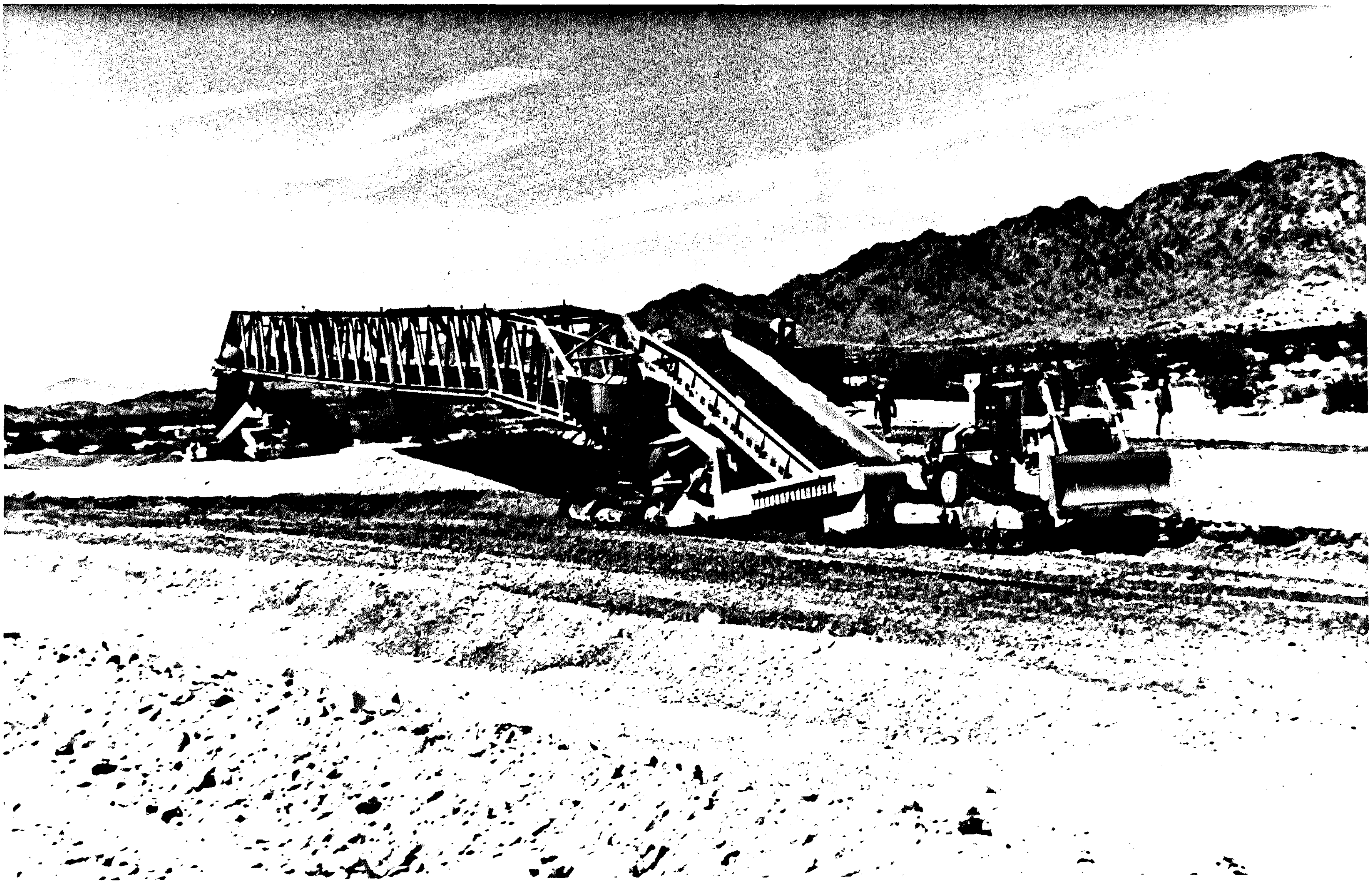


Figure 3-25
Holland Loader System in Use at the Central Arizona Project
State of Arizona, Maricopa Site, September 2, 1987

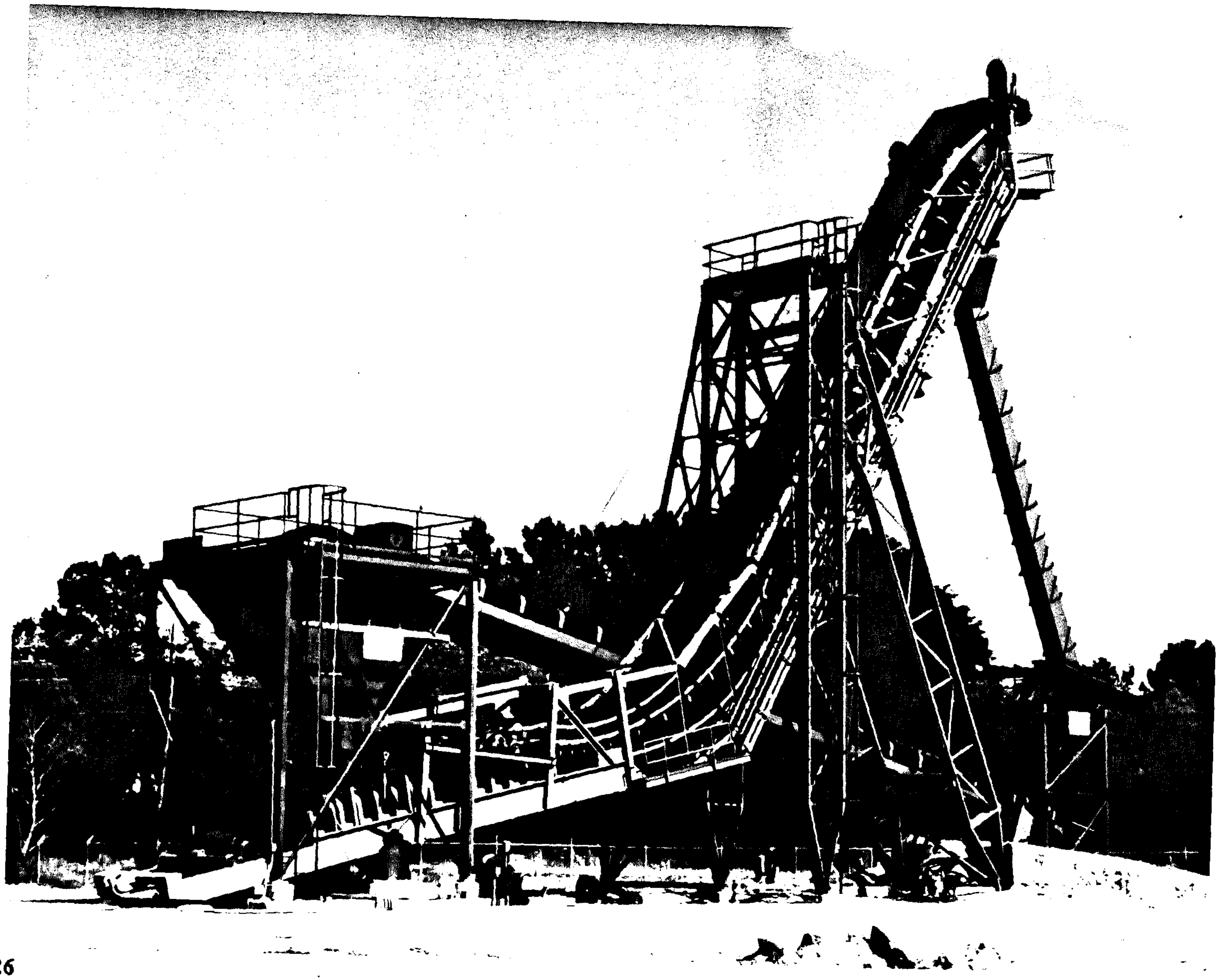


Figure 3-26
A Sandwich Belt High-Angle Conveyor System
State of Arizona, Maricopa Site, September 2, 1987

Alternative System. The continuously excavating, cast-in-place pipe laying and backfilling system developed by the R. A. Hanson Company, Inc. (RAHCO) for the U.S. Air Force provides a viable alternative to either of the systems discussed previously. The system was used to construct a test tunnel near Yuma, Arizona in fanglomerates similar to those present at the Maricopa Site.

The three-machine cast-in-place system consists of a mobile truck unloader, a slipform work jumbo, a form transporter, and collapsible innerforms. The equipment, which operates with a crew of 14, laid 5,089 feet of 6,000 psi concrete pipe during the test. The three-machine system placed nearly 700 feet of concrete pipe with an inside diameter of 14 feet 4 inches and a wall thickness of eight inches in eight hours.

This system could be coupled with existing RAHCO excavating equipment or with a Holland Loader to provide a continuously excavating, pipe laying, and backfilling system operationally capable of producing up to 1000 feet of finished concrete-lined tunnel per day.

3.5.4.2 Ring and Injector Complex Tunneling. In this proposal CUs with substantial segments lying deeper than 60 feet are assumed to require excavating by machine tunneling. Materials encountered at the Maricopa Site range from fanglomerate ("weak rock") in CUs 1 and 6, to plutonic and volcanic rocks ("hard rock") in CU 9. CUs 3, 4, 5, 8, and 10 have mixed conditions with both weak rock and hard rock sections.

Tunneling in Fanglomerate. Fanglomerate as a tunneling medium was field-tested for the Arizona SSC Project by the ANAMAX Mining Company which dug two short tunnels in the fanglomerate at the Twin Buttes open-pit mine on October 18, 1985 (Figure 3-27). A Gradall excavated two unsupported tunnels of 12 to 15 feet in diameter, 15 feet deep, to test the stand-up time, i.e., the amount of time that the ground can remain unsupported after excavation without local or general failure. The longer the stand-up time, the less chance that ground failure will cause problems during construction. In the more than 18 months since the test tunnels were dug, the fanglomerate has stood up remarkably well. Teeth marks of the Gradall are still visible in the back, face, and ribs of the openings. This test confirms what is clear from an examination of the miles of pit wall at the Twin Buttes Mine and from the measured physical properties of the material (see Section 3.5.2.1). Stand-up times of months to years are characteristic of fanglomerate.

As indicated in Section 3.5.3.1, the Papago Freeway Drainage Tunnels in Phoenix provide an example of successful tunneling in fanglomerates within Arizona. One tunnel has an excavated diameter of 17 feet, the other two have excavated diameters of 25 feet. All were excavated with backhoe diggers inside a shield, not the shielded TBMs with rotary cutterheads proposed for the Maricopa Site. The initial supports for all the Papago tunnels were precast segments similar to those proposed for the SSC tunnels bored into weak rock.

Although overall production comparisons between the SSC soft rock tunnels and the Papago Tunnels are not instructive because of the differences in tunnel

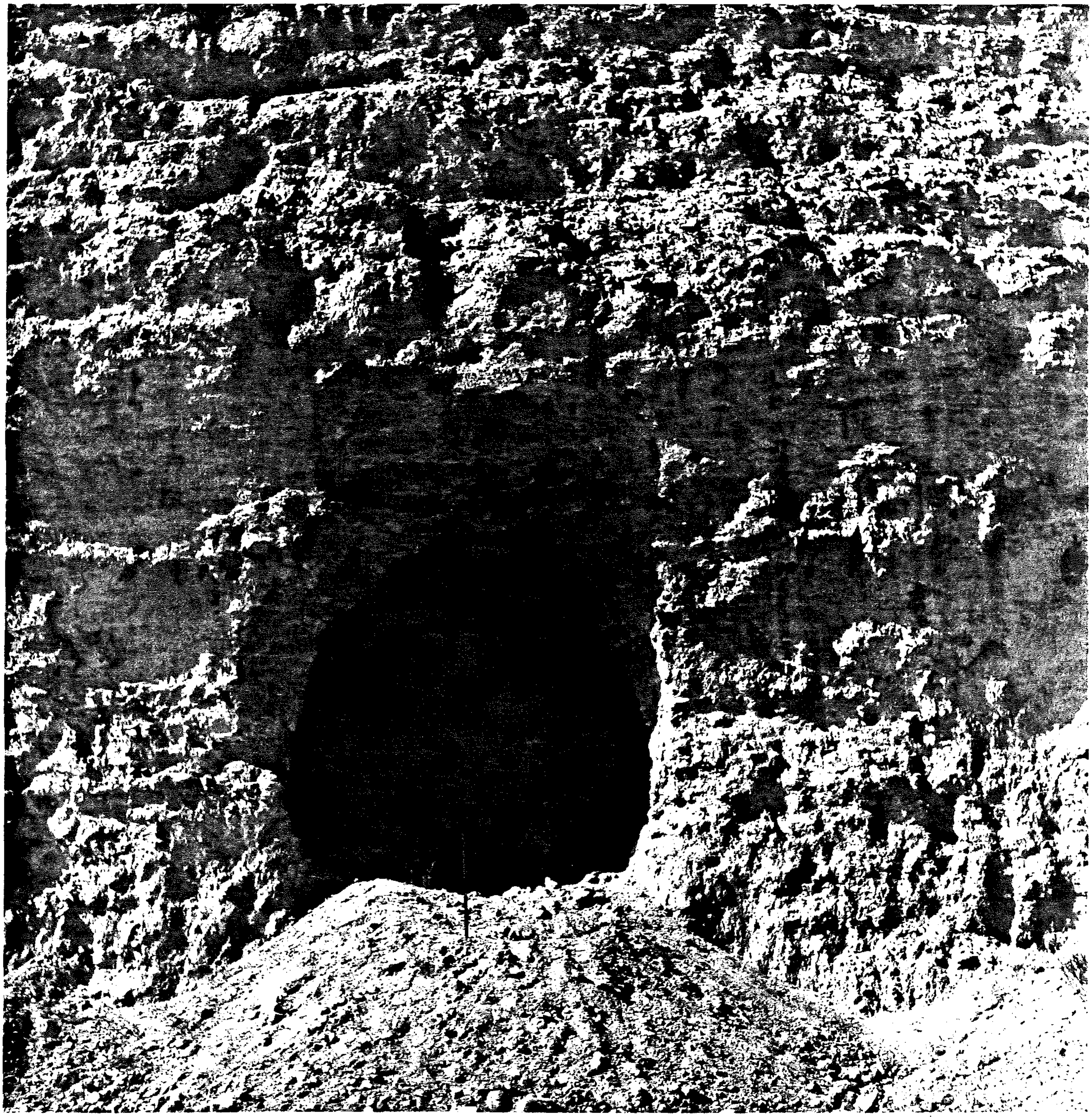


Figure 3-27
Gradall Excavated Tunnel Within Fanglomerate Assemblage Materials at the Twin Buttes Pit

size and engineering qualities of the materials, comparisons of the time for excavation and the set up of initial support systems of the Papago Tunnels with anticipated SSC systems is meaningful (see Table 3-13). The Maricopa figures may be calculated from the TBM Excavation Progress sheets for Maricopa CUs 1 and 6 (see Appendix 3-B).

Hard Rock Tunnels. A conventional hard rock TBM will be used for the hard- and medium-rock at the Maricopa Site. Currently, use of a full-face TBM using 17-inch disc cutters with thrust provided by a gripper system bearing on the rock walls is envisioned. This system will permit high advance rates, and allow the ground support to be tailored to the ground conditions (Figure 3-28). Recent use of TBMs similar to those proposed for the Maricopa Site have consistently averaged 145-feet-per-day (FPD) advances from start-up to hole-through in hard rock similar to that present at the Maricopa Site (Table 3-14). The Southwestern region has also experienced positive results from the application of TBM techniques in medium-rock conditions (Sperry, 1987). In 1972, the 20.5-foot diameter Navajo 3 tunnel advanced at 194 FPD over an 11-day period. In 1982 the 8.5-foot diameter McDowell Tunnel was completed at an overall advance rate of 209 FPD while working only two shifts per day. In 1983 a 700-foot-long 18-foot diameter tunnel was built, excavating one shift per day, at the Nevada Test Site. This tunnel was excavated in only three weeks; although the short length kept crews from reaching maximum efficiency, the last 250 feet were excavated in three shifts.

In the hard-rock tunnels ground support will include spot rockbolting, rockbolts with wire mesh and shotcrete and, in the most highly fractured zones, steel ribs and lagging. A total of 84 sets of steel ribs and lagging are expected to be required in CUs 3, 4, 5, and 8. All other ground conditions will require only rock bolts and mesh. Most reaches will require no support.

Based upon tests of rock samples representative of Maricopa Site lithologies, the Robbins Company determined cutter usage rates. TBM production is calculated using delay factors based on previous experience, the Robbins data, and analysis of published data (Sperry, 1987). Ground water inflow is assumed to be one gpm per 100 feet of tunnel in medium and hard rock. The inflow is not sufficiently concentrated in any one area to require grouting.

Other Conditions. The first 300 feet of each tunnel at the Maricopa Site will be excavated by drill-and-blast methods to provide a starting chamber for the tunneling machine. When tunneling is begun from a shaft, a 200-foot tail tunnel will also be excavated by drill-and-blast techniques.

3.5.4.3 Experimental Chambers. In order to keep costs down and to facilitate construction, the collision halls at the Maricopa Site are located close to the existing ground surface. Floor levels of chambers on the east side of the ring, near the injector complex, are 150 deep. Chambers on the west side are 100 feet deep with future chambers at 110- and 120-foot depths.

Drill-and-blast excavation will be required for the eastern chambers K1 and K2 which will be founded in small hills of granite. The excavations will be benched

TABLE 3-13

COMPARISON OF TBM UTILIZATION
PAPAGO FREEWAY DRAINAGE TUNNELS vs. SSC WEAK ROCK TUNNELS

	TBM Utilization[1] %	Segment Erection Delay[2] %
Papago Tunnels	47	19
SSC Weak Rock Tunnels	34	20

[1] TBM utilization is the time of actual TBM operation divided by the total calendar time. This table shows that the utilization factors used in the Sierrita Site estimates are conservative when compared with recent experience in similar conditions.

[2] Segment erection delay is the time required to erect a ring of segments divided by the total calendar time. Segment erection delays used in the Sierrita Site estimates are thought to be reliable based upon the Papago Tunnels construction experience.

TABLE 3-14

ADVANCE RATES ACHIEVED BY RECENT AMERICAN TUNNELS

TUNNEL	DIAMETER	ADVANCE Feet/day	YEAR
Chicago 73-162-2H, #1	14	145	1980
Chicago 73-162-2H, #2	14	179	1981
Sultan	14	138	1982
Sandbar	12	128	1985
Milwaukee	17	140	1987
Maricopa Hard Rock Tunnels[1]	10	132	
Maricopa Weak Rock Tunnels[1]	10	202	

[1] Estimated average advance rates from Tables 3-18 and 3-24.

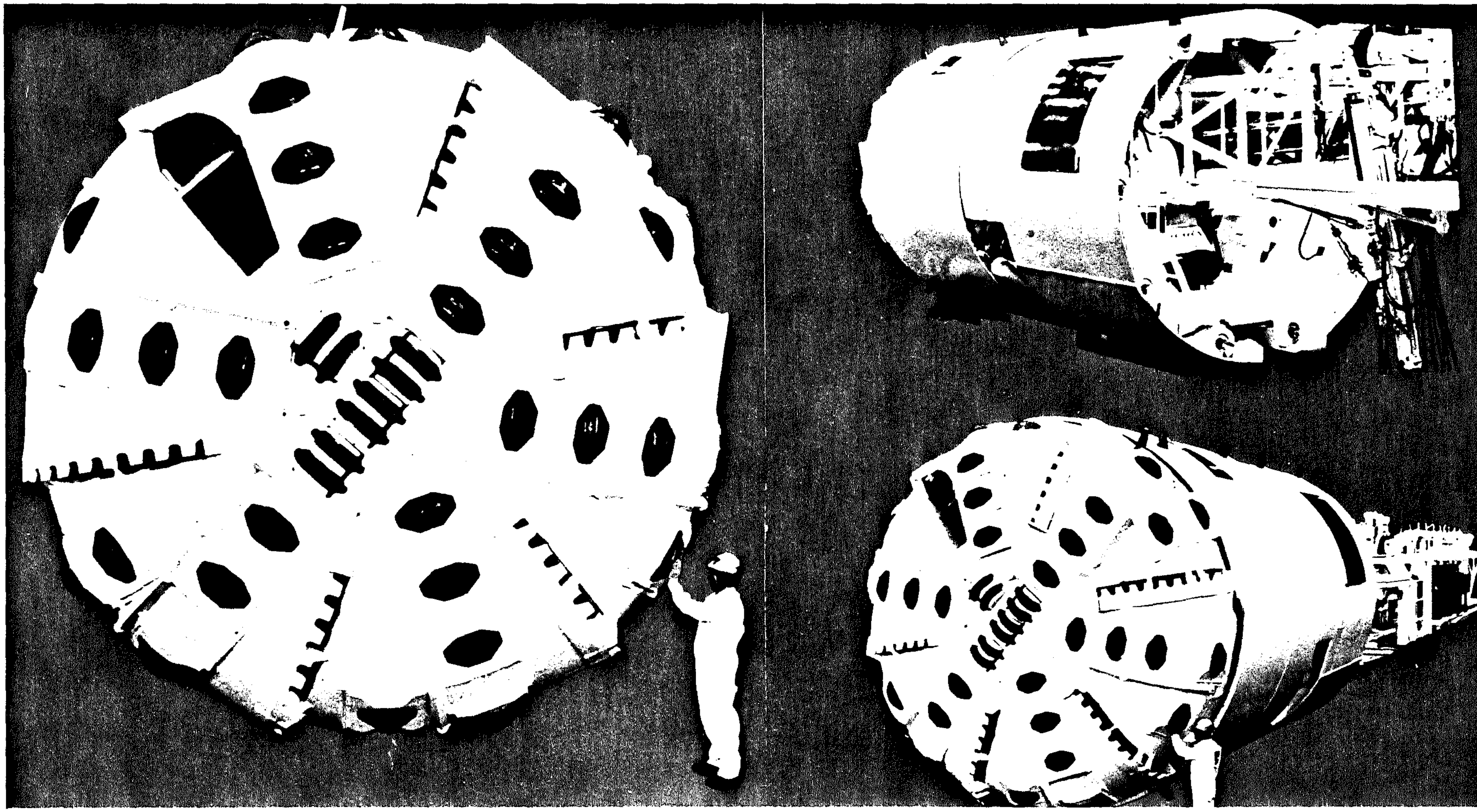


Figure 3-28
Tunnel-Boring Machine Proposed for Use at the Maricopa SSC Site

and require the limited use of rock bolts as necessary. Caterpillar 988-type front-end loaders with rock buckets will be used to load the muck onto crane hoists or a high-angle conveyor system. These chambers also could be excavated from short tunnels driven into the side of the hill. Because this approach would effectively place the chambers at the surface, it would decrease the total depth of the chambers by approximately 50 feet and lower operational costs.

Western chambers K-3 and K-4 will be founded in fanglomerate. Caterpillar 988-type front-end loaders will excavate the chambers in conjunction with the Holland Loader system suggested for ring excavation. Sixty-five ton trucks will remove muck via ramps located at the chamber site. The excellent stability and ease of excavation of the fanglomerate allows rapid, low-cost construction. Excavation walls are assumed to be stable with a slope angle of 60°, and no special ground stabilization will be required. The site can be excavated for construction of the experimental chambers in less than a month. An alternate method of construction is to install a tied-back, soldier pile/wale lateral support system. This system would provide lateral support while the excavation is being advanced vertically. This system could be made part of the permanent walls of the structure.

3.5.4.4 Shafts. Key information on the Maricopa Site shafts is provided in Table 3-15. Included are the location of each shaft by mile number, the construction unit in which it is located, the type of shaft, the depth of the shaft, and the major rock type to be encountered. Three of the shafts (Mile 5, 13.3, and 36.5) are to be box-trenched for tunneling purposes.

The shafts are 20 to 30 feet in inside diameter with depths ranging from 50 to 810 feet. An impact breaker mounted on a tractor base (see Figure 3-29) is recommended for the shafts collared in fanglomerate. The drill-and-blast method is recommended for excavating hard rock shafts.

The method of mucking out is an individual choice and can be based on the equipment already owned by the contractor. The estimated costs in this proposal were based on using a front end loader for mucking the 30-foot-diameter shafts and an Eimco 630 for the 20-foot-diameter shafts (Figure 3-30).

For the five shafts in fanglomerate less than 120 feet deep, an auger drilling method is recommended as possibly a less costly alternative. Since the water table is several hundred feet deep in these areas, it will not hinder the application of this technique. In Arizona, this method was effectively used to construct Titan II missile silos in fanglomerate similar to that present at the Maricopa Site. If the method is cost-effective large-diameter auger drilling methods would greatly increase safety when sinking these shafts.

A type of finish used in mines is considered suitable for the shafts and drifts. The recommended method is lining with welded wire mesh, rock bolts and shotcrete (Figure 3-31).

TABLE 3-15

MARICOPA SHAFTS

Mile	Construction Unit	Type[1]	Hoist Method	Costed Depth[2]	Actual Depth[2]	Rock Assemblage
0.0	1	E 3	Crane	250	260	Fanglomerate
2.5	1	F 2	Crane	100	120	Fanglomerate
5.0	1	E 2	Crane	80	80	Fanglomerate
7.5	2	F 1	Crane	60	55	Fanglomerate
10.0	2	E 1	Crane	60	50	Fanglomerate
13.3	3	F 10	Crane	240	110	Granitic
16.5	4	E 10	Crane	180	150	Granitic
18.9	4	F 9	Crane	210	185	Fanglomerate
21.45	5	E 9	Crane	330	300	Volcanic
24.0	5	F 8	Headframe	380	340	Volcanic
26.5	5	E 8	Headframe	350	335	Fanglomerate
29.0	6	F 7	Headframe	400	380	Fanglomerate
31.5	7	E 7	Crane	270	250	Fanglomerate
34.1	7	F 6	Crane	160	150	Fanglomerate
36.5	7	E 6	Crane	110	115	Fanglomerate
39.7	8	F 5	Crane	70	80	Fanglomerate
42.8	9	E 5	Crane	120	145	Fanglomerate
45.2	9	F 4	Headframe	370	460	Granitic
47.8	9	E 4	Headframe	800	810	Granitic
50.3	9	F 3	Headframe	470	480	Granitic

[1] E shafts are 20 feet in diameter. F shafts are 30 feet in diameter.

[2] Costed depth is the depth used to estimate the cost of construction, an adjustment to the ring tilt changed the shaft depths to the listed actual depth.

No shafts are in Construction Unit 10.

Figure 3-29
Tractor-Mounted Impact Breaker Proposed for Use at the Maricopa SSC Site

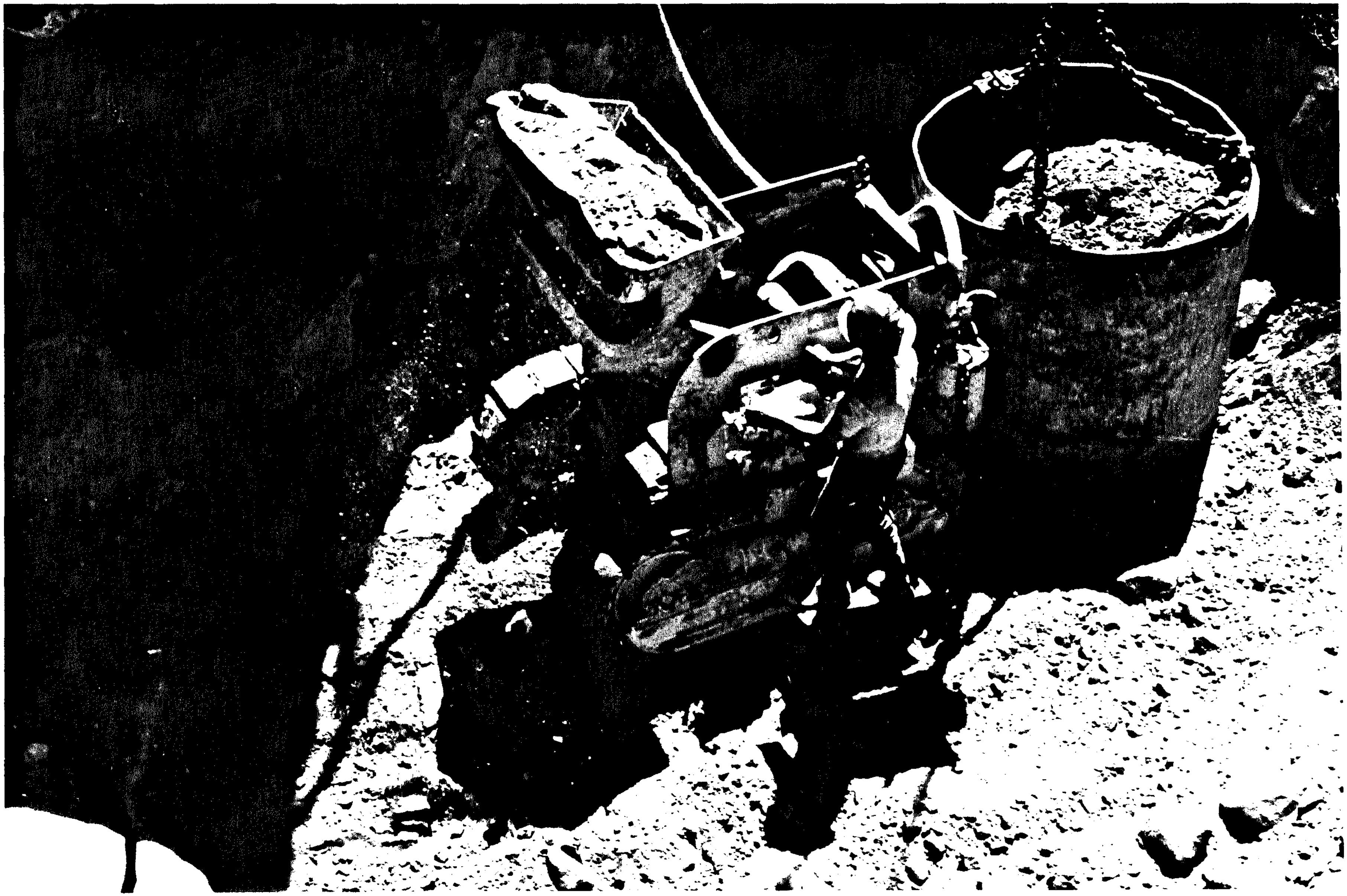


Figure 3-30
Proposed Shaft Mucking System

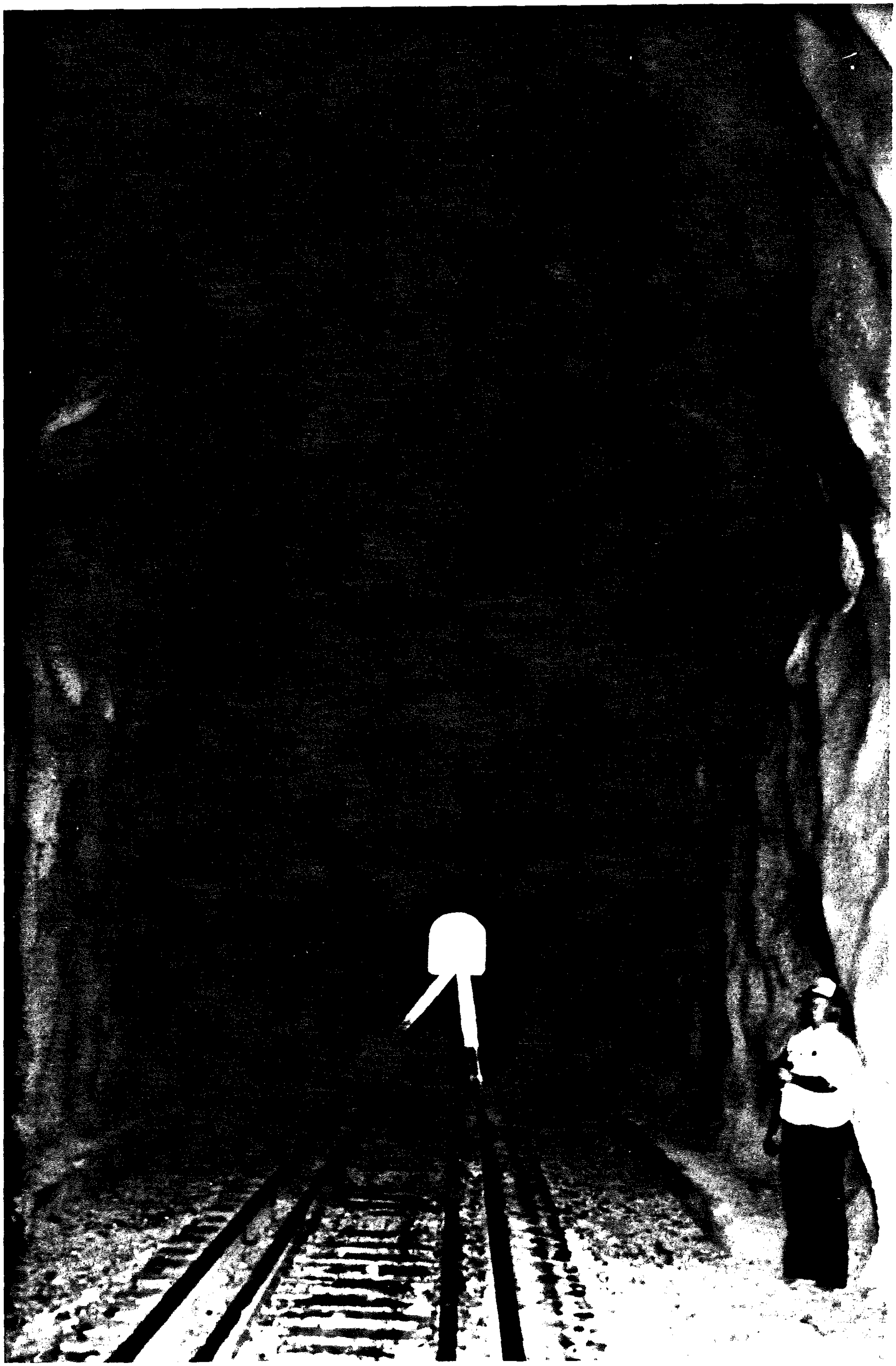


Figure 3-31
Typical Shaft Finish Proposed for Use at the Maricopa SSC Site

Since 1978 at least ten major shafts have been constructed for the mining industry in southern Arizona. The diameters of the four shafts listed in Table 3-16 are between 20 and 30 feet. The depths of these mining industry shafts ranged from 1,600 feet to 4,800 feet. The two shafts listed in Table 3-16 for Magma Copper Company's San Manuel Mine, 100 miles southeast of the Maricopa Site, were sunk through approximately 1,500 feet of Gila Conglomerate, a fanglomerate material present in the San Manuel region, and the San Manuel Fault, a low-angle normal fault of regional extent. From 2,000 to 4,000 feet below ground surface, continuous grout covers were used to bring water inflows down to manageable amounts. The Maricopa Site shafts have conditions much less severe than do these successfully constructed deep mining shafts. There is no doubt that the shafts at the Maricopa Site can be reliably constructed without impacting the project's schedule.

Heavy construction estimates were made for each of the Maricopa Site shafts. These estimates consider the geologic setting and depth of each shaft. Construction cost estimates are presented in Section 3.5.4.6 and Appendix 3-B. Experience gained from Arizona's deep underground mines demonstrates that Maricopa Site shaft depths will not restrict or add costs to the operation and maintenance at the sector service areas or exit shafts.

3.5.4.5 Safety. The Arizona Division of Occupational Safety and Health (ADOSH) has developed an innovative program of safety and health consultation service for the construction industry. ADOSH consulting personnel offer only information, advice and on-site inspections to help employers protect their workers at no cost to the contractor; they do not enforce standards or issue citations. ADOSH safety regulations meet or exceed Federal safety standards (ADOSH, 1986). The following services are available:

- On-site surveys to identify hazardous conditions.
- Advice on how to eliminate or reduce these hazards.
- Assistance in establishing safety programs.
- Advice on interpreting and applying the standards to specific situations.
- Assistance on specific safety or health problems during the planning and construction of the SSC.
- Training programs for employers, supervisors, and employees.

Several benefits will be realized from this program:

- Increased safety awareness.
- Reduced accident rate and less severe injuries.
- Reduced premiums for workman's compensation.
- Greater productivity.

ADOSH has committed to providing an on-site safety consultant full-time for the construction of the SSC at the Arizona Maricopa Site.

TABLE 3-16

RECENT LARGE SHAFTS IN ARIZONA

Mine	Diameter Ft.	Depth Ft.	Wall Inches	Excavation Ft./wk	Total Ft./wk	Geologic Setting[1]
Magma Copper Superior #9	22	4825	12	77	52	Volcanic
Magma Copper San Manuel #5	25	4200	24	46	28	Fanglom-erate/ Granitic
Magma Copper San Manuel #3D	22	3740	24	77	60	Fanglom-erate/ Granitic
Phelps Dodge Safford #2	25	1600	12	70	55	Volcanic

[1] The geologic setting is described in terms of the assemblages present at the Maricopa Site. The materials present at these shafts are correlative with those present at the Maricopa Site.

3.5.4.6 Project Costs. Several significant construction advantages at the Maricopa Site will reduce construction costs and shorten construction schedules. The presence of fanglomerate over much of the site with its excellent properties for rapid construction of both deep cut-and-fill and TBM tunneling means that construction will occur on a shorter schedule than that proposed by DOE. This advantage is reinforced by the availability of all lands necessary for critical path construction by April 1, 1989 (see Volume 6, Section 6.2). The mining industry and the Central Arizona Project have stimulated the development of fast low-cost construction techniques relevant to SSC facility construction, and the recent closing of nearby mines together with the completion of the Central Arizona Project make available a large and skilled work force in the immediate vicinity of the project.

Spoils from the SSC project construction will be used to reclaim existing mine waste dumps (see Section 3.5.5), affecting the natural environment only in beneficial ways. In addition, the ability to build the ring in a single, almost level plane will simplify magnet design, construction, initial tuning, and long-term operation, with consequent savings in cost and time.

Cost Estimating and Modeling Process. In 1985 the Arizona SSC Project assembled a site evaluation team to define the geotechnical studies required to locate the SSC in Arizona. The evaluation team recommended that a heavy construction estimate be developed to quantify the site's advantages using the appropriate site-specific geotechnical data. Data described in Sections 3.1 through 3.5 were gathered to produce accurate cost and scheduling estimates.

Heavy-construction cost and scheduling estimates were used for cut-and-fill and TBM tunnels and shafts. Building estimates were used for surface facility construction. This method was recommended by the Central Design Group in the Conventional Facilities Report.

The SSC Project is divided into ten CUs. As described in Section 3.2.3, a CU may include several different rock types with varying ground-support requirements but uses a single construction method. During screening studies alternative construction methods were evaluated for each of the CUs. Alternative configurations for the CUs were also evaluated. This earlier work defined the CUs and construction methods used to develop costs and schedules for this proposal. The Work Breakdown Structure (WBS) identifies costs by sector, and separates costs of cut-and-fill and TBM tunnels, shafts, and experimental chambers.

The most economic length for a tunnel construction contract is that which attracts tenders from a large number of qualified contractors and which is not so long that the excavation is delayed waiting for muck to be removed from the heading. Three subway tunnels in Los Angeles bid between January and June, 1987 have attracted eight or more bidders for contracts in the $30 - 70 million range. Based on these results it may be concluded that there is adequate competition in the southwestern U.S. for tunnel contracts in this cost range. Because there may be high demand for tunnel construction while the SSC is being built, the Arizona SSC tunnel CUs are all sized so that the SSC project contracts may be limited to $30 million.

The Maricopa Site tunnel contracts are designed to be as long as possible. Lengths are determined by surface topography, material specific TBM production rates, initial ground support construction, and muck removal methods. There are four contracts greater than seven miles each at the Maricopa Site.

Heavy-construction estimates for each construction method alternative in each CU were input into a computer model for evaluation of total facility costs, schedules, and resource requirements. The computer model used by the Arizona SSC Project is called a Decision Support System (DSS). The DSS permitted an unbiased evaluation of construction alternatives in sufficient detail to define project constraints. This evaluation allowed the examination of multiple interlocking alternatives, and a flexible approach to minimizing costs and schedules.

The DSS developed for Arizona's SSC program has evolved over the past 10 years on various mining projects (Miller and Milligan, 1987). Its basis is Project/2 software developed by Project Software Development Incorporated (PSDI). The DSS was adapted specifically for Arizona SSC Project analysis requirements and compatibility with the Central Design Group's work breakdown structure. The level of detail for Arizona's site-specific estimates met or exceeded that required for the DOE generic models.

Arizona's model allows total integration of cost and schedule with summation of cost and schedule by CU, by construction method, and sector. The model can monitor up to 99 geologic and geotechnical conditions for both ground support and instantaneous penetration rate of the TBM for each tunnel contract, regardless of the sectors that the tunnel crosses. This allows an accurate evaluation of the impact of changing geotechnical conditions as well as a realistic definition of contract lengths by economic, geologic, and topographic considerations. Another benefit of this approach is the reliable evaluation of the merits of alternative construction methods as they apply to individual construction units and to the project as a whole. The sensitivity of the Maricopa Site to innovations can be quantified to demonstrate accurately the benefits of Arizona's construction conditions.

Construction costs can be entered in a number of ways, for example as simply as a unit price, or as complex as a detailed estimate. The program allows the user to mix various estimating systems or methods in a single model.

Site-specific heavy-construction estimates were developed for all facets of construction except utility tie-ins and site infrastructure, which account for 19% of the total cost. These non-site-specific sections of the cost estimate are based upon the CDG Conventional Facilities Report.

Contingency Factors. In accordance with sound practices, the contingency for the project is the sum of separate bid, design, specification, geotechnical, and competition components that may be added to a rational estimate. Rational estimates are used to describe the most realistic estimate of the cost of the work that can be made at the time. A rational estimate is based on detailed and valid assumptions of construction methods, material and equipment costs, wage rates, labor requirements, and rates of progress. The overall contingency is applied as an umbrella surcharge.

Estimating the cost of underground construction involves considerable judgment. In general, the best accuracy that a contractor expects in a tunnel bid is 10%, that is, a 10% gap between the low and next lowest bidder. A 5% bid contingency was used for Maricopa Site estimates.

In the early design phases, before contract documents have been prepared, there is no specification basis for the estimate. The estimate is usually based upon specifications commonly used in the industry. If the owner agency is known to use specifications following the recommendations of "Better Contracting for Underground Construction," a publication of the U.S. National Committee on Tunneling Technology, no specification contingency need be added. Since the Department of Energy has used these specifications, no specification contingency was added.

The DOE and CDG have provided sufficient information to enable a contractor to make an intelligent and fair bid for SSC construction contracts; therefore, no design contingency was added.

The geotechnical contingency is often the largest contingency added to the estimate of an underground project. This provides for the cost of handling unanticipated geotechnical problems discovered during actual construction. The cost of this contingency can often be rationally evaluated, especially in those instances where only the extent of a known construction procedure is subject to change. For the Maricopa Site, a panel of construction and geotechnical engineers reviewed the information available for each rock type and the construction method planned (Miller et al., 1987). The geotechnical contingencies represent a consensus based on potential geotechnical variability, extent of characterization, and sensitivity of the construction method to the range of potential conditions. Contingency factors for each unit are given in Table 3-18.

The last contingency results from bid competition in the tunnel construction industry. For tunnels to be bid in the next several years, market conditions may be forecast from current industry capacity and a review of planned construction. A 1987 forecast suggests that a competitive contingency is not warranted for this study.

Inflation factors for wages, and cost of materials and equipment are added after the total contingency factor is applied. Table 3-17 summarizes the recommended contingencies that should be added to the estimated costs.

Cut-and-Fill for Ring and Injector Tunnels. Heavy construction estimates were developed for each of the cut-and-fill sections using methodology described in Section 3.5.4.1. Summations of this estimate are given in Tables 3-18 and 3-19 and a representative estimate is presented in Appendix 3-B. Table 3-18 summarizes the characteristics of the CUs in length, estimated daily production, and geotechnical contingency. Table 3-19 summarizes the costs of cut-and-fill construction at various depths. Tables summarizing cut-and-fill excavation details for the acceleration ring, high-energy booster, medium-energy booster, low-energy booster, and experimental chambers are provided in Appendix 3-B.

TBM for Ring and Injector Tunnels. Estimates were developed for each of the TBM tunnels using the methods described in Section 3.5.4.2. Summations of this

TABLE 3-17

CONTINGENCY FACTORS

DESCRIPTION	CONTINGENCY %
Bidding	5
Specification	NA*
Design	NA
Supply and Demand	5
Geotechnical	10
Competition	NA
Total Contingency	20

*NA = Not applicable.

TABLE 3-18

CONSTRUCTION METHOD SUMMARY OF CONSTRUCTION UNITS

Description		Construction Unit Length	Predicted Average Production Feet/Day	Geotechnical Contingency %
Unit 1	Weak Rock TBM	29,568	201	10
Unit 2	Cut-and-Fill	41,184	97[1]	5
Unit 3	Mixed Rock TBM	13,200	145	15
Unit 4	Mixed Rock TBM	31,680	185	15
Unit 5	Mixed TBM	39,600	182	20
Unit 6	Weak Rock TBM	45,408	204	5
Unit 7	Cut-and-Fill	21,648	95[1]	5
Unit 8	Mixed Rock TBM	18,480	168	15
Unit 9	Hard Rock TBM	38,016	123	10
Unit 10	Weak Rock TBM	42,600	201	5
Weighted Average for TBM			180	11
Weighted Average for Cut-and-Fill			96	5
Weighted Average for Project			164	10

[1] Cut-and-fill advance rates vary with depth and length of cut. Rather than providing faster advance rates, cut-and-fill construction allows construction to begin sooner, and construction can proceed at several points along a contract length simultaneously. It is possible for cut-and-fill construction to be completed before a TBM can be purchased and installed, despite the apparent slower advance rates.

TABLE 3-19

ESTIMATED CUT-AND-FILL TUNNEL CONSTRUCTION COST PER FOOT[1]

DESCRIPTION	DEPTH OF CUT IN FEET				
	60	70	80	90	100
Excavation Volume cu. yd.	121	157	196	240	288
Excavation $/ft.	49.61	64.37	80.36	98.40	114.80
Regular Backfill $/ft	57.02	75.02	94.52	116.52	140.52
Select Backfill $/ft.	7.66	7.66	7.66	7.66	7.66
Cast-in-Place Pipe Cost	253.47	253.47	253.47	253.47	253.47
G & A + Tax @ 12%	44.13	48.06	52.32	57.13	61.97
Profit @ 10%	36.78	40.05	43.60	47.61	51.64
Total $/ft.	448.67	488.63	531.93	580.79	630.06

[1] The tunnel excavation cost estimates assume using a Holland Loader system with a 60° slope profile.

Cost estimates are in 1987 dollars.

estimate are presented in Tables 3-20 through 3-24. Table 3-20 summarizes the TBM costs for CU 3 which is typical of the Maricopa Site, Table 3-21 the direct cost calculations for CU 3, Table 3-22 the plant and equipment cost calculations for CU 3, and Table 3-23 the indirect cost calculations for CU 3. Table 3-24 lists examples of unit costs for the three tunneling methods to be used at the Maricopa Site. A representative estimate is included in its entirety in the Appendix 3-B.

Comparison of TBM versus Cut-and-Fill. For purposes of this proposal, use of a TBM was assumed for ring depths greater than 60 feet. The experience of local contractors with the fanglomerate demonstrates, however, stable open-cut excavations to depths of between 80 and 100 feet. Table 3-24 lists a cost of $ 640/foot for a TBM tunnel in fanglomerate. Table 3-19 lists a price of $630/foot for a cut-and-fill tunnel in fanglomerate at a depth of 100 feet. Considering construction cost alone, the breakeven point between cut-and-fill and TBM tunneling occurs at a depth of about 100 feet. Assuming an 80-foot depth, there are seven additional miles of cut-and-fill construction at the Maricopa Site, and 15 additional miles at a 100-foot depth. The injector complex, by-pass tunnel, and 63% of the collider ring may be constructed with cut-and-fill methods by deepening the cuts. To be conservative in the estimates, a depth of 60 feet is assumed. However, experience shows there is significant increased flexibility and reduced costs using cut-and-fill as an alternative to TBM tunneling up to a depth of 100 feet.

Experimental Chambers. Heavy construction estimates were developed for the experimental chambers and injector complex using methods described in Section 3.5.4.3. Summations of this estimate are presented in Table 3-25.

Shafts. Heavy construction estimates were developed for the shafts using methods described in Section 3.5.4.4. Table 3-16 summarizes the CUs for shafts. Table 3-26 compares the unit cost of shaft construction at the Maricopa Site. The projected total cost of an "average" shaft is presented in Table 3-27. A complete representative estimate is included in Appendix 3-B.

Total Facility Cost. The total facility cost estimate for the Maricopa Site is $709 million (Table 3-28). Contingency factors are based upon Arizona conditions; estimates of AE/CM services are based upon percentages for the total project developed by the CDG and presented in the Conventional Facilities Report. Cost estimates for the Maricopa SSC Site are contrasted with the DOE's Projected SSC Construction Funding Profile for generic model "C" in Figure 3-32.

Schedule. Figures 3-33 to 3-37 summarize the Maricopa Site schedule and typical schedules for cut-and-fill, weak-rock TBM, hard-rock TBM, and shaft construction. The Maricopa Site schedule takes advantage of the fact that all the lands required for critical path construction will be available at the time of awarding the first contract (see Volume 6, Section 6.2). It also follows the basic premises used by the CDG schedules. The project can be completed in 2.5 years according to the DSS analysis.

TABLE 3-20

SUMMARY OF TBM COSTS[1]

COST	TOTAL COST	COST/FOOT OF TUNNEL
Direct[2]	$9,672,893	$327
Plant & Equipment[3]	$5,225,393	$178
Indirect[4]	$4,618,710	$156
TOTAL	$19,546,996	$661

[1] The displayed costs are for Construction Unit 1 which is typical of the Maricopa Site TBM Construction Units. The tunnel length is 29,568 feet in weak rock.

[2] See Table 3-21 for a detailed listing of Construction Unit 1 direct costs.

[3] See Table 3-22 for a detailed listing of Construction Unit 1 plant and equipment costs.

[4] See Table 3-23 for a detailed listing of Construction Unit 1 indirect costs.

AZ SSC MARICOPA 30-Jun-87 \AZMI-COS\DIR-COST

1	BID QUANTITY	29,568 LF	11.00 Feet Excavated Diameter	104,112 CY	
2			Box Portal Access		
3					
4	PRODUCTION:	201.0 FPD	(See Mole Excavation Progress calculation.)		
5–11					
12	f: TBM electrical power:		600 HP	35 FPH penetration	
13	c: TBM parts & supply: $1.00 $/CY				
14	b: TBM cutters:	$0.50 $/CY			
15					

PURCHASE SUPPORTS				Unit Cost	Cost
Rock Support Bolts			LF	$1.50	
CLF Split Sets			EA	$0.80	
Chain Link Fabric			SF	$0.35	
Steel Sets, ea	80	40,000	#	$0.60	24,000
Blocking & Lagging		8	MBF	$400.00	3,200
Shotcrete		180	CY	$80.00	14,400
TOTAL SUPPORT COST				d	41,600

PURCHASE CONCRETE					
Precast Segments	29,568	LF	$100.00		2,956,800
Invert Paving	8,072	CY	$60.00		484,324
TOTAL CONCRETE COST			e		3,441,124

16	B	C D E F	G	H	I	K	L	M	O	P	R	T	U	W	X	Z	AA	AC	AD
17			CREW			LABOR		EQUIP PARTS		EQUIP OWNERSHIP		EXPEND MATLS		PERM MATLS		SUBCONTRACTS		TOTAL DIRECT COST	
18	DESCRIPTION			QUAN	UNIT	UNIT	TOTAL $	UNIT	TOTAL $	UNIT	TOTAL $	UNIT	TOTAL $	UNIT	TOTAL $	UNIT	TOTAL $	UNIT	TOTAL $
19	Portal Excavation and Support		-	8900	CY											25	222,500		222,500
20	Starting Chamber Excavation and Support		DS	12	WD	7803	93,636	877	10,524					d	41,600				145,760
21	Tail Tunnel Excavation and Support		DS		WD														
22	Purchase Supports		-	-										e	3,441,124				3,441,124
23	TBM Excavation and Tunnel Support		TBM	147	WD	17813	2,620,372	781	114,889										2,735,261
24	TBM Operation		-	-				c	104,112			b	52,056						156,168
25	Install California Switch		TBM	4	WD	17813	71,252	400	1,600										72,852
26	Muck Disposal		-	104112	CY			f	15,206							4	416,448		431,654
27	Saturday Maintenance		SM	29	WD	5662	166,581	155	4,560										171,141
28	Remove Fanline, TBM & Trailing Floor	3,000 FPD	RF	10	WD	11961	117,888	777	7,658										125,546
29	Ex & Supt Electron Shielding Nitches	47 EA	ME	47	WD	9337	438,217	423	19,853			100	4,693	350	16,427				479,189
30	Excavate & Support Power Alcoves	7 EA	ME	29	WD	9337	273,866	423	12,407			300	8,799	1400	41,064				336,136
31	Purchase Concrete Lining Materials		-	-															
32	Place Shotcrete Lining 75 FPD	700 LF	SH	9	WD	12501	116,676	381	3,556										120,232
33	Place Invert Concrete	700 FPD	IC	44	WD	14741	652,142	701	31,012										683,154
34	Remove Utilities and Final Cleanup	1,000 FPD	CU	30	WD	10353	306,118	651	19,249										325,366
35																			
36																			
37																			
38																			
39	Small Tools and Expendables 4.67 % of Direct Labor												226,810						226,810
40																			
41																			
42																			
43	UNIT COST PER TUNNEL FOOT and TOTALS					164	4,856,746	12	344,626			10	292,359	120	3,540,214	22	638,948	$327	9,672,893

TABLE 3-21 Summary of TBM Direct Costs for Construction Unit 1.

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
22410.00	**TOTAL** WAREHOUSE I - GENERAL		1399923	0	0	0	0	1399923
992242000	WAREHOUSE II - GENER							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923
22420.00	**TOTAL** WAREHOUSE II - GENERAL		1399923	0	0	0	0	1399923
992243000	FIRE/SITE/RESCUE - G							
		1JAN89 TO 31DEC89	400008	0	0	0	0	400008
22430.00	**TOTAL** FIRE/SITE/RESCUE - GENERAL		400008	0	0	0	0	400008
992244000	VEHICLE SERVICE - GE							
		1JAN89 TO 31DEC89	299964	0	0	0	0	299964
22440.00	**TOTAL** VEHICLE SERVICE - GENERAL		299964	0	0	0	0	299964
992246000	HELIPAD - GENERAL							
		1JAN89 TO 31DEC89	34020	0	0	0	0	34020
22460.00	**TOTAL** HELIPAD - GENERAL		34020	0	0	0	0	34020
992311017	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	915	11592	0	1751	14258
23110.17	**TOTAL** LINAC TUNNEL/ENCLOSURE - EXCAV		0	915	11592	0	1751	14258
992311018	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	36734	23416	0	17985	78135
23110.18	**TOTAL** LINAC TUNNEL/ENCLOSURE - PIPIN		0	36734	23416	0	17985	78135
992311019	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	2418	6449	0	1241	10108
		1JAN91 TO 31DEC91	0	1838	5514	0	1029	8382
23110.19	**TOTAL** LINAC TUNNEL/ENCLOSURE - BACKF		0	4256	11963	0	2271	18490
992311020	LINAC TUNNEL/ENCLOSU							
		1JAN91 TO 31DEC91	0	0	0	8176	2044	10220
23110.20	**TOTAL** LINAC TUNNEL/ENCLOSURE - REVEG		0	0	0	8176	2044	10220
992315016	LINAC - ELECTRICAL							
		1JAN89 TO 31DEC89	123183	35100	2645	45270	0	206198
23150.16	**TOTAL** LINAC - ELECTRICAL		123183	35100	2645	45270	0	206198

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MARICOPA SITE
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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992316015	LINAC MECHANICAL - M							
		1JAN89 TO 31DEC89	176517	30755	3112	8218	8417	227019
23160.15	**TOTAL** LINAC MECHANICAL - MECHANICAL		176517	30755	3112	8218	8417	227019
992321018	LEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	3134	8358	0	1609	13102
		1JAN91 TO 31DEC91	0	50380	151141	0	28213	229734
23210.18	**TOTAL** LEB TUNNEL/ENCLOSURE - BACK FI		0	53515	159499	0	29822	242836
992321019	LEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	60826	38773	0	29782	129381
23210.19	**TOTAL** LEB TUNNEL/ENCLOSURE - PIPING		0	60826	38773	0	29782	129381
992321020	LEB TUNNEL/ENCLOSURE							
		1JAN91 TO 31DEC91	0	0	0	13541	3385	16926
23210.20	**TOTAL** LEB TUNNEL/ENCLOSURE - REVEGET		0	0	0	13541	3385	16926
992323030	SHAFT MOBILIZATION							
		1JAN91 TO 31DEC91	0	8978	233475	303690	189390	735533
23230.30	**TOTAL** SHAFT MOBILIZATION		0	8978	233475	303690	189390	735533
992323031	SHAFT SET UP							
		1JAN91 TO 31DEC91	0	260400	0	0	0	260400
23230.31	**TOTAL** SHAFT SET UP		0	260400	0	0	0	260400
992323033	SHAFT COLLAR							
		1JAN91 TO 31DEC91	0	417060	0	438755	99775	955590
23230.33	**TOTAL** SHAFT COLLAR		0	417060	0	438755	99775	955590
992323034	SHAFT SINKING							
		1JAN91 TO 31DEC91	0	1714650	0	267969	10725	1993344
23230.34	**TOTAL** SHAFT SINKING		0	1714650	0	267969	10725	1993344
992323035	SHAFT FURNISHING							
		1JAN91 TO 31DEC91	0	163300	0	14820	8732	186852
		1JAN92 TO 31DEC92	0	40825	0	3705	2183	46713
23230.35	**TOTAL** SHAFT FURNISHING		0	204125	0	18525	10915	233565

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FACILITIES ESTIMATE
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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992323036	SHAFT CLEAN UP & DEM							
		1JAN91 TO 31DEC91	0	210504	0	90188	61644	362336
		1JAN92 TO 31DEC92	0	52626	0	22547	15411	90584
23230.36	**TOTAL** SHAFT CLEAN UP & DEMOB		0	263130	0	112735	77055	452920
992323037	SHAFT MANWAY/DRIFT							
		1JAN91 TO 31DEC91	0	269724	0	649542	90813	1010079
		1JAN92 TO 31DEC92	0	14196	0	46396	6487	67079
23230.37	**TOTAL** SHAFT MANWAY/DRIFT		0	283920	0	695938	97300	1077158
992324101	LEB PS BUILD - COMPO							
		1JAN91 TO 31DEC91	481140	0	0	0	0	481140
		1JAN92 TO 31DEC92	139725	0	0	0	0	139725
23241.01	**TOTAL** LEB PS BUILD - COMPOSITE		620865	0	0	0	0	620865
992325016	LEB ELECTRICAL - ELE							
		1JAN89 TO 31DEC89	247373	76770	5779	89589	0	419511
23250.16	**TOTAL** LEB ELECTRICAL - ELECTRICAL		247373	76770	5779	89589	0	419511
992326015	LEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	50333	8621	949	0	2247	62350
23260.15	**TOTAL** LEB MECHANICAL - MECHANICAL		50333	8621	949	0	2247	62350
992331017	MEB TUNNEL/ENCLOSURE							
		1JAN89 TO 31DEC89	0	31081	393688	0	59468	484236
		1JAN90 TO 31DEC90	0	30009	380113	0	57417	467539
23310.17	**TOTAL** MEB TUNNEL/ENCLOSURE - EXCAV		0	61090	773801	0	116885	951775
992331018	MEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	91518	266596	0	50136	408250
		1JAN91 TO 31DEC91	0	125631	376892	0	70353	572876
23310.18	**TOTAL** MEB TUNNEL/ENCLOSURE - BFILL		0	217148	643488	0	120489	981126
992331019	MEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	463412	295397	0	226893	985702
23310.19	**TOTAL** MEB TUNNEL/ENCLOSURE - PIPE		0	463412	295397	0	226893	985702
992331020	MEB TUNNEL/ENCLOSURE							
		1JAN91 TO 31DEC91	0	0	0	103139	25785	128923

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
23310.20	**TOTAL** MEB TUNNEL/ENCLOSURE - REVEG		0	0	0	103139	25785	128923
992332017	MEB TO HEB TUNNEL -							
		1JAN89 TO 31DEC89	0	18508	234433	0	35412	288353
23320.17	**TOTAL** MEB TO HEB TUNNEL - EXCAVATION		0	18508	234433	0	35412	288353
992332018	MEB TO HEB TUNNEL -							
		1JAN89 TO 31DEC89	0	739	1970	0	379	3089
		1JAN90 TO 31DEC90	0	67961	199733	0	37477	305171
23320.18	**TOTAL** MEB TO HEB TUNNEL - BACK FILL		0	68700	201704	0	37856	308260
992332019	MEB TO HEB TUNNEL -							
		1JAN89 TO 31DEC89	0	240183	153102	0	117597	510882
23320.19	**TOTAL** MEB TO HEB TUNNEL - PIPING		0	240183	153102	0	117597	510882
992332020	MEB TO HEB TUNNEL -							
		1JAN90 TO 31DEC90	0	0	0	53458	13365	66823
23320.20	**TOTAL** MEB TO HEB TUNNEL - REVEG		0	0	0	53458	13365	66623
992333030	SHAFT MOBILIZATION							
		1JAN91 TO 31DEC91	0	10773	280170	364428	227268	882639
23330.30	**TOTAL** SHAFT MOBILIZATION		0	10773	280170	364428	227268	882639
992333031	SHAFT SET UP							
		1JAN91 TO 31DEC91	0	312480	0	0	0	312480
23330.31	**TOTAL** SHAFT SET UP		0	312480	0	0	0	312480
992333033	SHAFT COLLAR							
		1JAN91 TO 31DEC91	0	500472	0	526506	119730	1146708
23330.33	**TOTAL** SHAFT COLLAR		0	500472	0	526506	119730	1146708
992333034	SHAFT SINKING							
		1JAN91 TO 31DEC91	0	1935105	0	302223	12104	2249432
		1JAN92 TO 31DEC92	0	122475	0	19030	766	142271
23330.34	**TOTAL** SHAFT SINKING		0	2057580	0	321252	12870	2391702
992333035	SHAFT FURNISHING							
		1JAN91 TO 31DEC91	0	163300	0	14820	8732	186852

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN92 TO 31DEC92	0	81650	0	7410	4366	93426
23330.35	**TOTAL** SHAFT FURNISHING		0	244950	0	22230	13098	280278
992333036	SHAFT CLEAN UP & DEM							
		1JAN91 TO 31DEC91	0	210504	0	90188	61644	362336
		1JAN92 TO 31DEC92	0	105252	0	45094	30822	181168
23330.36	**TOTAL** SHAFT CLEAN UP & DEMOB		0	315756	0	135282	92466	543504
992333037	SHAFT MANWAY/DRIFT							
		1JAN91 TO 31DEC91	0	269724	0	649542	90813	1010079
		1JAN92 TO 31DEC92	0	70980	0	185583	25947	282510
23330.37	**TOTAL** SHAFT MANWAY/DRIFT		0	340704	0	835126	116760	1292590
992334100	MEB SURFACE BUILDING							
		1JAN91 TO 31DEC91	434988	0	0	0	0	434988
		1JAN92 TO 31DEC92	246168	0	0	0	0	246168
23341.00	**TOTAL** MEB SURFACE BUILDINGS		681156	0	0	0	0	681156
992335016	MEB ELECTRICAL - ELE							
		1JAN89 TO 31DEC89	879387	336600	25389	310453	0	1551829
23350.16	**TOTAL** MEB ELECTRICAL - ELECTRICAL		879387	336600	25389	310453	0	1551829
992336003	MEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	2718	1463	280	800	509	5770
23360.03	**TOTAL** MEB MECHANICAL - MECHANICAL		2718	1463	280	800	509	5770
992336015	MEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	3747644	1158505	145323	903419	441449	6396340
23360.15	**TOTAL** MEB MECHANICAL - MECHANICAL		3747644	1158505	145323	903419	441449	6396340
992341017	HEB TUNNEL/ENCLOSURE							
		1JAN89 TO 31DEC89	0	69670	882483	0	133301	1085455
23410.17	**TOTAL** HEB TUNNEL/ENCLOSURE - EXCAVAT		0	69670	882483	0	133301	1085455
992341018	HEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	274909	799606	0	150432	1224946
23410.18	**TOTAL** HEB TUNNEL/ENCLOSURE - EXCAVAT		0	274909	799606	0	150432	1224946

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992341019	HEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	1462512	932263	0	716068	3110844
23410.19	**TOTAL** HEB TUNNEL/ENCLOSURE - BACK FI		0	1462512	932263	0	716068	3110844
992341020	HEB TUNNEL/ENCLOSURE							
		1JAN91 TO 31DEC91	0	0	0	325510	81378	406888
23410.20	**TOTAL** HEB TUNNEL/ENCLOSURE - REVEG		0	0	0	325510	81378	406888
992342117	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	35573	450593	0	68063	554230
23421.17	**TOTAL** HEB TO COL TUNNEL - EXCAVATION		0	35573	450593	0	68063	554230
992342118	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	1977	5272	0	1015	8264
		1JAN90 TO 31DEC90	0	140878	412252	0	77438	630568
23421.18	**TOTAL** HEB TO COL TUNNEL - BACKFILL		0	142855	417524	0	78453	638832
992342119	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	642917	409820	0	314782	1367519
23421.19	**TOTAL** HEB TO COL TUNNEL - PIPING		0	642917	409820	0	314782	1367519
992342120	HEB TO COL TUNNEL -							
		1JAN90 TO 31DEC90	0	0	0	143091	35773	178864
23421.20	**TOTAL** HEB TO COL TUNNEL - REVEG		0	0	0	143091	35773	178864
992342121	HEB TO COL TUNNEL -							
		1JAN90 TO 31DEC90	2966376	0	0	0	0	2966376
23421.21	**TOTAL** HEB TO COL TUNNEL - SURF BUILD		2966376	0	0	0	0	2966376
992343031	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	355965	233475	303690	189390	1082520
23430.31	**TOTAL** SHAFT SET UP		0	355965	233475	303690	189390	1082520
992343033	SHAFT COLLAR							
		1JAN90 TO 31DEC90	0	384224	46695	588343	155077	1174339
		1JAN91 TO 31DEC91	0	64560	0	46645	8712	119917
23430.33	**TOTAL** SHAFT COLLAR		0	448784	46695	634988	163789	1294256

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992343034	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	465405	0	224494	9570	699469
		1JAN91 TO 31DEC91	0	287055	0	290169	117204	694428
23430.34	**TOTAL** SHAFT SINKING		0	752460	0	514664	126774	1393898
992343035	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	65320	0	14820	8732	88872
		1JAN91 TO 31DEC91	0	25526	0	19815	9691	55032
23430.35	**TOTAL** SHAFT FURNISHING		0	90846	0	34635	18423	143904
992343036	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	210504	0	90188	61644	362336
		1JAN91 TO 31DEC91	0	105252	0	45097	30822	181171
23430.36	**TOTAL** SHAFT CLEAN UP & DEMOB		0	315756	0	135285	92466	543507
992343037	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	851760	0	556750	77840	1466350
		1JAN91 TO 31DEC91	0	425880	0	338810	75360	840050
23430.37	**TOTAL** SHAFT MANWAY/DRIFT		0	1277640	0	895560	153200	2326400
992344101	HEB EXIT BUILD - COM							
		1JAN90 TO 31DEC90	909637	0	0	0	0	909637
		1JAN91 TO 31DEC91	662213	0	0	0	0	662213
23441.01	**TOTAL** HEB EXIT BUILD - COMPOSITE		1571850	0	0	0	0	1571850
992346016	HEB ELECTRICAL - ELE							
		1JAN89 TO 31DEC89	2076195	886500	66666	732840	0	3762401
23460.16	**TOTAL** HEB ELECTRICAL - ELECTRICAL		2076195	886500	66866	732840	0	3762401
992347015	HEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	870081	110514	11547	14184	29974	1036300
23470.15	**TOTAL** HEB MECHANICAL - MECHANICAL		870081	110514	11547	14184	29974	1036300
992412314	N ARC SEC B SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24123.14	**TOTAL** N ARC SEC B SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
1+23	**TOTAL** INJECTOR		17547516	16689639	7555163	9328946	4663101	55784364

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
1240000	COLLIDER RING							
911200000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3269376	0	0	3269376
		1JAN90 TO 31DEC90	0	0	2052864	0	0	2052864
912412A	**TOTAL** TUNNEL ACCESS		0	0	5322240	0	0	5322240
911210000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912412B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
911220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	2393207	0	495874	4123944	7013025
912412C	**TOTAL** TBM TUNNEL EXCAVATION		0	2393207	0	495874	4123944	7013025
911230000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	639644	0	3101984	0	3741628
912412D	**TOTAL** TBM TUNNEL SUPPORT		0	639644	0	3101984	0	3741628
911240000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	376827	0	23919	0	400746
912412E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	376827	0	23919	0	400746
911320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	240030	0	45661	371155	656845
		1JAN91 TO 31DEC91	0	85566	0	15285	123718	224569
912413C	**TOTAL** TBM TUNNEL EXCAVATION		0	325596	0	60946	494873	881415
911330000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	73705	0	372205	0	445910
912413D	**TOTAL** TBM TUNNEL SUPPORT		0	73705	0	372205	0	445910
911340000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	43020	0	2730	0	45750
912413E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750
911400000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3269376	0	0	3269376
		1JAN90 TO 31DEC90	0	0	2052864	0	0	2052864

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912414A	**TOTAL** TUNNEL ACCESS		0	0	5322240	0	0	5322240
911420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1062354	0	218603	2074270	3355227
912414C	**TOTAL** TBM TUNNEL EXCAVATION		0	1062354	0	218603	2074270	3355227
911430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	265338	0	1364478	0	1629816
912414D	**TOTAL** TBM TUNNEL SUPPORT		0	265338	0	1364478	0	1629816
911440000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	47844	0	3108	0	50952
		1JAN91 TO 31DEC91	0	124236	0	7812	0	132048
912414E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	172080	0	10920	0	183000
912120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	2238902	0	458400	3488455	6185758
		1JAN91 TO 31DEC91	0	171450	0	37764	290705	499919
912421C	**TOTAL** TBM TUNNEL EXCAVATION		0	2410352	0	496165	3779160	6685677
912130000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	574899	0	3099759	0	3674658
912421D	**TOTAL** TBM TUNNEL SUPPORT		0	574899	0	3099759	0	3674658
912140000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	345768	0	21966	0	367734
		1JAN92 TO 31DEC92	0	31059	0	1953	0	33012
912421E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	376827	0	23919	0	400746
912200000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	9049221	0	0	9049221
		1JAN90 TO 31DEC90	0	0	5682069	0	0	5682069
912422A	**TOTAL** TUNNEL ACCESS		0	0	14731290	0	0	14731290
912210000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	233870	0	25285	0	259155
912422B	**TOTAL** TBM SET UP CHAMBER		0	233870	0	25285	0	259155

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1833372	0	746927	7039933	9620232
		1JAN91 TO 31DEC91	0	1450550	0	373976	3132789	4957315
912422C	**TOTAL** TBM TUNNEL EXCAVATION		0	3283922	0	1120903	10172722	14577546
912230000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	1825009	0	5688649	0	7513658
912422D	**TOTAL** TBM TUNNEL SUPPORT		0	1825009	0	5688649	0	7513658
912240000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	846041	0	54945	0	900986
		1JAN92 TO 31DEC92	0	144942	0	9114	0	154056
912422E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	990983	0	64059	0	1055042
912320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	468920	0	119489	923995	1512404
912423C	**TOTAL** TBM TUNNEL EXCAVATION		0	468920	0	119489	923995	1512404
912330000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	158319	0	683307	0	841626
912423D	**TOTAL** TBM TUNNEL SUPPORT		0	158319	0	683307	0	841626
912340000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	91978	0	6420	0	98398
912423E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	91978	0	6420	0	98398
912420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1638986	0	331029	2655524	4625538
		1JAN91 TO 31DEC91	0	445770	0	96751	784586	1327107
912424C	**TOTAL** TBM TUNNEL EXCAVATION		0	2084756	0	427780	3440110	5952646
912430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	501194	0	2666114	0	3167308
912424D	**TOTAL** TBM TUNNEL SUPPORT		0	501194	0	2666114	0	3167308
912440000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	333807	0	21189	0	354996
912424E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	333807	0	21189	0	354996

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
913100000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	2043360	0	0	2043360
		1JAN90 TO 31DEC90	0	0	1283040	0	0	1283040
912431A	**TOTAL** TUNNEL ACCESS		0	0	3326400	0	0	3326400
913120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	239871	0	49591	471425	760887
912431C	**TOTAL** TBM TUNNEL EXCAVATION		0	239871	0	49591	471425	760887
913130000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	58964	0	310064	0	369028
912431D	**TOTAL** TBM TUNNEL SUPPORT		0	58964	0	310064	0	369028
913140000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	31059	0	1953	0	33012
912431E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750
913400000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	5020809	0	0	5020809
		1JAN90 TO 31DEC90	0	0	3152601	0	0	3152601
912434A	**TOTAL** TUNNEL ACCESS		0	0	8173410	0	0	8173410
913410000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912434B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
913420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	422645	0	88791	680249	1191685
912434C	**TOTAL** TBM TUNNEL EXCAVATION		0	422645	0	88791	680249	1191685
913430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	153191	0	559631	0	712822
912434D	**TOTAL** TBM TUNNEL SUPPORT		0	153191	0	559631	0	712822
913440000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	75687	0	4809	0	80496
912434E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	75687	0	4809	0	80496

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
914100000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3502866	0	0	3502866
		1JAN90 TO 31DEC90	0	0	2199474	0	0	2199474
912441A	**TOTAL** TUNNEL ACCESS		0	0	5702340	0	0	5702340
914110000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912441B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
914120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	782531	0	144130	1360023	2286684
912441C	**TOTAL** TBM TUNNEL EXCAVATION		0	782531	0	144130	1360023	2286684
914130000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	14741	0	82621	0	97362
		1JAN91 TO 31DEC91	0	247418	0	788358	0	1035776
912441D	**TOTAL** TBM TUNNEL SUPPORT		0	262159	0	870979	0	1133138
914140000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	96393	0	6111	0	102504
912441E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	108354	0	6888	0	115242
914220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1096644	0	175211	2239987	3511842
912442C	**TOTAL** TBM TUNNEL EXCAVATION		0	1096644	0	175211	2239987	3511842
914230000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	191633	0	992273	0	1183906
912442D	**TOTAL** TBM TUNNEL SUPPORT		0	191633	0	992273	0	1183906
914240000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	35883	0	2331	0	38214
		1JAN91 TO 31DEC91	0	82824	0	5208	0	88032
912442E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	118707	0	7539	0	126246
914300000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	1297353	0	0	1297353

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN90 TO 31DEC90	0	0	814617	0	0	814617
912443A	**TOTAL** TUNNEL ACCESS		0	0	2111970	0	0	2111970
914310000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912443B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
914320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	331258	0	54331	699996	1085585
912443C	**TOTAL** TBM TUNNEL EXCAVATION		0	331258	0	54331	699996	1085585
914330000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	183974	0	313874	0	497848
912443D	**TOTAL** TBM TUNNEL SUPPORT		0	183974	0	313874	0	497848
914340000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	31059	0	1953	0	33012
912443E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750
921200000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	392154	0	36666	0	428820
922412A	**TOTAL** ELECTRON SHIELDING NICHE		0	392154	0	36666	0	428820
921300000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	499002	0	43146	0	542148
922413A	**TOTAL** ELECTRON SHIELDING NICHE		0	499002	0	43146	0	542148
921400000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	168066	0	15714	0	183780
		1JAN91 TO 31DEC91	0	295320	0	25272	0	320592
922414A	**TOTAL** ELECTRON SHIELDING NICHE		0	463386	0	40986	0	504372
922100000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	392154	0	36666	0	428820
922421A	**TOTAL** ELECTRON SHIELDING NICHE		0	392154	0	36666	0	428820
922200000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	1049082	0	96138	0	1145220

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
922422A	**TOTAL** ELECTRON SHIELDING NICHE		0	1049082	0	96138	0	1145220
922300000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	516810	0	44226	0	561036
922423A	**TOTAL** ELECTRON SHIELDING NICHE		0	516810	0	44226	0	561036
922400000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	398090	0	37026	0	435116
922424A	**TOTAL** ELECTRON SHIELDING NICHE		0	398090	0	37026	0	435116
923100000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	93370	0	8730	0	102100
922431A	**TOTAL** ELECTRON SHIELDING NICHE		0	93370	0	8730	0	102100
923400000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	74696	0	6984	0	81680
922434A	**TOTAL** ELECTRON SHIELDING NICHE		0	74696	0	6984	0	81680
924100000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	37348	0	3492	0	40840
		1JAN91 TO 31DEC91	0	93370	0	8730	0	102100
922441A	**TOTAL** ELECTRON SHIELDING NICHE		0	130718	0	12222	0	142940
924200000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	130718	0	12222	0	142940
922442A	**TOTAL** ELECTRON SHIELDING NICHE		0	130718	0	12222	0	142940
924300000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	37348	0	3492	0	40840
922443A	**TOTAL** ELECTRON SHIELDING NICHE		0	37348	0	3492	0	40840
931200000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	261436	0	59444	0	320880
932412A	**TOTAL** POWER ALCOVE		0	261436	0	59444	0	320880
931300000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	209618	0	40734	0	250352
		1JAN92 TO 31DEC92	0	123050	0	23030	0	146080

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
932413A	**TOTAL** POWER ALCOVE		0	332668	0	63764	0	396432
931400000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	130718	0	29722	0	160440
		1JAN91 TO 31DEC91	0	196880	0	36848	0	233728
932414A	**TOTAL** POWER ALCOVE		0	327598	0	66570	0	394168
932100000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	242762	0	55198	0	297960
932421A	**TOTAL** POWER ALCOVE		0	242762	0	55198	0	297960
932200000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	726554	0	159262	0	885816
932422A	**TOTAL** POWER ALCOVE		0	726554	0	159262	0	885816
932300000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	319930	0	59878	0	379808
932423A	**TOTAL** POWER ALCOVE		0	319930	0	59878	0	379808
932400000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	267372	0	59804	0	327176
932424A	**TOTAL** POWER ALCOVE		0	267372	0	59804	0	327176
933100000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	74696	0	16984	0	91680
932431A	**TOTAL** POWER ALCOVE		0	74696	0	16984	0	91680
933400000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	37348	0	8492	0	45840
932434A	**TOTAL** POWER ALCOVE		0	37348	0	8492	0	45840
934100000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	18674	0	4246	0	22920
		1JAN91 TO 31DEC91	0	74696	0	16984	0	91680
932441A	**TOTAL** POWER ALCOVE		0	93370	0	21230	0	114600
934200000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	93370	0	21230	0	114600

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
932442A	**TOTAL** POWER ALCOVE		0	93370	0	21230	0	114600
934300000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	37348	0	8492	0	45840
932443A	**TOTAL** POWER ALCOVE		0	37348	0	8492	0	45840
941100000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	75756	294213
924113A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	75756	294213
941110000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	56064	0	0	0	56064
		1JAN90 TO 31DEC90	0	52080	0	0	0	52080
924113B	**TOTAL** SHAFT SET UP		0	108144	0	0	0	108144
941130000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	25824	0	228850	52424	307098
		1JAN90 TO 31DEC90	0	136056	0	182020	28667	346743
924113D	**TOTAL** SHAFT COLLAR		0	161880	0	410870	81091	653841
941140000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	0	0	15730	3932	19662
		1JAN90 TO 31DEC90	0	262477	0	428350	164722	855549
924113E	**TOTAL** SHAFT SINKING		0	262477	0	444080	168654	875211
941150000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	0	0	4000	1000	5000
		1JAN90 TO 31DEC90	0	32588	0	8517	4214	45319
924113F	**TOTAL** SHAFT FURNISHING		0	32588	0	12517	5214	50319
941160000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	121572	0	41634	30822	194028
924113G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	121572	0	41634	30822	194028
941170000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	0	0	121000	30250	151250
		1JAN90 TO 31DEC90	0	302745	0	256409	72678	631832
924113H	**TOTAL** SHAFT MANWAY/DRIFT		0	302745	0	377409	102928	783082

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
941300000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	34115	93390	143781	97398	368684
924133A	**TOTAL** SHAFT MOBILIZATION		0	34115	93390	143781	97398	368684
941310000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	136176	0	0	0	136176
924133B	**TOTAL** SHAFT SET UP		0	136176	0	0	0	136176
941320000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
924133C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920
941330000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	161880	0	270870	46091	478841
924133D	**TOTAL** SHAFT COLLAR		0	161880	0	270870	46091	478841
941340000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	1237786	0	695637	255496	2188919
		1JAN90 TO 31DEC90	0	459800	0	233052	75326	768178
924133E	**TOTAL** SHAFT SINKING		0	1697586	0	928690	330822	2957098
941350000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	28392	0	16053	9561	54006
		1JAN90 TO 31DEC90	0	65320	0	36311	16976	118607
924133F	**TOTAL** SHAFT FURNISHING		0	93712	0	52364	26537	172613
941360000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	52626	0	25090	16138	93854
		1JAN90 TO 31DEC90	0	52626	0	25090	16138	93854
924133G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	50180	32276	187708
941370000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	73485	0	138106	19460	231051
		1JAN90 TO 31DEC90	0	177450	0	239015	52174	468639
924133H	**TOTAL** SHAFT MANWAY/DRIFT		0	250935	0	377121	71634	699690
941400000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	66434	140085	227503	152262	586284

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924143A	**TOTAL** SHAFT MOBILIZATION		0	66434	140085	227503	152262	586284
941410000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	84096	0	0	0	84096
		1JAN90 TO 31DEC90	0	130200	0	0	0	130200
924143B	**TOTAL** SHAFT SET UP		0	214296	0	0	0	214296
941420000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
		1JAN90 TO 31DEC90	0	920	0	0	0	920
924143C	**TOTAL** SHAFT PRE-GROUT		0	1840	0	0	0	1840
941430000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	90384	0	135495	26136	252015
		1JAN90 TO 31DEC90	0	142992	0	238768	39910	421670
924143D	**TOTAL** SHAFT COLLAR		0	233376	0	374262	66046	673684
941440000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	636870	0	710710	295125	1642705
		1JAN90 TO 31DEC90	0	1420710	0	1296477	367900	3085087
924143E	**TOTAL** SHAFT SINKING		0	2057580	0	2007187	663025	4727792
941450000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	185816	0	79416	43794	309026
924143F	**TOTAL** SHAFT FURNISHING		0	185816	0	79416	43794	309026
941460000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	157878	0	70997	47686	276561
924143G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	157878	0	70997	47686	276561
941470000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	134862	0	160133	34783	329777
		1JAN90 TO 31DEC90	0	126186	0	355073	54196	535455
924143H	**TOTAL** SHAFT MANWAY/DRIFT		0	261048	0	515206	88979	865233
942100000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	75756	294213
924213A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	75756	294213

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
942110000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	160224	0	0	0	160224
924213B	**TOTAL** SHAFT SET UP		0	160224	0	0	0	160224
942130000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	144788	46695	551240	156538	899261
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924213D	**TOTAL** SHAFT COLLAR		0	235172	46695	686735	182674	1151275
942140000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	775675	0	524760	215661	1516096
		1JAN90 TO 31DEC90	0	432212	0	261508	116159	809879
924213E	**TOTAL** SHAFT SINKING		0	1207887	0	786268	331820	2325975
942150000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	64066	0	60874	26938	151876
		1JAN90 TO 31DEC90	0	27588	0	16102	7508	51198
924213F	**TOTAL** SHAFT FURNISHING		0	91654	0	76976	34446	203076
942160000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	105252	0	45094	30822	181168
		1JAN90 TO 31DEC90	0	52626	0	21320	15411	89357
924213G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	157878	0	66414	46233	270525
942170000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	127764	0	746111	154670	1028545
		1JAN90 TO 31DEC90	0	83202	0	197250	55900	336352
924213H	**TOTAL** SHAFT MANWAY/DRIFT		0	210966	0	943361	210570	1364897
942200000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
924223A	**TOTAL** SHAFT MOBILIZATION		0	1796	46695	60738	37878	147107
942210000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	95136	0	0	0	95136
924223B	**TOTAL** SHAFT SET UP		0	95136	0	0	0	95136
942220000	SHAFT PRE-GROUT							
		1JAN90 TO 31DEC90	0	920	0	0	0	920

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924223C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920
942230000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	122703	46695	362238	120655	652291
		1JAN90 TO 31DEC90	0	71496	0	119384	19955	210835
924223D	**TOTAL** SHAFT COLLAR		0	194199	46695	481622	140610	863126
942240000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	0	0	46260	11565	57825
		1JAN90 TO 31DEC90	0	1770988	0	1109376	461911	3342275
924223E	**TOTAL** SHAFT SINKING		0	1770988	0	1155636	473476	3400100
942250000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	0	0	15200	3800	19000
		1JAN90 TO 31DEC90	0	53590	0	21611	12736	87937
924223F	**TOTAL** SHAFT FURNISHING		0	53590	0	36811	16536	106937
942260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	105252	0	45404	31502	182158
924223G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	45404	31502	182158
942270000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	0	0	121000	30250	151250
		1JAN90 TO 31DEC90	0	126336	0	336438	75360	538134
924223H	**TOTAL** SHAFT MANWAY/DRIFT		0	126336	0	457438	105610	689384
942300000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	34115	93390	143781	95418	366704
924233A	**TOTAL** SHAFT MOBILIZATION		0	34115	93390	143781	95418	366704
942310000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	84096	0	0	0	84096
		1JAN90 TO 31DEC90	0	52080	0	0	0	52080
924233B	**TOTAL** SHAFT SET UP		0	136176	0	0	0	136176
942320000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
924233C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
942330000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	90384	0	135495	26136	252015
		1JAN90 TO 31DEC90	0	71496	0	119384	19955	210835
924233D	**TOTAL** SHAFT COLLAR		0	161880	0	254879	46091	462850
942340000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	717288	0	606815	189260	1513363
		1JAN90 TO 31DEC90	0	661365	0	504924	172879	1339168
924233E	**TOTAL** SHAFT SINKING		0	1378653	0	1111739	362139	2852531
942350000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	96001	0	49365	25221	170587
924233F	**TOTAL** SHAFT FURNISHING		0	96001	0	49365	25221	170587
942360000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	105252	0	50180	32275	187707
924233G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	50180	32275	187707
942370000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	134862	0	153727	32952	321541
		1JAN90 TO 31DEC90	0	106470	0	225235	36567	368272
924233H	**TOTAL** SHAFT MANWAY/DRIFT		0	241332	0	378962	69519	689813
942400000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	73776	292233
924243A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	73776	292233
942410000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	52080	0	0	0	52080
		1JAN90 TO 31DEC90	0	4672	0	0	0	4672
924243B	**TOTAL** SHAFT SET UP		0	56752	0	0	0	56752
942420000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
		1JAN90 TO 31DEC90	0	920	0	0	0	920
924243C	**TOTAL** SHAFT PRE-GROUT		0	1840	0	0	0	1840
942430000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	71496	0	434384	98705	604585

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924243D	**TOTAL** SHAFT COLLAR		0	161880	0	569879	124841	856600
942440000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	318435	0	420833	134490	873758
		1JAN90 TO 31DEC90	0	57960	0	0	0	57960
924243E	**TOTAL** SHAFT SINKING		0	376395	0	420833	134490	931718
942450000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	24495	0	39614	13675	77784
		1JAN90 TO 31DEC90	0	36784	0	21133	9854	67771
924243F	**TOTAL** SHAFT FURNISHING		0	61279	0	60747	23529	145555
942460000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	52626	0	20817	15411	88854
		1JAN90 TO 31DEC90	0	52626	0	20817	15365	88808
924243G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	41634	30776	177662
942470000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	56784	0	597571	133095	787450
		1JAN90 TO 31DEC90	0	212940	0	282939	65511	561390
924243H	**TOTAL** SHAFT MANWAY/DRIFT		0	269724	0	880510	198606	1348840
943210000	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	56064	0	0	0	56064
924323B	**TOTAL** SHAFT SET UP		0	56064	0	0	0	56064
943230000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924323D	**TOTAL** SHAFT COLLAR		0	92180	46695	196233	64014	399121
943240000	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	156332	0	72619	40386	269337
924323E	**TOTAL** SHAFT SINKING		0	156332	0	72619	40386	269337
943250000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	9196	0	7045	3284	19525

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924323F	**TOTAL** SHAFT FURNISHING		0	9196	0	7045	3284	19525
943260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	52626	0	21320	15411	89357
924323G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	52626	0	21320	15411	89357
943270000	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	83202	0	197250	55900	336352
924323H	**TOTAL** SHAFT MANWAY/DRIFT		0	83202	0	197250	55900	336352
944200000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
924425A	**TOTAL** SHAFT MOBILIZATION		0	1796	46695	60738	37878	147107
944210000	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	56064	0	0	0	56064
924425B	**TOTAL** SHAFT SET UP		0	56064	0	0	0	56064
944230000	SHAFT COLLAR							
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924425D	**TOTAL** SHAFT COLLAR		0	90384	0	135495	26136	252015
944240000	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	51520	0	0	0	51520
924425E	**TOTAL** SHAFT SINKING		0	51520	0	0	0	51520
944250000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	27588	0	24135	11274	62997
924425F	**TOTAL** SHAFT FURNISHING		0	27588	0	24135	11274	62997
944260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	13800	0	0	0	13800
924425G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	13800	0	0	0	13800
944270000	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	141302	0	289387	52174	482863
924425H	**TOTAL** SHAFT MANWAY/DRIFT		0	141302	0	289387	52174	482863

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
971000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	4438	56215	0	8491	69144
912431X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	4438	56215	0	8491	69144
971100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	362	966	0	186	1514
		1JAN90 TO 31DEC90	0	17875	51722	0	9743	79340
912431Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	18237	52687	0	9929	80853
971200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	117786	75082	0	57670	250538
912431Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	117786	75082	0	57670	250538
971300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	26214	6553	32767
912431W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	26214	6553	32767
972000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	17430	220782	0	33350	271562
912432X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	17430	220782	0	33350	271562
972100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1811	4828	0	929	7568
		1JAN90 TO 31DEC90	0	73474	210910	0	39814	324197
912432Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	75284	215738	0	40743	331765
972200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	588931	375408	0	288350	1252689
912432Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	588931	375408	0	288350	1252689
972300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	131076	32769	163845
912432W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	131076	32769	163845
973000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	23386	296219	0	44745	364349
912433X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	23386	296219	0	44745	364349

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
973100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1931	5150	0	991	8072
		1JAN90 TO 31DEC90	0	94349	272902	0	51415	418665
912433Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	96280	278051	0	52406	426737
973200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	628193	400435	0	307573	1336201
912433Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	628193	400435	0	307573	1336201
973300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	139815	34954	174769
912433W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	139815	34954	174769
974000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	15632	198007	0	29909	243548
912434X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	15632	198007	0	29909	243548
974100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	845	2253	0	434	3531
		1JAN90 TO 31DEC90	0	59281	173404	0	32576	265260
912434Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	60126	175656	0	33009	268791
974200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	274835	175190	0	134563	564588
912434Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	274835	175190	0	134563	564588
974300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	61170	15293	76463
912434W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	61170	15293	76463
977000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	18101	229275	0	34633	282008
912443X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	18101	229275	0	34633	282008
977100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1448	3862	0	744	6054
		1JAN90 TO 31DEC90	0	72633	210290	0	39609	322532
912443Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	74081	214153	0	40353	328587

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
977200000	CUT & COVER TUNNEL P							
		1JAN90 TO 31DEC90	0	471145	300326	0	230680	1002151
912443Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	471145	300326	0	230680	1002151
977300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	104818	26205	131023
912443W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	104818	26205	131023
978000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	16726	211865	0	32003	260594
912444X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	16726	211865	0	32003	260594
978100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1931	5150	0	991	8072
		1JAN90 TO 31DEC90	0	72151	206308	0	38984	317444
912444Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	74082	211458	0	39976	325516
978200000	CUT & COVER TUNNEL P							
		1JAN90 TO 31DEC90	0	628193	400435	0	307573	1336201
912444Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	628193	400435	0	307573	1336201
978300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	139815	34954	174769
912444W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	139815	34954	174769
981000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	58645	742836	0	112207	913688
912411X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	58645	742836	0	112207	913688
981100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	6035	16092	0	3098	25224
		1JAN90 TO 31DEC90	0	246725	705469	0	133727	1085921
912411Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	252759	724561	0	136825	1114145
981200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	1635920	1042800	0	800971	3479691
		1JAN90 TO 31DEC90	0	327184	208560	0	160194	695938
912411Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	1963104	1251360	0	961165	4175629

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
981300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	436920	109230	546150
912411W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	436920	109230	546150
992411300	N ARC SEC A SHAFT -							
		1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24113.00	**TOTAL** N ARC SEC A SHAFT - SURF BUILD		46620	0	0	0	0	46620
992411314	N ARC SEC A SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24113.14	**TOTAL** N ARC SEC A SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992411515	N ARC SEC A MECHANIC							
		1JAN89 TO 31DEC89	90756	24305	48066	6645	10272	180044
24115.15	**TOTAL** N ARC SEC A MECHANICAL - MECHA		90756	24305	48066	6645	10272	180044
992412416	N ARC SEC B ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24124.16	**TOTAL** N ARC SEC B ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992412515	N ARC SEC B MECHANIC							
		1JAN89 TO 31DEC89	115093	65379	65379	6646	16488	268985
24125.15	**TOTAL** N ARC SEC B MECHANICAL - MECHA		115093	65379	65379	6646	16488	268985
992413300	N ARC SEC C SHAFT -							
		1JAN89 TO 31DEC89	27750	0	0	0	0	27750
		1JAN90 TO 31DEC90	18870	0	0	0	0	18870
24133.00	**TOTAL** N ARC SEC C SHAFT - SURF BUILD		46620	0	0	0	0	46620
992413314	N ARC SEC C SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24133.14	**TOTAL** N ARC SEC C SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992413416	N ARC SEC C ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24134.16	**TOTAL** N ARC SEC C ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992413515	N ARC SEC C MECHANIC							
		1JAN89 TO 31DEC89	115091	28568	65738	6645	12114	228156

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
24135.15	**TOTAL** N ARC SEC C MECHANICAL - MECHA		115091	28568	65738	6645	12114	228156
992414300	N ARC SEC D SHAFT -							
		1JAN90 TO 31DEC90	93240	0	0	0	0	93240
24143.00	**TOTAL** N ARC SEC D SHAFT - SURF BUILD		93240	0	0	0	0	93240
992414314	N ARC SEC D SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24143.14	**TOTAL** N ARC SEC D SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992414416	N ARC SEC D ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24144.16	**TOTAL** N ARC SEC D ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992414515	N ARC SEC D MECHANIC							
		1JAN89 TO 31DEC89	195153	46710	114417	10764	20627	387671
24145.15	**TOTAL** N ARC SEC D MECHANICAL - MECHA		195153	46710	114417	10764	20627	387671
992421300	S ARC SEC E SHAFT -							
		1JAN89 TO 31DEC89	74370	0	0	0	0	74370
		1JAN90 TO 31DEC90	18870	0	0	0	0	18870
24213.00	**TOTAL** S ARC SEC E SHAFT - SITEWORK		93240	0	0	0	0	93240
992421314	S ARC SEC E SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24213.14	**TOTAL** S ARC SEC E SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992421515	S ARC SEC E MECHANIC							
		1JAN89 TO 31DEC89	120512	31397	66168	7671	13681	239429
24215.15	**TOTAL** S ARC SEC E MECHANICAL - MECHA		120512	31397	66168	7671	13681	239429
992421516	MECH SYS - ELECTRICA							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24215.16	**TOTAL** MECH SYS - ELECTRICAL		5506327	2302602	313727	1872422	0	9995078
992422300	S ARC SEC F SHAFT -							
		1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24223.00	**TOTAL** S ARC SEC F SHAFT - SURF BUILD		46620	0	0	0	0	46620

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992422314	S ARC SEC F SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24223.14	**TOTAL** S ARC SEC F SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992422416	S ARC SEC F ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24224.16	**TOTAL** S ARC SEC F ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992422515	S ARC SEC F MECHANIC							
		1JAN89 TO 31DEC89	129804	36248	66903	9430	14636	257021
24225.15	**TOTAL** S ARC SEC F MECHANICAL - MECHA		129804	36248	66903	9430	14636	257021
992423300	S ARC SEC G SHAFT -							
		1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24233.00	**TOTAL** S ARC SEC G SHAFT - SURF BUILD		46620	0	0	0	0	46620
992423314	S ARC SEC G SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24233.14	**TOTAL** S ARC SEC G SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992423416	S ARC SEC G ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24234.16	**TOTAL** S ARC SEC G ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992423515	S ARC SEC G MECHANIC							
		1JAN89 TO 31DEC89	127868	35237	66750	9064	14437	253356
24235.15	**TOTAL** S ARC SEC G MECHANICAL - MECHA		127868	35237	66750	9064	14437	253356
992424300	S ARC SEC H SHAFT -							
		1JAN89 TO 31DEC89	12210	0	0	0	0	12210
		1JAN90 TO 31DEC90	34410	0	0	0	0	34410
24243.00	**TOTAL** S ARC SEC H SHAFT - SURF BUILD		46620	0	0	0	0	46620
992424314	S ARC SEC H SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24243.14	**TOTAL** S ARC SEC H SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992424416	S ARC SEC H ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
24244.16	**TOTAL** S ARC SEC H ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992424515	S ARC SEC H MECHANIC							
		1JAN89 TO 31DEC89	202897	50753	114850	12229	21340	402069
24245.15	**TOTAL** S ARC SEC H MECHANICAL - MECHA		202897	50753	114850	12229	21340	402069
992431416	E CONNEC V ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24314.16	**TOTAL** E CONNEC V ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992432416	E CONNEC X ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24324.16	**TOTAL** E CONNEC X ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992432515	E CONNEC X MECHANICA							
		1JAN89 TO 31DEC89	36364	11097	17415	2746	4376	71998
24325.15	**TOTAL** E CONNEC X MECHANICAL - MECHAN		36364	11097	17415	2746	4376	71998
992433416	E CONNEC Y ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24334.16	**TOTAL** E CONNEC Y ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992434416	E CONNEC Z ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24344.16	**TOTAL** E CONNEC Z ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992441616	W CONNEC Q ELECTRICA							
		1JAN89 TO 31DEC89	1708854	703889	93229	598234	0	3104206
24416.16	**TOTAL** W CONNEC Q ELECTRICAL - ELECTR		1708854	703889	93229	598234	0	3104206
992441715	W CONNEC Q MECHANICA							
		1JAN89 TO 31DEC89	758519	164629	254741	243556	79551	1500996
24417.15	**TOTAL** W CONNEC Q MECHANICAL - MECHAN		758519	164629	254741	243556	79551	1500996
992442616	W CONNEC R ELECTRICA							
		1JAN89 TO 31DEC89	1614594	673686	90412	551888	0	2930580
24426.16	**TOTAL** W CONNEC R ELECTRICAL - ELECTR		1614594	673686	90412	551888	0	2930580

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992442715	W CONNEC R MECHANICA							
		1JAN89 TO 31DEC89	758517	164627	254742	243549	86179	1507614
24427.15	**TOTAL** W CONNEC R MECHANICAL - MECHAN		758517	164627	254742	243549	86179	1507614
992443416	W CONNEC S ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24434.16	**TOTAL** W CONNEC S ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992444416	W CONNEC T ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24444.16	**TOTAL** W CONNEC T ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992461101	A40 PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	2285472	0	0	0	0	2285472
24611.01	**TOTAL** A40 PUMP/COMPRES - COMPOSITE		2285472	0	0	0	0	2285472
992462101	E40 PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	1754916	0	0	0	0	1754916
		1JAN91 TO 31DEC91	530556	0	0	0	0	530556
24621.01	**TOTAL** E40 PUMP/COMPRES - COMPOSITE		2285472	0	0	0	0	2285472
992463101	XR PUMP/COMPRES - CO							
		1JAN90 TO 31DEC90	495300	0	0	0	0	495300
		1JAN91 TO 31DEC91	336804	0	0	0	0	336804
24631.01	**TOTAL** XR PUMP/COMPRES - COMPOSITE		832104	0	0	0	0	832104
992464101	RR PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	832104	0	0	0	0	832104
24641.01	**TOTAL** RR PUMP/COMPRES - COMPOSITE		832104	0	0	0	0	832104
1+24	**TOTAL** COLLIDER RING		60716289	73011425	56812928	60429229	39358607	290328478
992513102	HALL Y TYPE B - SITE							
		1JAN89 TO 31DEC89	9366132	0	0	0	0	9366132
		1JAN90 TO 31DEC90	3968700	0	0	0	0	3968700
25131.02	**TOTAL** HALL Y TYPE B - SITE WORK		13334832	0	0	0	0	13334832

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992513716	HALL Y ELE SYS - ELE							
		1JAN89 TO 31DEC89	788358	365771	27529	142897	0	1324555
25137.16	**TOTAL** HALL Y ELE SYS - ELECTRICAL		788358	365771	27529	142897	0	1324555
992513815	HALL Y MEC SYS - MEC							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25138.15	**TOTAL** HALL Y MEC SYS - MECHANICAL		629992	248536	29554	70908	73290	1052280
992514101	HALL Z - COMPOSITE							
		1JAN89 TO 31DEC89	9366132	0	0	0	0	9366132
		1JAN90 TO 31DEC90	3968700	0	0	0	0	3968700
25141.01	**TOTAL** HALL Z - COMPOSITE		13334832	0	0	0	0	13334832
992514716	HALL Z ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561
25147.16	**TOTAL** HALL Z ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992514815	HALL Z MECH SYSTEM							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25148.15	**TOTAL** HALL Z MECH SYSTEM		629992	248536	29554	70908	73290	1052280
992521102	HALL S TYPE A - SITE							
		1JAN89 TO 31DEC89	8651766	0	0	0	0	8651766
		1JAN90 TO 31DEC90	4683066	0	0	0	0	4683066
25211.02	**TOTAL** HALL S TYPE A - SITE WORK		13334832	0	0	0	0	13334832
992521716	HALL S ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561
25217.16	**TOTAL** HALL S ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992521815	HALL S MECH SYS - ME							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25218.15	**TOTAL** HALL S MECH SYS - MECHANICAL		629992	248536	29554	70908	73290	1052280
992522101	HALL T TYPE A - COMP							
		1JAN89 TO 31DEC89	8651766	0	0	0	0	8651766
		1JAN90 TO 31DEC90	4683066	0	0	0	0	4683066
25221.01	**TOTAL** HALL T TYPE A - COMPOSITE		13334832	0	0	0	0	13334832

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER.	SURFACE, BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992522716	HALL T ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561
25227.16	**TOTAL** HALL T ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992522815	HALL T MECH SYS - ME							
		1JAN89 TO 31DEC89	630342	248746	29587	70936	73346	1052957
25228.15	**TOTAL** HALL T MECH SYS - MECHANICAL		630342	248746	29587	70936	73346	1052957
1+25____	**TOTAL** EXPERIMENTAL FACILITIES		59013090	2457444	228368	855245	293215	62847362

3.0 SCHEDULES - DEVELOPED ON PROJECT/2

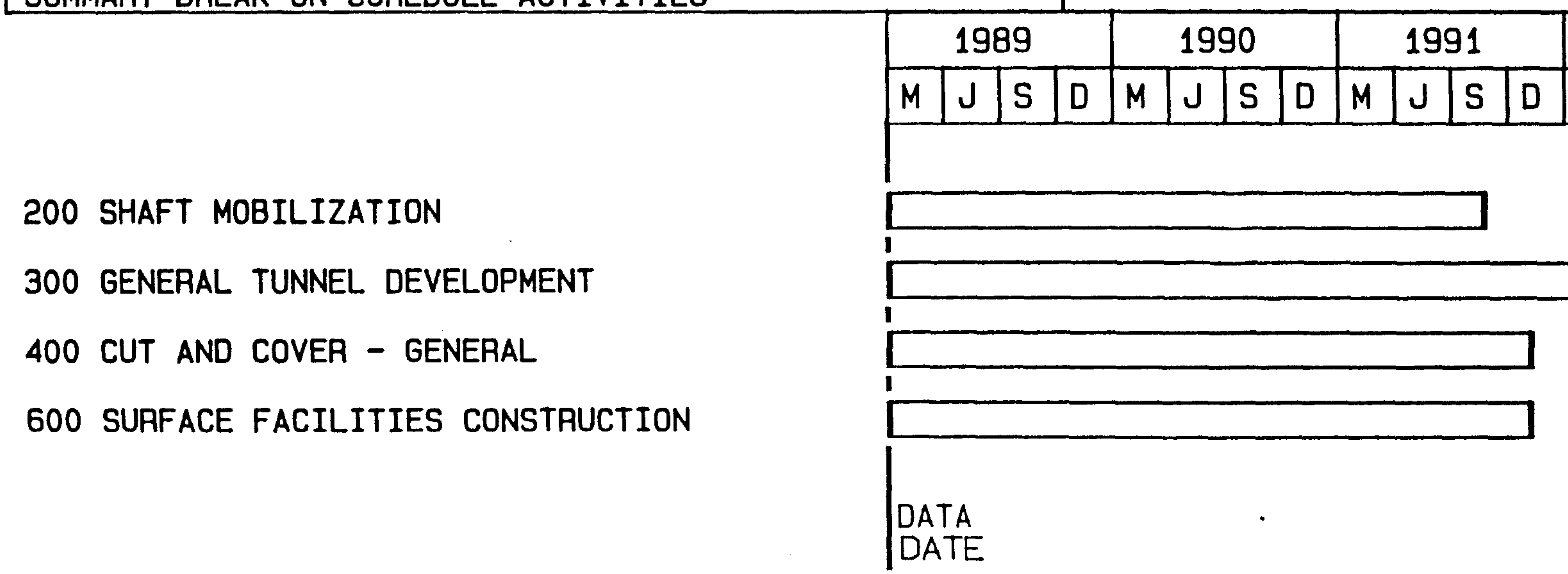
3.1 TOTAL PROJECT SCHEDULES

These graphs present the overall Conventional Facilities construction schedule from various points of reference. First, the project schedule is summarized by construction method demonstrating the balanced nature of the overall project. Second, construction is summarized by sector showing the availability of various major facilities components. Third, the project schedule is presented by construction unit. Forth, the project is presented by work package showing the continuity of the various activities. Finally, construction activities are grouped by geology.

Project schedules are presented in the following order:

Construction Method Summary
Sector Summary
Contract Summary
Work Package Details
Summary by Geology

PROJECT MIFP2 PLOT MIFP2A PAGE 1 SHEET 1	START 3JAN89 FINISH 17JAN92 DATA DATE 2JAN89		RUN 10JUL87 06:53 PROJECT/2 SCHEDULE BAR CHART
ARIZONA SSC PROJECT MARICOPA GUNG HO RING SCHEDULE CONSTRUCTION METHOD SUMMARY		MODE C/FE INTERVAL: 3 MONTH(S)	
SUMMARY W O R K I N G SCHEDULE			
SUMMARY BREAK ON SCHEDULE ACTIVITIES			



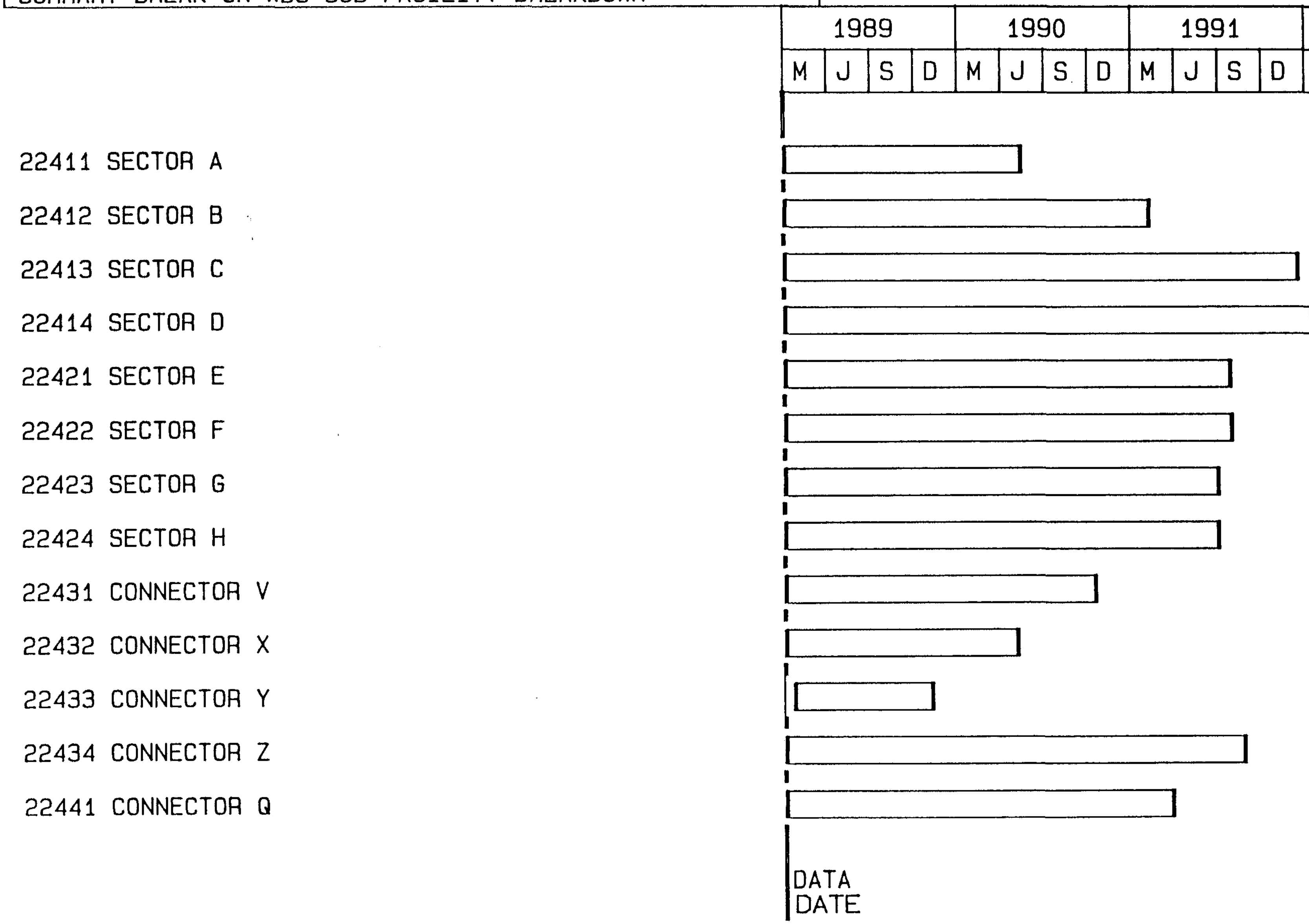
PAGE 1 SHEET 1 | DATA DATE 2JAN89 | SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
SECTOR SUMMARY

MODE C/FE
INTERVAL: 3 MONTH (S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON WBS SUB FACILITY BREAKDOWN



PROJECT SIFP2
PLOT MSECT
PAGE 1 SHEET 2

START 3JAN89
FINISH 17JAN92
DATA DATE 2JAN89

RUN 24JUL87 12: 35
PROJECT/2
SCHEDULE BAR CHART

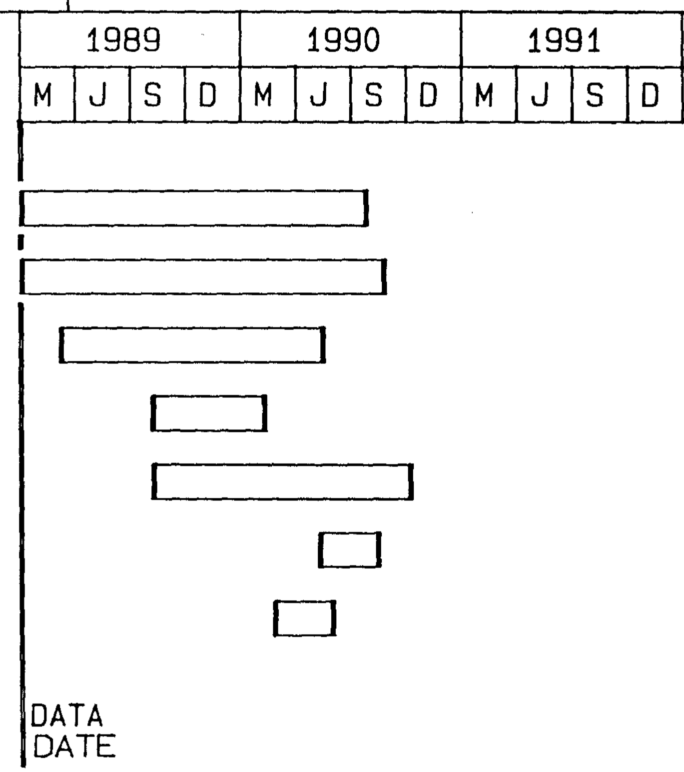
ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
SECTOR SUMMARY

MODE C/FE
INTERVAL: 3 MONTH (S)

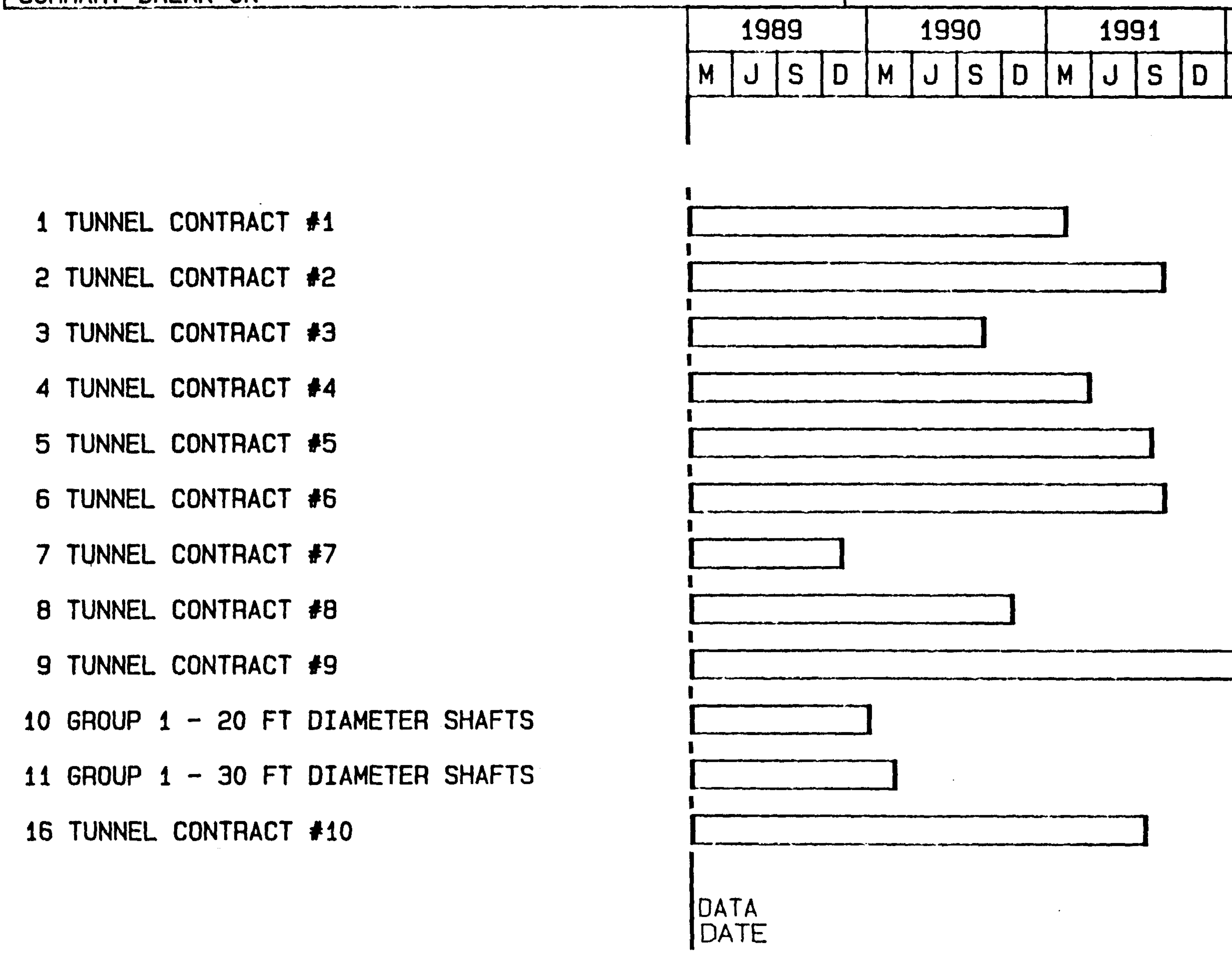
SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON WBS SUB FACILITY BREAKDOWN

22442 CONNECTOR R
22443 CONNECTOR S
22444 CONNECTOR T
22461 CRYOGENIC FACILITIES - NORTH ARC
22462 CRYOGENIC FACILITIES - SOUTH ARC
22463 CRYOGENIC FACILITIES - EAST CLUSTER
22464 CRYOGENIC FACILITIES - WEST CLUSTER



ARIZONA SSC PROJECT MARICOPA GUNG HO RING SCHEDULE CONTRACT SUMMARY	MODE C/FE INTERVAL: 3 MONTH (S)
SUMMARY W O R K I N G SCHEDULE	
SUMMARY BREAK ON	



PROJECT MIFP2
PLOT MIFP2B
PAGE 1 SHEET 2

START 3JAN89
FINISH 17JAN92
DATA DATE 2JAN89

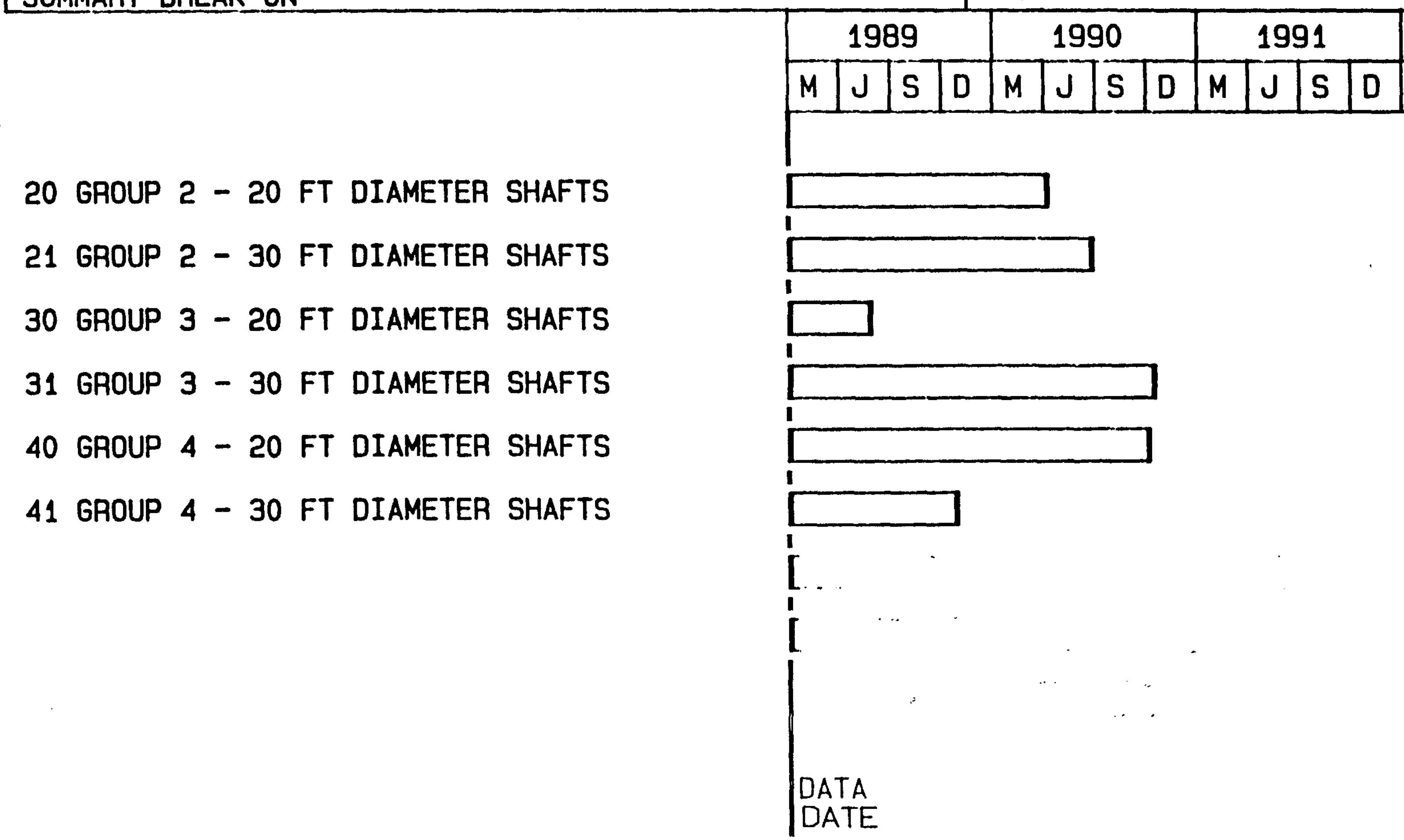
RUN 10JUL87 06:54
PROJECT/2
SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
CONTRACT SUMMARY

MODE C/FE
INTERVAL: 3 MONTH(S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON



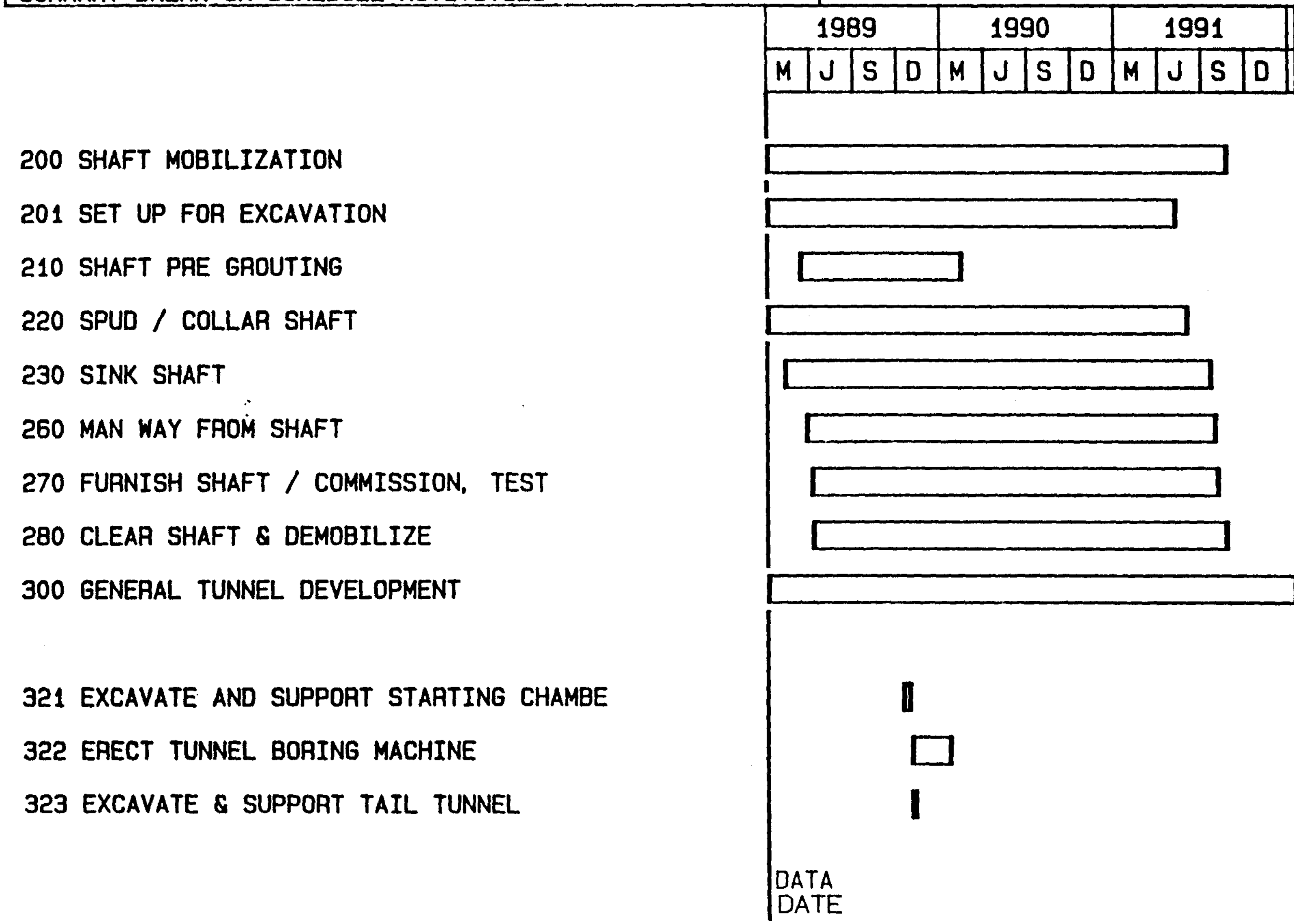
PLOT MIFP2 | FINISH 17JAN92 | PROJECT/2
PAGE 1 SHEET 1 | DATA DATE 2JAN89 | SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
WORK PACKAGE DETAILS

MODE C/FE
INTERVAL: 3 MONTH(S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON SCHEDULE ACTIVITIES



PLOT MIFP2 PAGE 1 SHEET 2	FINISH 17JAN92 DATA DATE 2JAN89		PROJECT/2 SCHEDULE BAR CHART

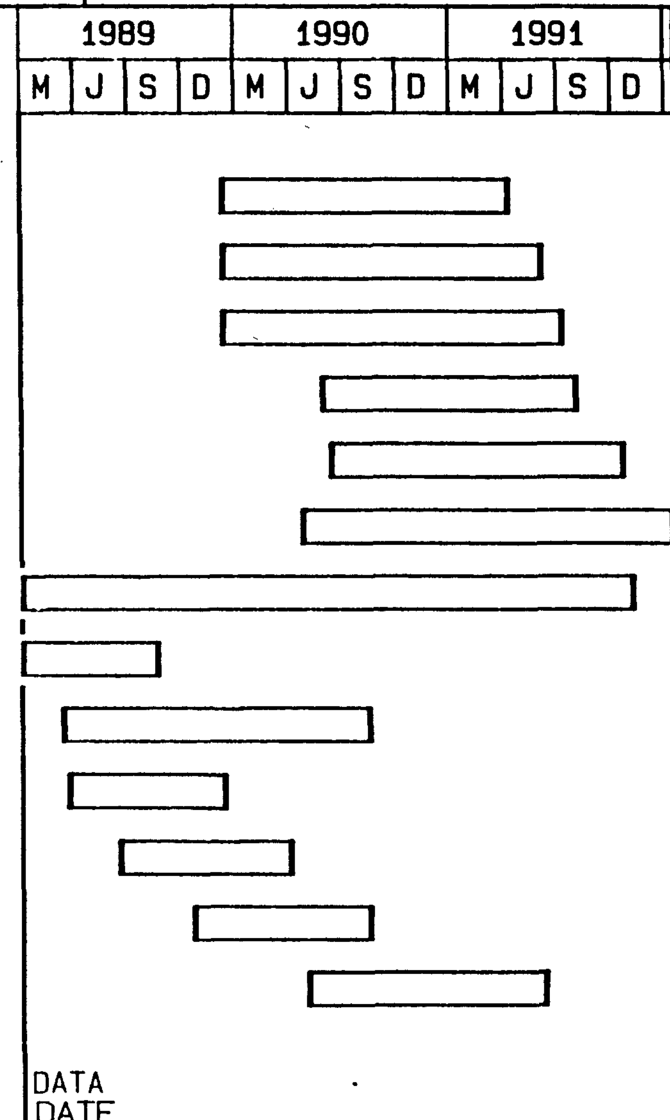
ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
WORK PACKAGE DETAILS

MODE C/FE
INTERVAL: 3 MONTH (S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON SCHEDULE ACTIVITIES

330 SATURDAY MAINTENANCE
331 EXCAVATE TUNNEL
350 INSTALL FINAL LINER / CONCRETE
351 PLACE SHOTCRETE
352 PLACE INVERT PAVING
380 REMOVE TRAILING FLOOR, FANLINES, & T
400 CUT AND COVER - GENERAL
420 CUT TRENCH
430 STABILIZE TRENCH BOTTOM
440 PLACE CAST IN PLACE PIPE AND STABILI
445 PLACE CAST IN PLACE PIPE INVERT
450 REVEGETATE AREA
510 EXCAV & SUPPORT ELECTRON SHIELDING N



SUMMARY

DATA

Location of project site ---------------	ARIZONA
Urban (1), rural (2), or remote (3) -----	2
Rock type -----------------------------	SOFT
Method of tunnel excavation ------------	TBM
Tunnel access via portal (1) or shaft (2)	1
Tunnel should be wet (1) or dry (2)------	1
Haulageway width	10.0 feet
Tunnel length	29,568 feet

	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
							SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION						PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
BUILDINGS & YARD						121,754	35,685	86,069		200	17,864	93,662	2,680	512			1,000	201,987
UTILITIES						997,313	231,121	766,192	600	16,000	20,020	27,382	6,037	1,732			7,500	845,463
HOISTING AND CRANES						69,178	32,375	36,803	14,574	2,200	4,928	2,870	1,971	1,148			1,500	65,993
HAUL - RUBBER						243,230	53,088	190,142		1,000	15,400	8,916	6,160	871			2,500	224,989
HAUL - RAIL						1,336,552	516,879	819,674		57,600	47,432	12,760	18,788	2,921			21,500	980,674
SURFACE EXCAVATION EQUIPMENT						131,900	51,441	80,459		100							500	81,059
ROCK DRILLS AND EQUIPMENT						5,719	777	4,942										4,942
TUNNEL & SHAFT MUCKERS						40,070	13,735	26,335	9,962	3,500							2,650	42,446
TUNNEL & SHAFT MACHINES						3,242,427	1,076,129	2,166,298		31,200	58,520	4,612	23,408	1,845			6,500	2,292,383
CONCRETE & SHOTCRETE						547,534	307,644	239,890		21,600	1,540	512	308	102			4,500	268,453
GENERAL PLANT & EQUIPMENT						317,053	72,290	244,763		100	1,232	410					500	247,005
TOTAL PLANT AND EQUIPMENT COST						7,052,730	2,391,164	4,661,566	25,135	133,500	166,936	151,124	59,352	9,132			48,650	5,255,393

PLANT & EQUIPMENT SUMMARY

TABLE 3-22 Summary of TBM Plant and Equipment Costs for Construction Unit 1.

AZ SSC MARICOPA 01-Jul-87 \AZMI-COS\INDIRECT

Row	Input data		Value
49	INPUT DATA FROM OTHER FILES	Labor Cost, $ per man-shift:	308
50		Small tools, %	4.67
51		Sales Tax Rate, %	0
52		Power cost, cents per KWH	4
53		Payroll, millions of $:	8.5
54		Contract Amt, millions of $:	19.6
55		P&E Ave Value, millions of $:	4.7
56			
57			
58	SCHEDULE DURATIONS IN MONTHS	Shaft Excavation	
59		Tunnel Excavation	9.5
60		Tunnel Concreting	3.7
61		Total Project	25.6
62			

Row	DESCRIPTION	D NO.	E MONTHS	F MAN	G RATE	H COST	I DTC	J VEH	K MOVE IN
66	ENGINEERING								
67	PROJECT ENGINEER	1.0	24.6	24.6	8408	206,667	1	1	1
68	OFFICE ENGINEER	1.0	23.6	23.6	5174	122,005	1		
69	COST ENGINEER	1.0	22.6	22.6	5174	116,831	1		
70	TUNNEL ENGINEER	1.0	10.5	10.5	6468	68,174	1	1	1
71	DRAFTSMAN	1.0	13.2	13.2	3234	42,835	1		
72									
73	FIELD ENGINEER	1.0	13.7	13.7	7115	97,795	1	1	1
74	PARTY CHIEF	1.0	13.2	13.2	6468	85,670	1	1	
75	INSTRUMENTMAN	1.0	13.2	13.2	5821	77,103			
76	RODMAN		13.2		5174				
77									
78	SAFETY ENGINEER	1.0	13.7	13.7	6468	88,904	1	1	
79	FIRST AID PERSONS	3.0	13.2	39.7	3234	128,506			
80									
81	ADMINISTRATIVE								
82	OFFICE MANAGER	1.0	23.6	23.6	7115	167,757	1	1	1
83	PURCHASING AGENT	1.0	13.2	13.2	5174	68,536	1		
84	ACCOUNTANT	1.0	22.6	22.6	3881	87,623	1		
85	PAYMASTER		13.2		3881				
86	TIMEKEEPER	1.0	13.2	13.2	3234	42,835	1		
87	CLERK	1.0	13.2	13.2	3234	42,835	1		
88	SECRETARY	1.0	22.6	22.6	1940	43,812	1		
89	WAREHOUSEMAN	1.0	13.7	13.7	6468	88,904	1		
90	GUARDS, FULL TIME	1.0	16.2	16.2	1940	31,522			
91	GUARDS, WEEKEND	1.0	16.2	16.2	1940	31,522			
92									
93	INDIRECT COSTS								

DESCRIPTION	O NO.	P MONTHS	Q MAN MONTHS	R RATE	S COST	T DTC	U VEH	V MOVE IN
SUPERVISION								
PROJECT MANAGER	1.0	25.6	25.6	9702	248,164	1	1	1
GENERAL SUPT	1.0	16.2	16.2	9055	147,104	1	1	1
TUNNEL SUPT	1.0	13.7	13.7	8408	115,576	1	1	1
EXCAVATION WALKERS	3.0	9.5	28.6	7762	222,140			3
CONCRETE WALKERS	3.0	3.7	11.1	7762	86,274			
EQUIPMENT SUPT	1.0	16.2	16.2	8408	136,597	1	1	1
SHAFT SUPT				7762				
EXCAVATION SUPT				7762				
ELECTRICAL SUPERINTENDENT		16.2		9055		1	1	
CARPENTER SUPT				7762				
CONCRETE SUPT				7762				

INDIRECT COST SUMMARY

	NO	MAN-MONTHS		COST	DTC	VEH	MOVE IN
OVERHEAD LABOR							
SUPERVISION	10.0	111.6	955,854		5	5	7
ENGINEERING	12.0	188.2	1,034,490		8	5	3
ADMINISTRATIVE	9.0	154.7	605,348		7	1	1
TOTAL OVERHEAD LABOR	31.0	454.5	-	$2,595,692	20	11	11
OVERHEAD EXPENSE							
MOVE IN	*	11 EA AT 8,000	$88,000				
VEHICLE OPERATION	*	$250 /MONTH	41,925				
MAINTAIN SUPERVISION	*	$1,000 /MONTH	11,000	140,925			
GENERAL OPERATIONS	LABOR		780,323				
	EXPENSE		47,977	828,300			
MISCELLANEOUS JOB EXPENSE				230,410			
INSURANCE, TAXES AND BOND				823,384			
TOTAL INDIRECT COST				$4,618,710			

1 INDIRECT COST SUMMARY

TABLE 3-23 Summary of TBM Indirect Costs for Construction Unit 1.

TABLE 3-24

TBM UNIT COST PER FOOT

DESCRIPTION	WEAK ROCK TBM	HARD ROCK TBM	DRILL AND BLAST
Tunnel Length	29,568	43,100	2,400
Advance Rate Ft./Day	202	132	18
Direct Cost $/Ft.	327	290	890
Plant and Equipment $/Ft.	178	170	570
Indirect Cost $/Ft.	156	190	830
Total Cost $/Ft.	660	650	2,290

NOTE: Cost estimates are in 1987 dollars.

TABLE 3-25

EXPERIMENTAL CHAMBERS AND INJECTOR COMPLEX
ESTIMATED CONSTRUCTION COST
(In $1,000,000)[1]

DESCRIPTION	MARICOPA	CDG[2]	PERCENT SAVINGS
Site & Infrastructure	70	90	22
Campus	26	45	42
Injector Complex	56	42	0
Experimental Chambers	63	61	0
TOTAL	215	238	10

[1] Cost estimates are in 1987 dollars.

[2] CDG generic site "C" 1986 cost estimate inflated by 5%.

TABLE 3-26

ESTIMATED SHAFT
UNIT COSTS

SHAFT[1]	COSTED DEPTH[2]	COST $/FT.
E 3	250	5,784
F 2	100	12,869
E 2	80	9,988
F 1	60	18,617
E 1	60	12,067
F 10	240	6,808
E 10	180	5,822
F 9	210	8,638
E 9	330	4,867
F 8	380	5,650
E 8	350	4,891
F 7	400	7,093
E 7	270	5,356
F 6	160	9,906
E 6	110	9,027
F 5	70	15,957
E 5	120	7,775
F 4	370	5,803
E 4	800	3,298
F 3	470	6,130

[1] E shafts are 20 feet in diameter.
F shafts are 30 feet in diameter.

[2] Depths shown were used to estimate cost. Actual depths are given in Table 3-15.

Cost estimates are in 1987 dollars.

TABLE 3-27

ACCESS SHAFT E7 COST SUMMARY[1]

ACTIVITY	ESTIMATED COST
Mobilize and Set-Up	$195,000
Collar	$127,000
Shaft	$854,000
Furnish	$56,000
Clear and Demobilize	$94,000
Drifts	$120,000
Total	$1,446,000

[1] Access shaft E7 is "typical" of shafts to be constructed at the Maricopa Site. The depth used for estimating cost is 270 feet; whereas the actual depth is 250 feet.

Cost estimates are in 1987 dollars.

TABLE 3-28

ESTIMATED TOTAL FACILITY
CONSTRUCTION COST
(In $1,000,000)

Facility	Maricopa Site[1]	CDG[2]	% Savings[3]
Collider Ring	290	382	24
Injector, Surface	215	238	10
Total Direct	505	620	19
AE/CM Services	81	99	18
Contingency	123	187	34
TOTAL	709	906	22

[1] 52.8 mile ring plus 8 miles of by-pass tunnel. Estimate is 1987 dollars.

[2] CDG generic site model "C" inflated to a 52.8 mile ring plus 8 miles of by-pass tunnel. 1986 cost estimate inflated by 5%.

[3] Percent savings realized with construction at the Maricopa SSC site.

Cost estimates are in 1987 dollars.

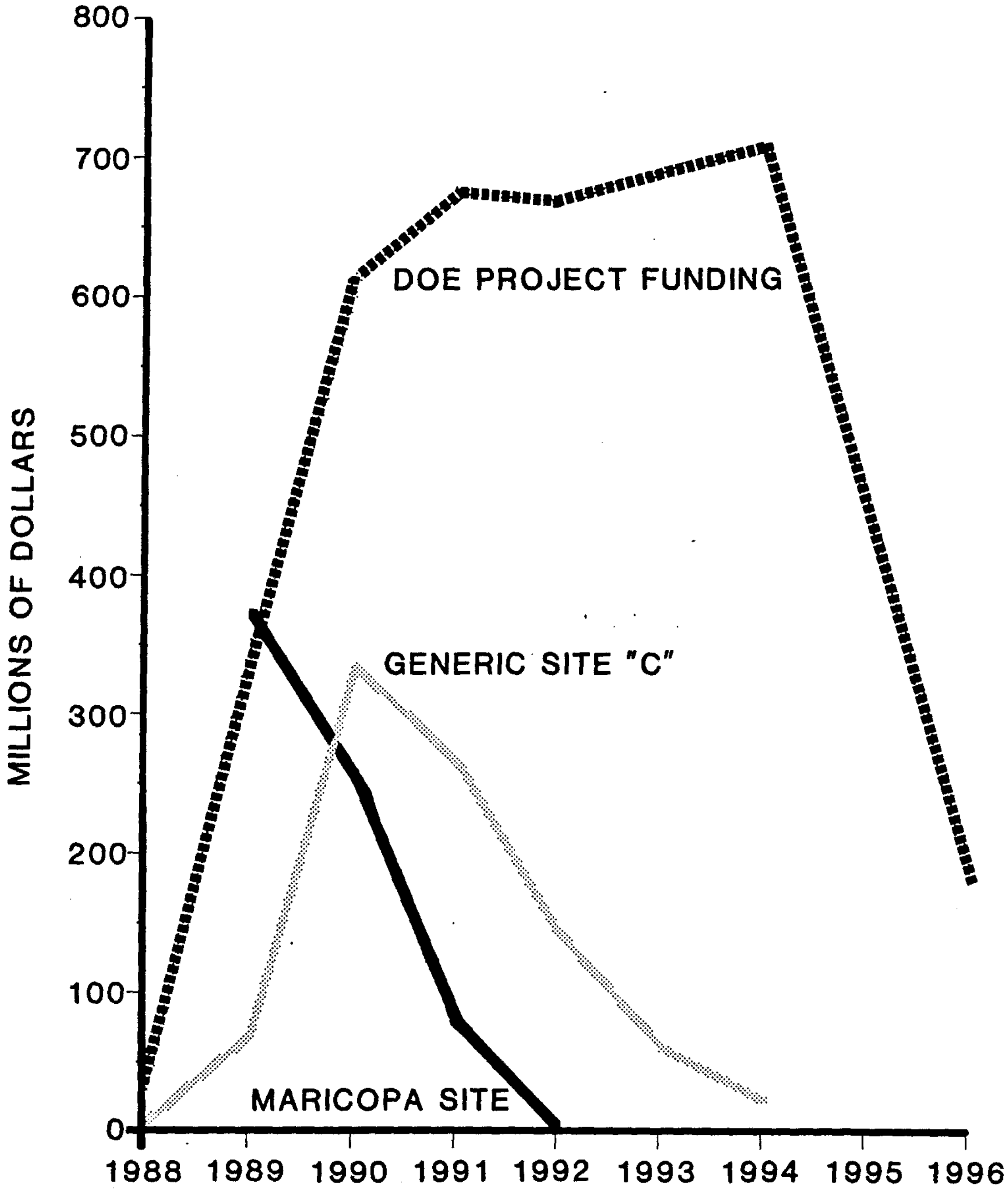


FIGURE 3-32
COMPARISON OF DOE AND MARICOPA SITE CONSTRUCTION EXPENDITURES

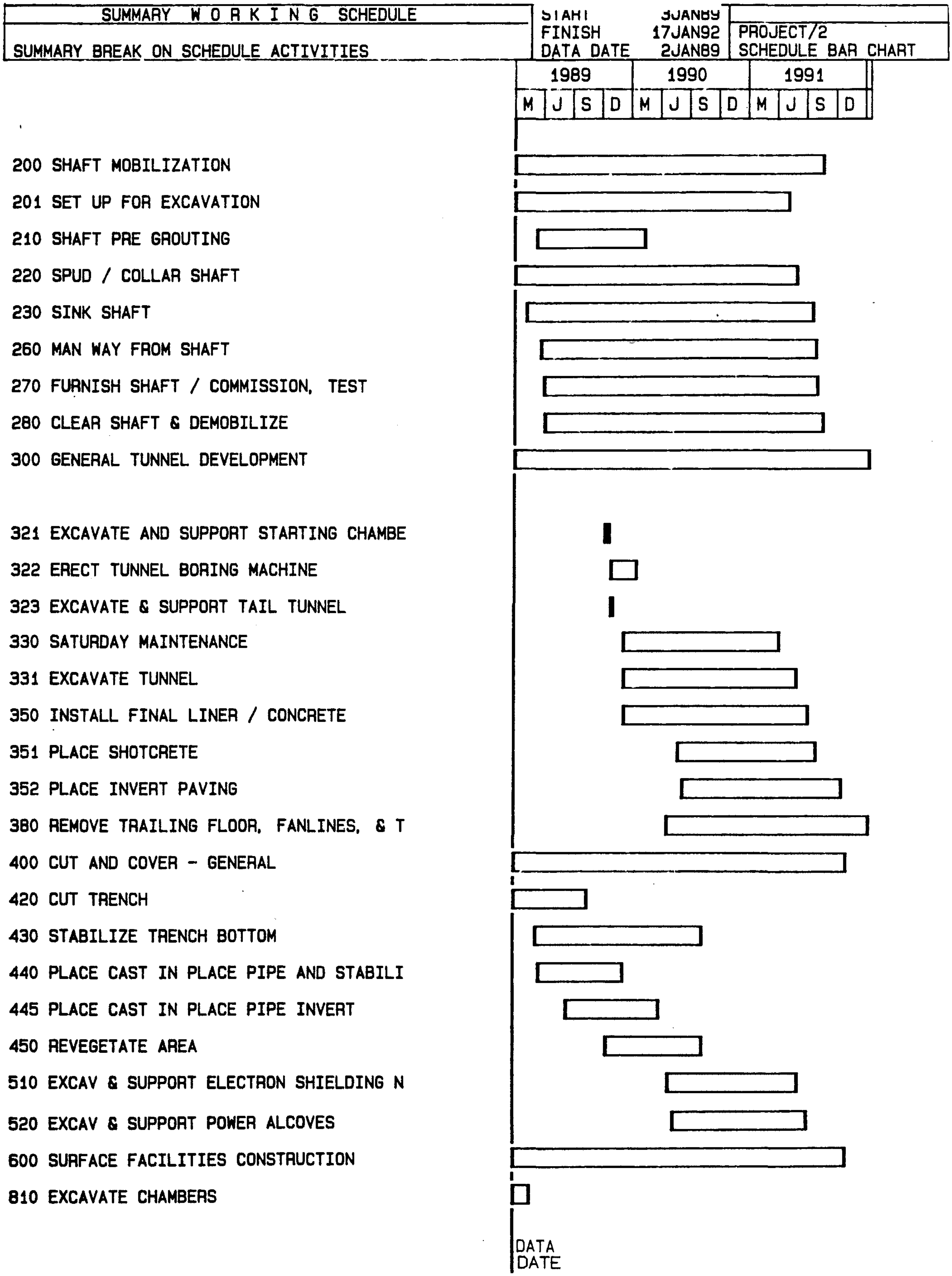


FIGURE 3-33

PROPOSED MARICOPA SSC SITE CONSTRUCTION SCHEDULE

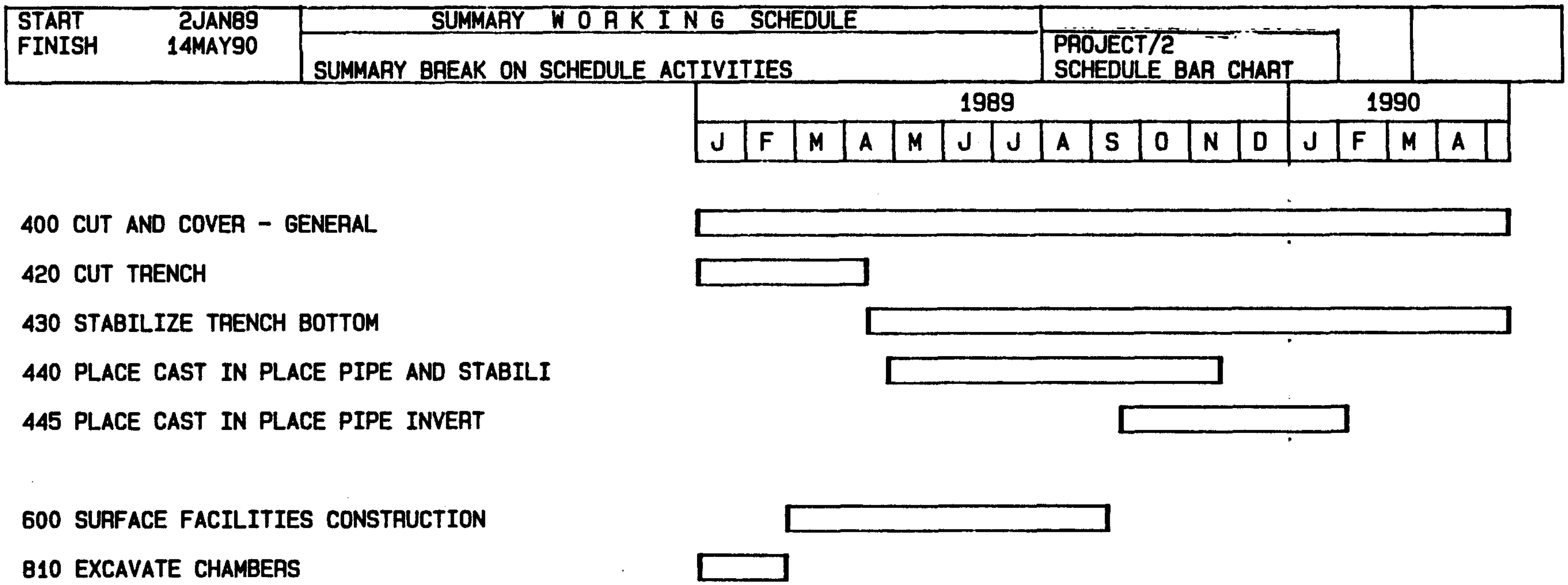


FIGURE 3-34
PROPOSED SCHEDULE FOR MARICOPA SSC SITE CUT-AND -FILL EXCAVATIONS

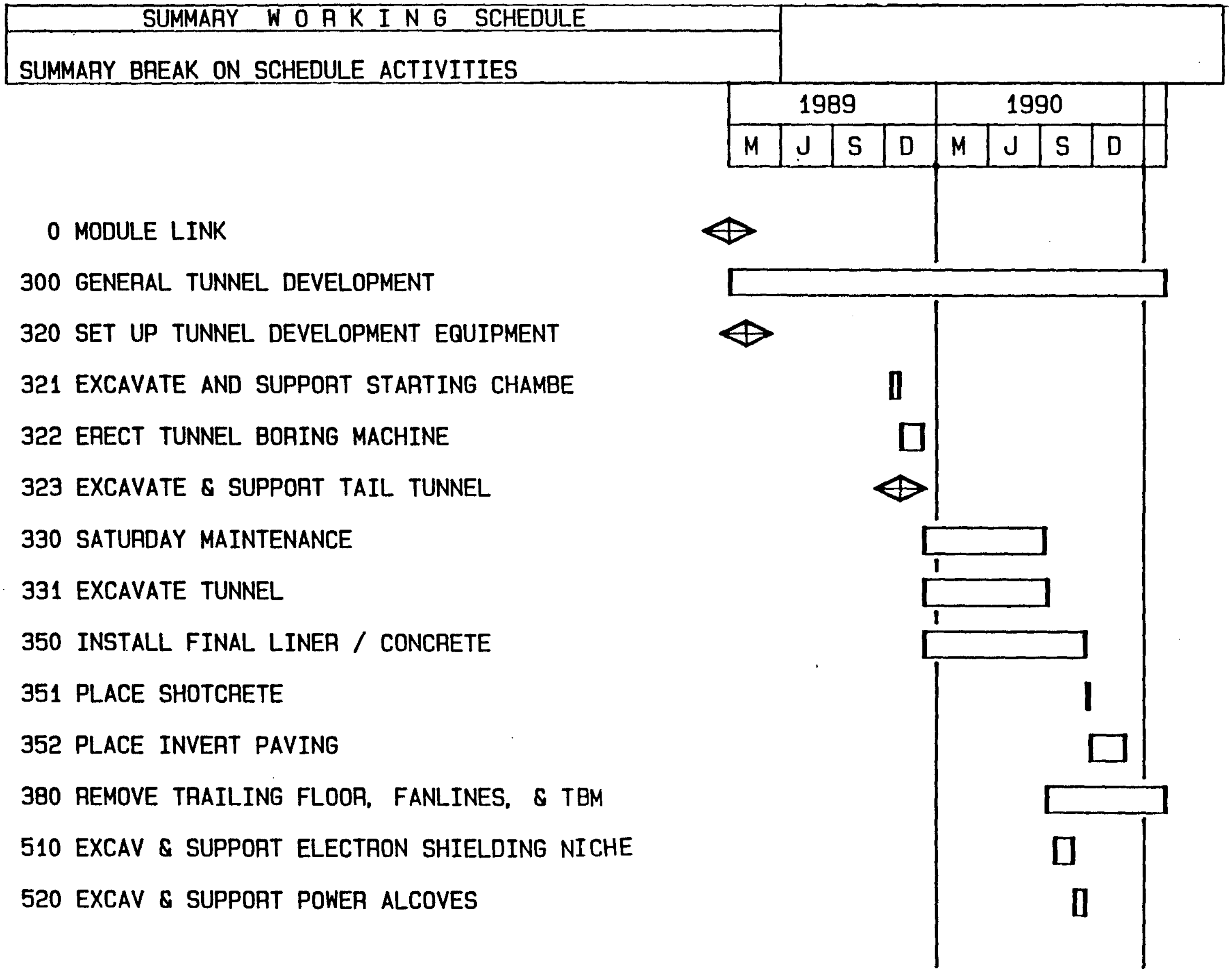


FIGURE 3-35
PROPOSED SCHEDULE FOR MARICOPA SSC SITE WEAK ROCK TUNNELING

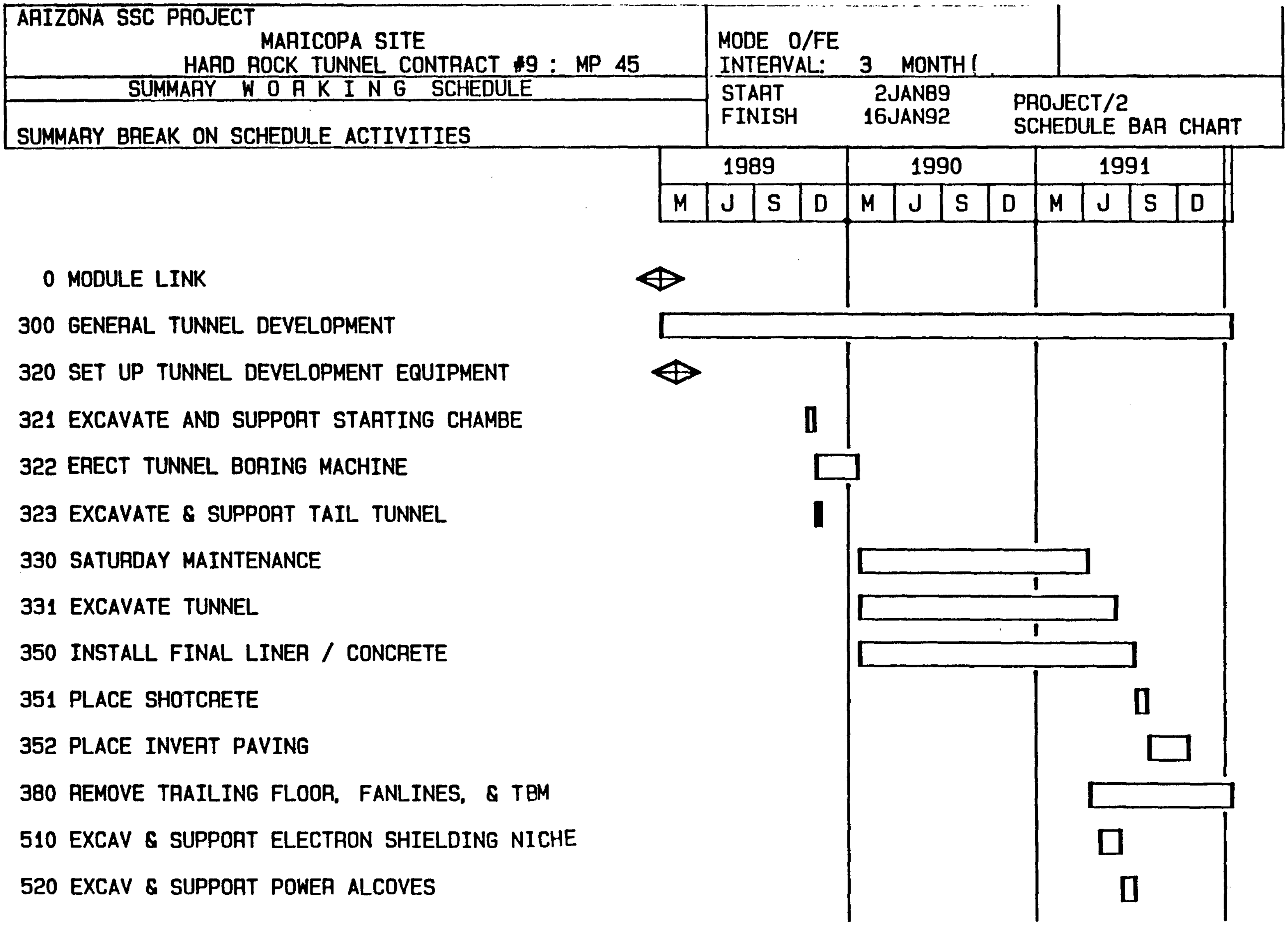


FIGURE 3-36

PROPOSED SCHEDULE FOR MARICOPA SSC SITE HARD ROCK TUNNELING

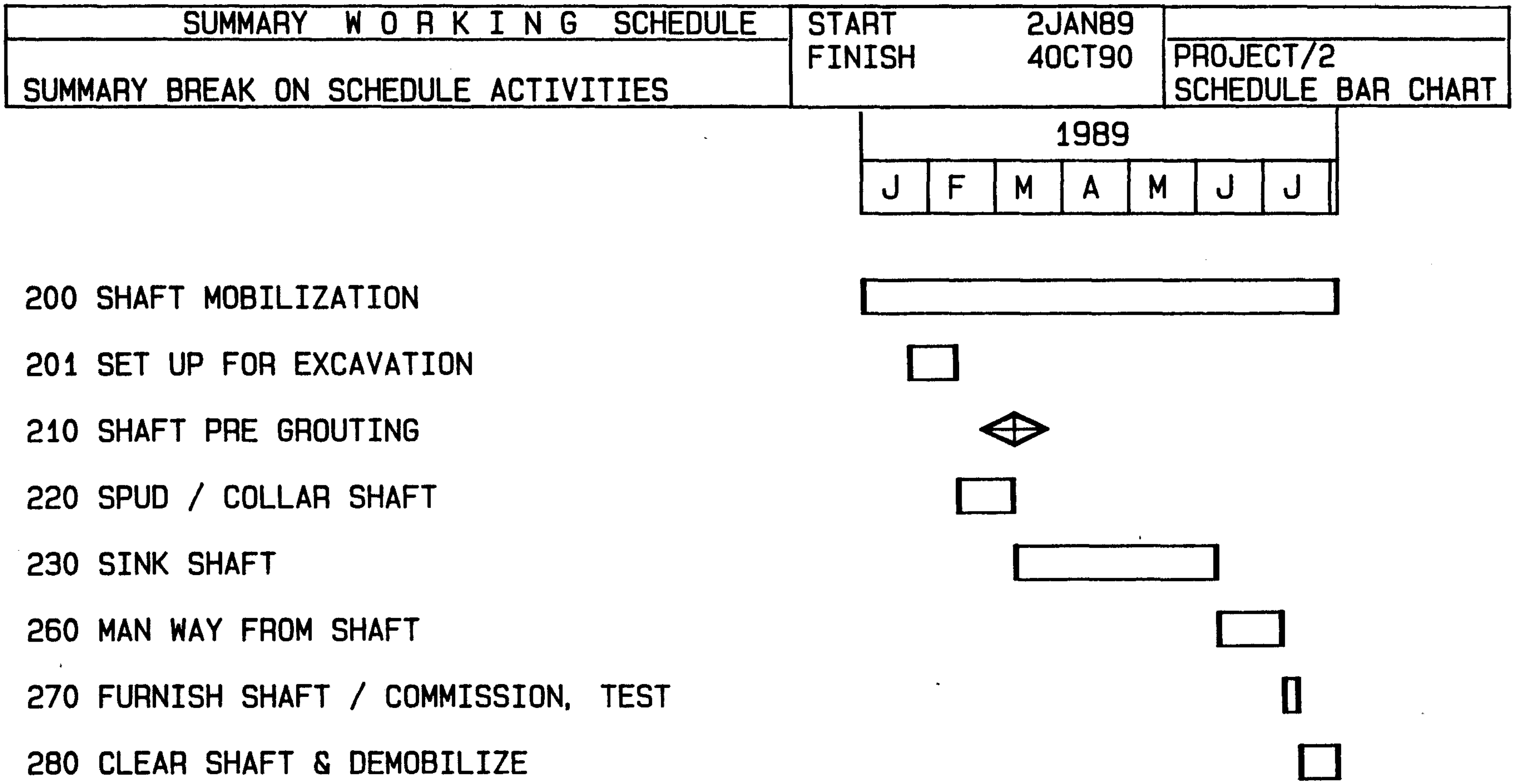


FIGURE 3-37
PROPOSED SCHEDULE FOR MARICOPA SITE SSC SHAFT CONSTRUCTION

Sufficient land to commence critical path construction at the Maricopa Site will be available at the start of the project (85% of the collider ring and the main campus by April, 1989 and the remaining lands by January, 1990; see Volume 6, Section 6.2), thus allowing the schedule to proceed without complications resulting from land acquisition delays. Schedule advantages provided by the Maricopa Site will permit construction to be completed two years sooner than the CDG generic site schedule, and meet all CDG beneficial occupancy goals. This allows more time for the magnets to be installed and still maintain the overall project schedule. It also allows magnets to be placed directly into the ring where they can be fine-tuned instead of being stored in a warehouse. If the magnets are ready the whole project could be shortened, allowing the experiments to be initiated two or more years sooner than the base estimate.

Because the project can use a staggered bid schedule additional advantage results from a shorter construction schedule. Construction bids can be let at intervals of four to six weeks. This reduces the load on the DOE design team, and allows all qualified contractors to bid on each section. Experience has shown that toward the end of the process bidding becomes more competitive with significant savings for the owner.

If funding for the project is delayed or reduced, the project can still be completed on time at the Maricopa Site, because of the flexibility afforded by the short construction schedule. If annual funding allocations are less than suggested by the CDG outline, construction can still continue and end on time at the Maricopa Site because construction costs are very low.

Low Risk Management. The innovative CU concept, flexibility in construction method applications, detailed heavy-construction estimates submitted with this site proposal (Appendix 3-B), supportive State of Arizona regulatory agencies, and cooperative trade union participation will permit construction at the Maricopa Site to take full advantage of Risk Management, Risk Sharing, Stimulation and Innovation, and other cost-saving principles detailed in Recommendations on Better Contracting for Underground Construction (USNCTT, 1976).

The Maricopa Site's low overall geotechnical contingency and readily characterized construction conditions indicate an uncommonly low risk for changes in construction conditions, thus allowing simplified changed-condition clauses and a reduced potential for litigation. An extension of these geotechnical advantages is that a short construction schedule combined with advance acquisition of the right-of-way will allow conventional SSC facilities to be constructed during the term of a single labor agreement. As a result, the risk of wage and price increases is reduced, and the possibility that no-strike and work-rule agreements may be concluded is thereby improved.

Heavy-construction estimates that evaluate alternative construction systems for the Maricopa Site provide benefits to DOE resulting from Alternative Bidding and Value Engineering proposals. These estimates will also permit DOE to let bids in a manner that minimizes risks associated with schedule delays. The advantages to DOE are threefold:

- the elimination of artificial shortages in materials and labor;
- the providing of newer equipment and increased productivity by permitting several manufacturers to share heavy equipment supply; and
- the reduction of contingency estimates as a result of more reliable estimating concepts.

Contract Packaging Concept. Arizona's supportive regulatory agencies and cooperative trade unions will allow innovations in bidding, bonding, and wrap-up insurance. The CU concept and the opportunity to substitute cut-and-fill for TBM tunneling on 63% of the site will permit the packaging of contracts to fit the bidding climate. CUs, for example, may be packaged to encourage contractors to bid single or multiple contracts. DOE can establish a structure of bid evaluation that will award the contract to the bid package containing the best combination of benefits. The application of contract packaging principles will also reduce premiums for bonding and public liability insurance. The State of Arizona can assist DOE in establishing a "Wrap-Up" insurance program.

3.5.5 LOCATION AND CAPACITY OF DISPOSAL SITES

Construction of the SSC at the Maricopa Site will produce 1,430,000 cubic yards of spoils. Since the Maricopa Site surrounds Wilderness Study Areas, the assumption is made that spoils will be transported to one of the dormant copper mines in the region and used for dust control and reclamation, so that the current environment of the Maricopa Site would not suffer unacceptable degradation (Scartaccini, 1987). A cost of $10 per cubic yard is budgeted for disposal of the spoils off-site (see Appendix 3-B).

The New Cornelia mine at Ajo is 60 miles south of the Maricopa Site. At current trucking rates of $0.09/ton-mile disposal at this location would cost $5.40/ton or $8.40/cubic yard. The Sacaton mine 50 miles east of the site near Casa Grande is also available for spoils disposal. Trucking costs are approximately $4.50/ton or $7.00/cubic yard. The Sacaton mine also allows the use of rail haulage at $5.50/ton or $8.50/cubic yard.

Alternatively, the spoils may be placed on-site inside the High Energy Booster (HEB) ring. The HEB has an area of 31,000,000 square feet or 700 acres. The full 1,430,000 cubic yards of spoils would cover this area to a depth of 1.25 feet. Haulage costs average less than $2.20/cubic yard. Reclamation costs are about $2,200,000 or $1.50/cubic yard. Trucking and reclamation costs total $3.70/cubic yard. If this option is selected, a portion of the savings generated by on-site disposal could be placed into a fund and used to stimulate and develop environmental programs in the region.

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APPENDIX 3-A

Maricopa Subsidence Report

Background. Theoretically, any overdraft of ground water in unconsolidated materials will result in some subsidence, but it is generally undetectable.

Two things can prevent land subsidence from ground-water withdrawal: (1) dewatering only non-compactible deposits, or (2) permitting ground-water declines less than some threshold value (where vertical effective stress exceeds preconsolidation stress) that initiates subsidence. In Arizona, water-table declines of 100 feet are thought to be sufficient to initiate noticeable subsidence. However, this relationship is site-specific, and subsidence has been measured in areas with only 50 feet of ground-water decline and undetected in areas with 150 feet of ground-water decline. The controlling factors are the characteristics of the material to be dewatered. Because of the difficulty and cost of determining these characteristics over so large an area and their costs, the chosen approach is to control the water-table decline. For this reason a ground-water decline of 50 feet over 40 years was used as the maximum allowable from milepost 0 to milepost 5 at the Maricopa SSC Site (see Figure 3A-1).

The following report addresses two questions related to concerns about potential subsidence at the Maricopa SSC Site. These are:

(1) Given that over a 40 year period pumping must be controlled around the site, what cumulative pumping rates can be tolerated, for the life of the project, without exceeding a conservative threshold water-table decline of 50 feet at the ring location?

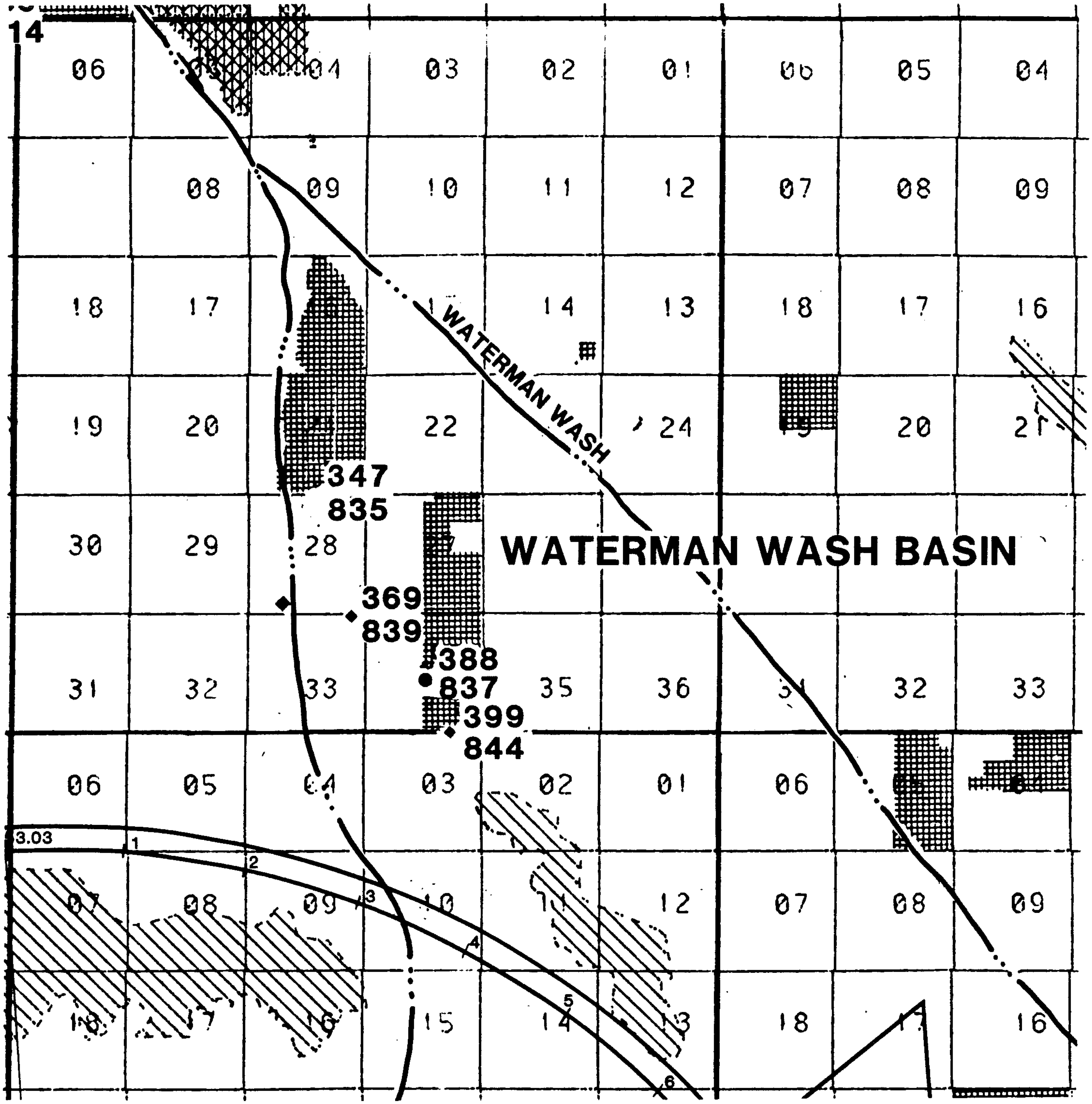
(2) Assuming current pumping practices in the Waterman Wash agriculture area continue and that they cannot be controlled until the "safe yield"[1] concept takes effect in 2025, how much water table decline will occur from SSC milepost 0 to milepost 5?

In determining projected water table declines for the northeastern sections of the Maricopa SSC site numerous conditions were assumed. These include: (1) that the pumping rate assumed will continue for the life of the projection, and, (2) all assumptions inherent in using the Theis solution apply.

The first assumption is reasonable because, at worst, pumping will continue at the same rate, but in reality pumping should decrease in the future as agriculture declines. Additionally, if these agricultural lands are converted to urban use, a savings of 50 to 75% in water use would be realized. Irrigated agriculture currently consumes more than 85% of the water used in Arizona.

The agreement with the Theis assumptions is considered adequate except for the concept that the aquifer is of infinite areal extent. Impermeable boundaries in the form of bedrock or clay deposits are a possibility in the area of

[1] Safe yield is that which occurs when ground-water withdrawal by pumping equals what is being recharged. Thus, no general lowering of the water table occurs.



LEGEND

300 1390 (1975) -WATER LEVEL DATA POINTS — DEPTH TO WATER / ELEVATION OF WATER TABLE (YEAR MEASURED*)

• -WATER QUALITY DATA

*DATA YEAR IS 1986 UNLESS NOTED OTHERWISE.

- IRRIGATED GROUNDWATER RIGHTS
- TYPE-1 GROUNDWATER RIGHTS
- HARD ROCK AREAS
- SECTION LINES
- TOWNSHIP RANGE LINES

NORTH

BASE MAPPING PRODUCED BY ARIZONA DEPARTMENT OF WATER RESOURCES GEOGRAPHIC INFORMATION SYSTEMS

SCALE 1:62500

0 1 2 MILES

FIGURE 3A-1
WELLS USED IN SUBSIDENCE STUDY

concern. However, possible occurrences of these boundaries are not thought to be close enough to greatly change the calculated values.

PROBLEM: To calculate the allowable volume and rate of ground water that could be pumped assuming certain specifications with regard to water table drawdown over a certain period of time.

THEORY: Because drawdown will be taken to be much less than the total aquifer height, we can use the Theis (1935) solution to calculate drawdown (S):

$$S = \frac{Q\,W(u)}{4\pi T}$$

$$\text{where } u = \frac{r^2 s}{4 T t}$$

T = transmissivity
s = specific yield
r = radius of cone of drawdown
t = time in days

solving for the pumping rate, Q,

$$Q = \frac{S\,4\pi T}{W(u)}$$

Transmissivities used were determined based on aquifer tests described in reports by the U.S. Geological Survey (Wilson, 1979) and the Arizona State Land Department (White, 1963).

Transmissivity, T, values ranging from 4,500 to 13,000 ft^2/day with an average value of 8000 ft^2/day was determined for the upper unit (the unit which would be dewatered) in the Waterman Wash Basin by the USGS. Toward the basin margins the values are generally seen to decrease as evidenced by 700 ft^2/day value found near the town of Mobile and the 800 ft^2/day value in the upper Bosque Basin near mile 32 of the ring. However a hole drilled at D-3-1 33ccc, which is only one mile north of mile 2 on the ring for the SSC project, encountered saturated material composed of a moderately sorted coarse sand and gravel with minor amounts of fines. Although no aquifer testing was done visual inspection of the material suggested a hydraulic conductivity (K) value of 25 to 65 ft/day. Assuming a 600 foot saturated zone (based on gravity modeling) this gives T values in the range of 15,000 to 69,000 ft^2/day. Of course the K value can be expected to decrease with depth effectively lowering the T value to better match those found elsewhere in the basin. To thoroughly cover the range of possible values, a worst case of T= 600 ft^2/day, a reasonable case of T= 8,000 ft^2/day, and a best case of 20,000 ft^2/day will be used in the calculations.

Specific Yields, s, have been estimated by the USGS and private consultants working in the area to be .10. This value is generally considered low. In these calculations values of .05, .10, and .25 are used.

SAMPLE CALCULATION:

Consider r = 1 mile or 5280 feet

Case 1: (worst case scenario)

$T = 600\ ft^2/day \qquad s = .05$

Basic Equation:

$$S = \frac{Q\ W(u)}{4\pi T}$$

$$u = \frac{r^2 s}{4\ T\ t}$$

$$u = \frac{(5280\ ft)^2(.05)}{4\ (600\ ft^2/day)(14600\ days)}$$

$$u = .039$$

$$W(u) = 2.70$$

$$Q = \frac{S\ 4\pi T}{W(u)} \quad \text{then}$$

$$Q = \frac{50\ ft\ (4)\ (600\ ft^2/day)}{2.70}$$

$$Q = 139{,}600\ ft^3/day \text{ or } 725\ gpm$$

The results using the various conditions are as seen in Table 1.

Table 1

Allowable Pumping Rates
(in gpm)

	1/2 mile[1]	1 mile[1]	2 miles[1]	5 miles[1]
Worst-Case Scenario[2]	483	725	1379	8742
Reasonable-Case Scenario[3]	4400	5738	8159	17,883
Best-Case Scenario[4]	11,007	14,346	20,656	44,104

[1] - distance from centroid of pumping
[2] - worst case is T = 600 ft^2/day and s = .05
[3] - reasonable case is T = 8000 ft^2/day and s = .10
[4] - best case is T = 20,000 ft^2/day and s = .25

Currently there are only five large production wells in operation within five miles of the northeast section of the ring and these are all from 1.5 miles to three miles away from the ring. Their total 1986 pumping rate amounted to 2450 gpm. Even under a worst-case scenario these wells are a marginal concern at worst. Combining the indications that aquifer properties do not match those of the worst-case scenario along with the continuing decline in agriculture in the area, subsidence from ground water decline is not considered a potential threat.

Water Level Drawdowns Along the SSC Alignment Caused by Existing Wells

The second part of this study concerns the potential water-level declines from existing wells within seven miles of the mile 0 to mile 5 section. See Figure 3A-1 for location of the wells. The analyses will use both the wells' maximum possible pumping rate and their most recent (1986) pumping rates for a 40 year period. As previously mentioned there are only five producing (>35 gpm) wells within seven miles of the northwest (mile 0 to mile 5) section of the ring. The following data summarizes existing well data:

Table 2

Well Designation	Max. Yield (gpm)	Withdrawal in 1986 (acre-feet)	Distance from Tunnel (miles)	Distance from summation point, (X)* (miles)
21DCC1	3000	730	~3	~3.25
28CDD	2100	521	~2	~2.25
28DDD	3700	834	~2	~2.25
34ACC	2600	755	~1.75	~1.75
34DCD	3450	1100	~1.3	~1.4

*X - distance from well to point X on map. Point X was determined to be the point along the tunnel alignment where the sum of all the wells' drawdown would be greatest.

Summary of results:

For each well, drawdowns in feet were calculated using the Theis (1935) solution. Drawdowns were calculated, at the summation point X, using a specific yield of .10 and transmissivities of 600 ft^2/day and 8000 ft^2/day.

Table 3

Well	Drawdowns assuming max. pumping rates[1] (feet)		Drawdowns assuming 1986 actual pumping rates[1] (feet)	
	W[2]	R[3]	W[2]	R[3]
21 DCC1	22	13	3	2
28 CDD	37	12	6	2
28 DDD	66	21	9	3
34 ACC	70	17	13	3
34 DCD	128	25	25	5
Total	323	88	56	15

Explanation:
[1] - pumping rates continuous for 40 years
[2] W - worst-case scenario, T = 600 ft^2/day, s = .10
[3] R - reasonable-case scenario, T = 8000 ft^2/day, s = .10

As the results in Table 3 show, using the current pumping rates, which are expected to decrease in the future, even assuming the worst-case aquifer parameters, the maximum drawdown would be only 56 feet. These results combined with the generally coarse, granular nature of the aquifer indicate that subsidence will not pose any future hazard to the region.

The worst-case scenario, which assumes unusually low transmissivity and the theoretical maximum pumping rate, suggests a potential problem. Future geotechnical and hydrological work is planned which will better identify the regional aquifer properties. If conditions warrant it, the State is fully prepared to purchase the land and retire the water rights.

APPENDIX 3-B

ESTIMATED PROJECT COSTS AND SCHEDULES

TABLE OF CONTENTS

APPENDIX 3-B

TABLE OF CONTENTS (Continued)

1.0 MODEL DISCUSSION

In order to evaluate the potential of the Maricopa Site in a national competition, a review of the construction feasibility was needed. This review process, initiated in October 1985, was conducted by a primary Site Selection Team composed of a selected panel of U.S. underground construction experts. The Site Review Team included: Dr. Ron Heuer, Mr. Ian Hynd, Mr. Terry McCusker, Mr. Robert Miller, Dr. Charles R. Nelson, Dr. Roy Scott, and Mr. P.E. Sperry. Quantitative geologic, geotechnical, surface construction, and underground tunneling information was collected for the Maricopa Site. This data was used to develop the site specific construction cost and schedule estimate alternatives for each Construction Unit at the Maricopa Site. These detailed alternatives formed the basis of a sophisticated computer model which was used to estimate cost and develop schedules for the project.

The computer model developed for the Arizona SSC Project is termed a Decision Support System (DSS). The DSS provides a framework for quantifying the consequences of changes in construction conditions, design, operating methods, schedule requirements, resource allocation and availability, productivity, and economic and financial indicators. It was used to understand and rank the impact of alternative construction methods on the overall Maricopa Site project schedule. This system provided a structure allowing the Arizona SSC Project Team to focus on construction methods that would allow the shortest project schedule with the lowest project cost. Over the past two years this system allowed the project team to evaluate various alternative sites within the state.

Any project has the most freedom of action at the outset when there is the least information. The DSS allowed a uniform evaluation of alternatives in enough detail to define site specific project constraints. The result was to focus the project on construction methods with the greatest cost and schedule flexibility for site specific ground conditions. The system allowed numerous alternatives to be evaluated with limited time and budget available for evaluation while maintaining a high level of detail, and complete integration of cost and schedule.

The DSS is analogous to a recording studio used by a musical group. The tracks of the record (modules) are developed independently, each containing a specific aspect of the song such as the percussion instruments (set of variables). The tracks are combined by the mixer (alternative cases) in slightly different combinations (master option schedule) until a good tonal blend is found. Alternative paths generate different cases by combining different modules or updating the existing information within a module. Iteration paths modify parameters set by the master schedule to create a different case. One typical parameter would be excavation rate.

The DSS developed for Arizona's SSC program has evolved over the past 10 years on various mining projects. It has been used to evaluate strategic and tactical design, operating, and development decisions. The DSS is based upon proven project control software commercially developed, sold, and maintained. Project control software integrates costs, schedule, and resource allocation and provides the capability to analyze alternatives. These were key features for developing a Decision Support System. Project/2 software developed by Project

Software Development Incorporated (PSDI) is the basis for the Arizona SSC Decision Support System.

During early design stages DSS "what if" questions relate to evaluating basic alternatives to achieving a goal. In contrast, project control "what if" questions relate to evaluating consequences of alternate manpower or funding levels, or other resource constraints for a project whose construction methods have been fixed. Examples of DSS types of questions are: what are the manpower, cash flow, and schedule implications of using a TBM system with preformed concrete segments instead of using cut and fill techniques.

Systematic heavy-construction estimates for each Construction Unit were the basic input for Arizona's model.

Arizona's model allows total integration of cost and schedule with summation of cost and schedule by contract as well as by sector. Arizona's model can monitor up to 99 geological and geotechnical conditions for both ground support and instantaneous penetration rate of the tunneling machine for each tunnel contract regardless of the sectors that the tunnel crosses. This allows an accurate evaluation of the impact of changing geotechnical conditions as well as a realistic definition of contract lengths by economic, geologic, and topographic considerations. Another benefit of this approach is the ability to reliably evaluate the merits of alternative construction methods as they apply to individual contracts and to the project as a whole. Sensitivity of the project to innovations was accurately quantified and demonstrated showing the benefits of Arizona's construction conditions.

The number of data manipulations run during the analysis gives an idea of the level of detail of the model developed for the Arizona project. For the current model there are: 4000 activities, 350 summary cost elements, 800 cost accounts, three primary excavation methods, two development advance rates, 500 resources and six identified cases for a ten year period. The schedule module makes about 33 million data manipulations for the eight cases. The cost model makes an additional 92 million data manipulations for the six cases. A primary cost model takes about 3.5 CPU hours to run on a VAX 8600 computer. The model currently allows construction contracts to be designed without regard to changing sector boundaries while tracking cost and schedule for varying geologic and depth conditions.

The DSS was used to develop the best case for the Maricopa site.

Construction costs were entered in a number of ways depending on the level of detail available. Site specific heavy construction type estimates were developed for TBM and cut-and-fill tunnel construction, for shaft construction, and for surface buildings. Examples of the Project/2 output and of the input details are given in this appendix.

2.0 TOTAL PROJECT COSTS DEVELOPED ON PROJECT/2

2.1 Total Project Costs Grouped by Construction Activity, Totaled for the Project

This report details the total cost of Conventional Facilities Construction using the Central Design Group's Work Breakdown Structure. Costs are detailed by year, and grouped by activity. Costs are totaled for the project at the end of the report. This total is the Direct Cost referred to in Volume 3.

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
1000000	ARIZONA SSC							
902121000	CONSTRUCTION SUPPORT							
		1JAN89 TO 31DEC89	964000	0	0	0	0	964000
21210.00	**TOTAL** CONSTRUCTION SUPPORT		964000	0	0	0	0	964000
911200000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3269376	0	0	3269376
		1JAN90 TO 31DEC90	0	0	2052864	0	0	2052864
912412A	**TOTAL** TUNNEL ACCESS		0	0	5322240	0	0	5322240
911210000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912412B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
911220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	2393207	0	495874	4123944	7013025
912412C	**TOTAL** TBM TUNNEL EXCAVATION		0	2393207	0	495874	4123944	7013025
911230000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	639644	0	3101984	0	3741628
912412D	**TOTAL** TBM TUNNEL SUPPORT		0	639644	0	3101984	0	3741628
911240000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	376827	0	23919	0	400746
912412E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	376827	0	23919	0	400746
911320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	240030	0	45661	371155	656845
		1JAN91 TO 31DEC91	0	85566	0	15285	123718	224569
912413C	**TOTAL** TBM TUNNEL EXCAVATION		0	325596	0	60946	494873	881415
911330000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	73705	0	372205	0	445910
912413D	**TOTAL** TBM TUNNEL SUPPORT		0	73705	0	372205	0	445910
911340000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	43020	0	2730	0	45750
912413E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
911400000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3269376	0	0	3269376
		1JAN90 TO 31DEC90	0	0	2052864	0	0	2052864
912414A	**TOTAL** TUNNEL ACCESS		0	0	5322240	0	0	5322240
911420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1062354	0	218603	2074270	3355227
912414C	**TOTAL** TBM TUNNEL EXCAVATION		0	1062354	0	218603	2074270	3355227
911430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	265338	0	1364478	0	1629816
912414D	**TOTAL** TBM TUNNEL SUPPORT		0	265338	0	1364478	0	1629816
911440000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	47844	0	3108	0	50952
		1JAN91 TO 31DEC91	0	124236	0	7812	0	132048
912414E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	172080	0	10920	0	183000
912120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	2238902	0	458400	3488455	6185758
		1JAN91 TO 31DEC91	0	171450	0	37764	290705	499919
912421C	**TOTAL** TBM TUNNEL EXCAVATION		0	2410352	0	496165	3779160	6685677
912130000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	574899	0	3099759	0	3674658
912421D	**TOTAL** TBM TUNNEL SUPPORT		0	574899	0	3099759	0	3674658
912140000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	345768	0	21966	0	367734
		1JAN92 TO 31DEC92	0	31059	0	1953	0	33012
912421E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	376827	0	23919	0	400746
912200000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	9049221	0	0	9049221
		1JAN90 TO 31DEC90	0	0	5682069	0	0	5682069
912422A	**TOTAL** TUNNEL ACCESS		0	0	14731290	0	0	14731290
912210000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	233870	0	25285	0	259155

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912422B	**TOTAL** TBM SET UP CHAMBER		0	233870	0	25285	0	259155
912220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1833372	0	746927	7039933	9620232
		1JAN91 TO 31DEC91	0	1450550	0	373976	3132789	4957315
912422C	**TOTAL** TBM TUNNEL EXCAVATION		0	3283922	0	1120903	10172722	14577546
912230000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	1825009	0	5688649	0	7513658
912422D	**TOTAL** TBM TUNNEL SUPPORT		0	1825009	0	5688649	0	7513658
912240000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	846041	0	54945	0	900986
		1JAN92 TO 31DEC92	0	144942	0	9114	0	154056
912422E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	990983	0	64059	0	1055042
912320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	468920	0	119489	923995	1512404
912423C	**TOTAL** TBM TUNNEL EXCAVATION		0	468920	0	119489	923995	1512404
912330000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	158319	0	683307	0	841626
912423D	**TOTAL** TBM TUNNEL SUPPORT		0	158319	0	683307	0	841626
912340000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	91978	0	6420	0	98398
912423E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	91978	0	6420	0	98398
912420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1638986	0	331029	2655524	4625538
		1JAN91 TO 31DEC91	0	445770	0	96751	784586	1327107
912424C	**TOTAL** TBM TUNNEL EXCAVATION		0	2084756	0	427780	3440110	5952646
912430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	501194	0	2666114	0	3167308
912424D	**TOTAL** TBM TUNNEL SUPPORT		0	501194	0	2666114	0	3167308
912440000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	333807	0	21189	0	354996

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912424E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	333807	0	21189	0	354996
913100000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	2043360	0	0	2043360
		1JAN90 TO 31DEC90	0	0	1283040	0	0	1283040
912431A	**TOTAL** TUNNEL ACCESS		0	0	3326400	0	0	3326400
913120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	239871	0	49591	471425	760887
912431C	**TOTAL** TBM TUNNEL EXCAVATION		0	239871	0	49591	471425	760887
913130000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	58964	0	310064	0	369028
912431D	**TOTAL** TBM TUNNEL SUPPORT		0	58964	0	310064	0	369028
913140000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	31059	0	1953	0	33012
912431E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750
913400000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	5020809	0	0	5020809
		1JAN90 TO 31DEC90	0	0	3152601	0	0	3152601
912434A	**TOTAL** TUNNEL ACCESS		0	0	8173410	0	0	8173410
913410000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912434B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
913420000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	422645	0	88791	680249	1191685
912434C	**TOTAL** TBM TUNNEL EXCAVATION		0	422645	0	88791	680249	1191685
913430000	TBM TUNNEL SUPPORT							
		1JAN91 TO 31DEC91	0	153191	0	559631	0	712822
912434D	**TOTAL** TBM TUNNEL SUPPORT		0	153191	0	559631	0	712822
913440000	TBM TUNNEL FIT AND C							
		1JAN91 TO 31DEC91	0	75687	0	4809	0	80496

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912434E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	75687	0	4809	0	80496
914100000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	3502866	0	0	3502866
		1JAN90 TO 31DEC90	0	0	2199474	0	0	2199474
912441A	**TOTAL** TUNNEL ACCESS		0	0	5702340	0	0	5702340
914110000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912441B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
914120000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	782531	0	144130	1360023	2286684
912441C	**TOTAL** TBM TUNNEL EXCAVATION		0	782531	0	144130	1360023	2286684
914130000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	14741	0	82621	0	97362
		1JAN91 TO 31DEC91	0	247418	0	788358	0	1035776
912441D	**TOTAL** TBM TUNNEL SUPPORT		0	262159	0	870979	0	1133138
914140000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	96393	0	6111	0	102504
912441E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	108354	0	6888	0	115242
914220000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	1096644	0	175211	2239987	3511842
912442C	**TOTAL** TBM TUNNEL EXCAVATION		0	1096644	0	175211	2239987	3511842
914230000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	191633	0	992273	0	1183906
912442D	**TOTAL** TBM TUNNEL SUPPORT		0	191633	0	992273	0	1183906
914240000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	35883	0	2331	0	38214
		1JAN91 TO 31DEC91	0	82824	0	5208	0	88032
912442E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	118707	0	7539	0	126246

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
914300000	TUNNEL ACCESS							
		1JAN89 TO 31DEC89	0	0	1297353	0	0	1297353
		1JAN90 TO 31DEC90	0	0	814617	0	0	814617
912443A	**TOTAL** TUNNEL ACCESS		0	0	2111970	0	0	2111970
914310000	TBM SET UP CHAMBER							
		1JAN90 TO 31DEC90	0	101439	0	11401	0	112840
912443B	**TOTAL** TBM SET UP CHAMBER		0	101439	0	11401	0	112840
914320000	TBM TUNNEL EXCAVATIO							
		1JAN90 TO 31DEC90	0	331258	0	54331	699996	1085585
912443C	**TOTAL** TBM TUNNEL EXCAVATION		0	331258	0	54331	699996	1085585
914330000	TBM TUNNEL SUPPORT							
		1JAN90 TO 31DEC90	0	183974	0	313874	0	497848
912443D	**TOTAL** TBM TUNNEL SUPPORT		0	183974	0	313874	0	497848
914340000	TBM TUNNEL FIT AND C							
		1JAN90 TO 31DEC90	0	11961	0	777	0	12738
		1JAN91 TO 31DEC91	0	31059	0	1953	0	33012
912443E	**TOTAL** TBM TUNNEL FIT AND COMMISSION		0	43020	0	2730	0	45750
921200000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	392154	0	36666	0	428820
922412A	**TOTAL** ELECTRON SHIELDING NICHE		0	392154	0	36666	0	428820
921300000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	499002	0	43146	0	542148
922413A	**TOTAL** ELECTRON SHIELDING NICHE		0	499002	0	43146	0	542148
921400000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	168066	0	15714	0	183780
		1JAN91 TO 31DEC91	0	295320	0	25272	0	320592
922414A	**TOTAL** ELECTRON SHIELDING NICHE		0	463386	0	40986	0	504372
922100000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	392154	0	36666	0	428820
922421A	**TOTAL** ELECTRON SHIELDING NICHE		0	392154	0	36666	0	428820

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
922200000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	1049082	0	96138	0	1145220
922422A	**TOTAL** ELECTRON SHIELDING NICHE		0	1049082	0	96138	0	1145220
922300000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	516810	0	44226	0	561036
922423A	**TOTAL** ELECTRON SHIELDING NICHE		0	516810	0	44226	0	561036
922400000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	398090	0	37026	0	435116
922424A	**TOTAL** ELECTRON SHIELDING NICHE		0	398090	0	37026	0	435116
923100000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	93370	0	8730	0	102100
922431A	**TOTAL** ELECTRON SHIELDING NICHE		0	93370	0	8730	0	102100
923400000	ELECTRON SHIELDING N							
		1JAN91 TO 31DEC91	0	74696	0	6984	0	81680
922434A	**TOTAL** ELECTRON SHIELDING NICHE		0	74696	0	6984	0	81680
924100000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	37348	0	3492	0	40840
		1JAN91 TO 31DEC91	0	93370	0	8730	0	102100
922441A	**TOTAL** ELECTRON SHIELDING NICHE		0	130718	0	12222	0	142940
924200000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	130718	0	12222	0	142940
922442A	**TOTAL** ELECTRON SHIELDING NICHE		0	130718	0	12222	0	142940
924300000	ELECTRON SHIELDING N							
		1JAN90 TO 31DEC90	0	37348	0	3492	0	40840
922443A	**TOTAL** ELECTRON SHIELDING NICHE		0	37348	0	3492	0	40840
931200000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	261436	0	59444	0	320880
932412A	**TOTAL** POWER ALCOVE		0	261436	0	59444	0	320880
931300000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	209618	0	40734	0	250352

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN92 TO 31DEC92	0	123050	0	23030	0	146080
932413A	**TOTAL** POWER ALCOVE		0	332668	0	63764	0	396432
931400000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	130718	0	29722	0	160440
		1JAN91 TO 31DEC91	0	196880	0	36848	0	233728
932414A	**TOTAL** POWER ALCOVE		0	327598	0	66570	0	394168
932100000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	242762	0	55198	0	297960
932421A	**TOTAL** POWER ALCOVE		0	242762	0	55198	0	297960
932200000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	726554	0	159262	0	885816
932422A	**TOTAL** POWER ALCOVE		0	726554	0	159262	0	885816
932300000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	319930	0	59878	0	379808
932423A	**TOTAL** POWER ALCOVE		0	319930	0	59878	0	379808
932400000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	267372	0	59804	0	327176
932424A	**TOTAL** POWER ALCOVE		0	267372	0	59804	0	327176
933100000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	74696	0	16984	0	91680
932431A	**TOTAL** POWER ALCOVE		0	74696	0	16984	0	91680
933400000	POWER ALCOVE							
		1JAN91 TO 31DEC91	0	37348	0	8492	0	45840
932434A	**TOTAL** POWER ALCOVE		0	37348	0	8492	0	45840
934100000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	18674	0	4246	0	22920
		1JAN91 TO 31DEC91	0	74696	0	16984	0	91680
932441A	**TOTAL** POWER ALCOVE		0	93370	0	21230	0	114600
934200000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	93370	0	21230	0	114600

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
932442A	**TOTAL** POWER ALCOVE		0	93370	0	21230	0	114600
934300000	POWER ALCOVE							
		1JAN90 TO 31DEC90	0	37348	0	8492	0	45840
932443A	**TOTAL** POWER ALCOVE		0	37348	0	8492	0	45840
941100000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	75756	294213
924113A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	75756	294213
941110000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	56064	0	0	0	56064
		1JAN90 TO 31DEC90	0	52080	0	0	0	52080
924113B	**TOTAL** SHAFT SET UP		0	108144	0	0	0	108144
941130000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	25824	0	228850	52424	307098
		1JAN90 TO 31DEC90	0	136056	0	182020	28667	346743
924113D	**TOTAL** SHAFT COLLAR		0	161880	0	410870	81091	653841
941140000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	0	0	15730	3932	19662
		1JAN90 TO 31DEC90	0	262477	0	428350	164722	855549
924113E	**TOTAL** SHAFT SINKING		0	262477	0	444080	168654	875211
941150000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	0	0	4000	1000	5000
		1JAN90 TO 31DEC90	0	32588	0	8517	4214	45319
924113F	**TOTAL** SHAFT FURNISHING		0	32588	0	12517	5214	50319
941160000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	121572	0	41634	30822	194028
924113G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	121572	0	41634	30822	194028
941170000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	0	0	121000	30250	151250
		1JAN90 TO 31DEC90	0	302745	0	256409	72678	631832
924113H	**TOTAL** SHAFT MANWAY/DRIFT		0	302745	0	377409	102928	783082

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
941300000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	34115	93390	143781	97398	368684
924133A	**TOTAL** SHAFT MOBILIZATION		0	34115	93390	143781	97398	368684
941310000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	136176	0	0	0	136176
924133B	**TOTAL** SHAFT SET UP		0	136176	0	0	0	136176
941320000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
924133C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920
941330000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	161880	0	270870	46091	478841
924133D	**TOTAL** SHAFT COLLAR		0	161880	0	270870	46091	478841
941340000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	1237786	0	695637	255496	2188919
		1JAN90 TO 31DEC90	0	459800	0	233052	75326	768178
924133E	**TOTAL** SHAFT SINKING		0	1697586	0	928690	330822	2957098
941350000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	28392	0	16053	9561	54006
		1JAN90 TO 31DEC90	0	65320	0	36311	16976	118607
924133F	**TOTAL** SHAFT FURNISHING		0	93712	0	52364	26537	172613
941360000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	52626	0	25090	16138	93854
		1JAN90 TO 31DEC90	0	52626	0	25090	16138	93854
924133G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	50180	32276	187708
941370000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	73485	0	138106	19460	231051
		1JAN90 TO 31DEC90	0	177450	0	239015	52174	468639
924133H	**TOTAL** SHAFT MANWAY/DRIFT		0	250935	0	377121	71634	699690
941400000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	66434	140085	227503	152262	586284

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924143A	**TOTAL** SHAFT MOBILIZATION		0	66434	140085	227503	152262	586284
941410000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	84096	0	0	0	84096
		1JAN90 TO 31DEC90	0	130200	0	0	0	130200
924143B	**TOTAL** SHAFT SET UP		0	214296	0	0	0	214296
941420000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
		1JAN90 TO 31DEC90	0	920	0	0	0	920
924143C	**TOTAL** SHAFT PRE-GROUT		0	1840	0	0	0	1640
941430000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	90384	0	135495	26136	252015
		1JAN90 TO 31DEC90	0	142992	0	238768	39910	421670
924143D	**TOTAL** SHAFT COLLAR		0	233376	0	374262	66046	673684
941440000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	636870	0	710710	295125	1642705
		1JAN90 TO 31DEC90	0	1420710	0	1296477	367900	3085087
924143E	**TOTAL** SHAFT SINKING		0	2057580	0	2007187	663025	4727792
941450000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	185816	0	79416	43794	309026
924143F	**TOTAL** SHAFT FURNISHING		0	185816	0	79416	43794	309026
941460000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	157878	0	70997	47686	276561
924143G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	157878	0	70997	47686	276561
941470000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	134862	0	160133	34783	329777
		1JAN90 TO 31DEC90	0	126186	0	355073	54196	535455
924143H	**TOTAL** SHAFT MANWAY/DRIFT		0	261048	0	515206	88979	865233
942100000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	75756	294213
924213A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	75756	294213

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
942110000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	160224	0	0	0	160224
924213B	**TOTAL** SHAFT SET UP		0	160224	0	0	0	160224
942130000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	144788	46695	551240	156538	899261
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924213D	**TOTAL** SHAFT COLLAR		0	235172	46695	686735	182674	1151275
942140000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	775675	0	524760	215661	1516096
		1JAN90 TO 31DEC90	0	432212	0	261508	116159	809879
924213E	**TOTAL** SHAFT SINKING		0	1207887	0	786268	331820	2325975
942150000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	64066	0	60874	26936	151878
		1JAN90 TO 31DEC90	0	27588	0	16102	7508	51196
924213F	**TOTAL** SHAFT FURNISHING		0	91654	0	76976	34446	203076
942160000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	105252	0	45094	30822	181168
		1JAN90 TO 31DEC90	0	52626	0	21320	15411	89357
924213G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	157878	0	66414	46233	270525
942170000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	127764	0	746111	154670	1028545
		1JAN90 TO 31DEC90	0	83202	0	197250	55900	336352
924213H	**TOTAL** SHAFT MANWAY/DRIFT		0	210966	0	943361	210570	1364897
942200000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
924223A	**TOTAL** SHAFT MOBILIZATION		0	1796	46695	60738	37878	147107
942210000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	95136	0	0	0	95136
924223B	**TOTAL** SHAFT SET UP		0	95136	0	0	0	95136
942220000	SHAFT PRE-GROUT							
		1JAN90 TO 31DEC90	0	920	0	0	0	920

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924223C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920
942230000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	122703	46695	362238	120655	652291
		1JAN90 TO 31DEC90	0	71496	0	119384	19955	210835
924223D	**TOTAL** SHAFT COLLAR		0	194199	46695	481622	140610	863126
942240000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	0	0	46260	11565	57825
		1JAN90 TO 31DEC90	0	1770988	0	1109376	461911	3342275
924223E	**TOTAL** SHAFT SINKING		0	1770988	0	1155636	473476	3400100
942250000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	0	0	15200	3800	19000
		1JAN90 TO 31DEC90	0	53590	0	21611	12736	87937
924223F	**TOTAL** SHAFT FURNISHING		0	53590	0	36811	16536	106937
942260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	105252	0	45404	31502	182158
924223G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	45404	31502	182158
942270000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	0	0	121000	30250	151250
		1JAN90 TO 31DEC90	0	126336	0	336438	75360	538134
924223H	**TOTAL** SHAFT MANWAY/DRIFT		0	126336	0	457438	105610	689364
942300000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	34115	93390	143781	95418	366704
924233A	**TOTAL** SHAFT MOBILIZATION		0	34115	93390	143781	95418	366704
942310000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	84096	0	0	0	84096
		1JAN90 TO 31DEC90	0	52080	0	0	0	52080
924233B	**TOTAL** SHAFT SET UP		0	136176	0	0	0	136176
942320000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
924233C	**TOTAL** SHAFT PRE-GROUT		0	920	0	0	0	920

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
942330000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	90384	0	135495	26136	252015
		1JAN90 TO 31DEC90	0	71496	0	119384	19955	210835
924233D	**TOTAL** SHAFT COLLAR		0	161880	0	254879	46091	462850
942340000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	717288	0	606815	189260	1513363
		1JAN90 TO 31DEC90	0	661365	0	504924	172879	1339168
924233E	**TOTAL** SHAFT SINKING		0	1378653	0	1111739	362139	2852531
942350000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	96001	0	49365	25221	170587
924233F	**TOTAL** SHAFT FURNISHING		0	96001	0	49365	25221	170587
942360000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	105252	0	50180	32275	187707
924233G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	50180	32275	187707
942370000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	134862	0	153727	32952	321541
		1JAN90 TO 31DEC90	0	106470	0	225235	36567	368272
924233H	**TOTAL** SHAFT MANWAY/DRIFT		0	241332	0	378962	69519	689813
942400000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	3591	93390	121476	73776	292233
924243A	**TOTAL** SHAFT MOBILIZATION		0	3591	93390	121476	73776	292233
942410000	SHAFT SET UP							
		1JAN89 TO 31DEC89	0	52080	0	0	0	52080
		1JAN90 TO 31DEC90	0	4672	0	0	0	4672
924243B	**TOTAL** SHAFT SET UP		0	56752	0	0	0	56752
942420000	SHAFT PRE-GROUT							
		1JAN89 TO 31DEC89	0	920	0	0	0	920
		1JAN90 TO 31DEC90	0	920	0	0	0	920
924243C	**TOTAL** SHAFT PRE-GROUT		0	1840	0	0	0	1840
942430000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	71496	0	434384	98705	604585

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924243D	**TOTAL** SHAFT COLLAR		0	161880	0	569879	124841	856600
942440000	SHAFT SINKING							
		1JAN89 TO 31DEC89	0	318435	0	420833	134490	873758
		1JAN90 TO 31DEC90	0	57960	0	0	0	57960
924243E	**TOTAL** SHAFT SINKING		0	376395	0	420833	134490	931718
942450000	SHAFT FURNISHING							
		1JAN89 TO 31DEC89	0	24495	0	39614	13675	77784
		1JAN90 TO 31DEC90	0	36784	0	21133	9854	67771
924243F	**TOTAL** SHAFT FURNISHING		0	61279	0	60747	23529	145555
942460000	SHAFT CLEAN UP & DEM							
		1JAN89 TO 31DEC89	0	52626	0	20817	15411	88854
		1JAN90 TO 31DEC90	0	52626	0	20817	15365	88808
924243G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	105252	0	41634	30776	177662
942470000	SHAFT MANWAY/DRIFT							
		1JAN89 TO 31DEC89	0	56784	0	597571	133095	787450
		1JAN90 TO 31DEC90	0	212940	0	282939	65511	561390
924243H	**TOTAL** SHAFT MANWAY/DRIFT		0	269724	0	880510	198606	1348840
943210000	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	56064	0	0	0	56064
924323B	**TOTAL** SHAFT SET UP		0	56064	0	0	0	56064
943230000	SHAFT COLLAR							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924323D	**TOTAL** SHAFT COLLAR		0	92180	46695	196233	64014	399121
943240000	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	156332	0	72619	40386	269337
924323E	**TOTAL** SHAFT SINKING		0	156332	0	72619	40386	269337
943250000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	9196	0	7045	3284	19525

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
924323F	**TOTAL** SHAFT FURNISHING		0	9196	0	7045	3284	19525
943260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	52626	0	21320	15411	89357
924323G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	52626	0	21320	15411	89357
943270000	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	83202	0	197250	55900	336352
924323H	**TOTAL** SHAFT MANWAY/DRIFT		0	83202	0	197250	55900	336352
944200000	SHAFT MOBILIZATION							
		1JAN89 TO 31DEC89	0	1796	46695	60738	37878	147107
924425A	**TOTAL** SHAFT MOBILIZATION		0	1796	46695	60738	37878	147107
944210000	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	56064	0	0	0	56064
924425B	**TOTAL** SHAFT SET UP		0	56064	0	0	0	56064
944230000	SHAFT COLLAR							
		1JAN90 TO 31DEC90	0	90384	0	135495	26136	252015
924425D	**TOTAL** SHAFT COLLAR		0	90384	0	135495	26136	252015
944240000	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	51520	0	0	0	51520
924425E	**TOTAL** SHAFT SINKING		0	51520	0	0	0	51520
944250000	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	27588	0	24135	11274	62997
924425F	**TOTAL** SHAFT FURNISHING		0	27588	0	24135	11274	62997
944260000	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	13800	0	0	0	13800
924425G	**TOTAL** SHAFT CLEAN UP & DEMOB		0	13800	0	0	0	13800
944270000	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	141302	0	289387	52174	482863
924425H	**TOTAL** SHAFT MANWAY/DRIFT		0	141302	0	289387	52174	482863

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
971000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	4438	56215	0	8491	69144
912431X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	4438	56215	0	8491	69144
971100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	362	966	0	186	1514
		1JAN90 TO 31DEC90	0	17875	51722	0	9743	79340
912431Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	18237	52687	0	9929	80853
971200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	117786	75082	0	57670	250538
912431Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	117786	75082	0	57670	250538
971300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	26214	6553	32767
912431W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	26214	6553	32767
972000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	17430	220782	0	33350	271562
912432X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	17430	220782	0	33350	271562
972100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1811	4828	0	929	7568
		1JAN90 TO 31DEC90	0	73474	210910	0	39814	324197
912432Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	75284	215738	0	40743	331765
972200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	588931	375408	0	288350	1252689
912432Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	588931	375408	0	288350	1252689
972300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	131076	32769	163845
912432W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	131076	32769	163845
973000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	23386	296219	0	44745	364349
912433X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	23386	296219	0	44745	364349

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
973100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1931	5150	0	991	8072
		1JAN90 TO 31DEC90	0	94349	272902	0	51415	418665
912433Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	96280	278051	0	52406	426737
973200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	628193	400435	0	307573	1336201
912433Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	628193	400435	0	307573	1336201
973300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	139815	34954	174769
912433W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	139815	34954	174769
974000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	15632	198007	0	29909	243548
912434X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	15632	198007	0	29909	243548
974100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	845	2253	0	434	3531
		1JAN90 TO 31DEC90	0	59281	173404	0	32576	265260
912434Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	60126	175656	0	33009	268791
974200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	274835	175190	0	134563	584588
912434Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	274835	175190	0	134563	584588
974300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	61170	15293	76463
912434W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	61170	15293	76463
977000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	18101	229275	0	34633	282008
912443X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	18101	229275	0	34633	282008
977100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1448	3862	0	744	6054
		1JAN90 TO 31DEC90	0	72633	210290	0	39609	322532
912443Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	74081	214153	0	40353	328587

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977200000	CUT & COVER TUNNEL P							
		1JAN90 TO 31DEC90	0	471145	300326	0	230680	1002151
9124432	**TOTAL** CUT & COVER TUNNEL PIPE		0	471145	300326	0	230680	1002151
977300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	104818	26205	131023
912443W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	104818	26205	131023
978000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	16726	211865	0	32003	260594
912444X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	16726	211865	0	32003	260594
978100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	1931	5150	0	991	8072
		1JAN90 TO 31DEC90	0	72151	206308	0	38984	317444
912444Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	74082	211458	0	39976	325516
978200000	CUT & COVER TUNNEL P							
		1JAN90 TO 31DEC90	0	628193	400435	0	307573	1336201
912444Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	628193	400435	0	307573	1336201
978300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	139815	34954	174769
912444W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	139815	34954	174769
981000000	CUT & COVER TUNNEL E							
		1JAN89 TO 31DEC89	0	58645	742836	0	112207	913688
912411X	**TOTAL** CUT & COVER TUNNEL EXCAVATION		0	58645	742836	0	112207	913688
981100000	CUT & COVER TUNNEL B							
		1JAN89 TO 31DEC89	0	6035	16092	0	3098	25224
		1JAN90 TO 31DEC90	0	246725	708469	0	133727	1088921
912411Y	**TOTAL** CUT & COVER TUNNEL BACKFILL		0	252759	724561	0	136825	1114145
981200000	CUT & COVER TUNNEL P							
		1JAN89 TO 31DEC89	0	1635920	1042800	0	800971	3479691
		1JAN90 TO 31DEC90	0	327184	208560	0	160194	695938
912411Z	**TOTAL** CUT & COVER TUNNEL PIPE		0	1963104	1251360	0	961165	4175629

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981300000	CUT & COVER REVEGETA							
		1JAN90 TO 31DEC90	0	0	0	436920	109230	546150
912411W	**TOTAL** CUT & COVER REVEGETATION		0	0	0	436920	109230	546150
992131000	MAIN CAMPUS UTILITIE							
		1JAN89 TO 31DEC89	157347	0	0	0	0	157347
		1JAN90 TO 31DEC90	314695	0	0	0	0	314695
21310.00	**TOTAL** MAIN CAMPUS UTILITIES		472042	0	0	0	0	472042
992142000	ELECTRICAL DISTRIBUT							
		1JAN89 TO 31DEC89	19635000	0	0	0	0	19635000
		1JAN90 TO 31DEC90	19635000	0	0	0	0	19635000
21420.00	**TOTAL** ELECTRICAL DISTRIBUTION		39270000	0	0	0	0	39270000
992151100	WATER/WASTE WATER DI							
		1JAN89 TO 31DEC89	1393750	0	0	0	0	1393750
		1JAN90 TO 31DEC90	4181250	0	0	0	0	4181250
21511.00	**TOTAL** WATER/WASTE WATER DISTRIBUTION		5575000	0	0	0	0	5575000
992171000	AUX SYSTEMS GENERAL							
		1JAN90 TO 31DEC90	10245000	0	0	0	0	10245000
21710.00	**TOTAL** AUX SYSTEMS GENERAL		10245000	0	0	0	0	10245000
992181100	SITE WORK - CAMPUS R							
		1JAN90 TO 31DEC90	12882000	0	0	0	0	12882000
21811.00	**TOTAL** SITE WORK - CAMPUS ROADS		12882000	0	0	0	0	12882000
992210000	LAB BUILDING							
		1JAN89 TO 31DEC89	12632690	0	0	0	0	12632690
		1JAN90 TO 31DEC90	6167140	0	0	0	0	6167140
22100.00	**TOTAL** LAB BUILDING		18799830	0	0	0	0	18799830
992221000	HVY WORKS BUILD I -							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923
22210.00	**TOTAL** HVY WORKS BUILD I - GENERAL		1399923	0	0	0	0	1399923
992222000	HVY WORKS BUILD II -							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
22220.00	**TOTAL** HVY WORKS BUILD II - GENERAL		1399923	0	0	0	0	1399923
992223000	HVY WORKS BUILD III							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22230.00	**TOTAL** HVY WORKS BUILD III - GENERAL		899976	0	0	0	0	899976
992224000	HVY WORKS BUILD IV -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22240.00	**TOTAL** HVY WORKS BUILD IV - GENERAL		899976	0	0	0	0	899976
992225000	HVY WORKS BUILD V -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22250.00	**TOTAL** HVY WORKS BUILD V - GENERAL		899976	0	0	0	0	899976
992226000	HVY WORKS BUILD VI -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22260.00	**TOTAL** HVY WORKS BUILD VI - GENERAL		899976	0	0	0	0	899976
992231000	SHOP BUILD I - GENER							
		1JAN89 TO 31DEC89	499968	0	0	0	0	499968
22310.00	**TOTAL** SHOP BUILD I - GENERAL		499968	0	0	0	0	499968
992232000	SHOP BUILD II - GENE							
		1JAN89 TO 31DEC89	400050	0	0	0	0	400050
22320.00	**TOTAL** SHOP BUILD II - GENERAL		400050	0	0	0	0	400050
992233000	SHOP BUILD III - GEN							
		1JAN89 TO 31DEC89	400050	0	0	0	0	400050
22330.00	**TOTAL** SHOP BUILD III - GENERAL		400050	0	0	0	0	400050
992241000	WAREHOUSE I - GENERA							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923
22410.00	**TOTAL** WAREHOUSE I - GENERAL		1399923	0	0	0	0	1399923
992242000	WAREHOUSE II - GENER							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923
22420.00	**TOTAL** WAREHOUSE II - GENERAL		1399923	0	0	0	0	1399923

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992243000	FIRE/SITE/RESCUE - G							
		1JAN89 TO 31DEC89	400008	0	0	0	0	400008
22430.00	**TOTAL** FIRE/SITE/RESCUE - GENERAL		400008	0	0	0	0	400008
992244000	VEHICLE SERVICE - GE							
		1JAN89 TO 31DEC89	299964	0	0	0	0	299964
22440.00	**TOTAL** VEHICLE SERVICE - GENERAL		299964	0	0	0	0	299964
992246000	HELIPAD - GENERAL							
		1JAN89 TO 31DEC89	34020	0	0	0	0	34020
22460.00	**TOTAL** HELIPAD - GENERAL		34020	0	0	0	0	34020
992311017	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	915	11592	0	1751	14258
23110.17	**TOTAL** LINAC TUNNEL/ENCLOSURE - EXCAV		0	915	11592	0	1751	14258
992311018	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	36734	23416	0	17985	78135
23110.18	**TOTAL** LINAC TUNNEL/ENCLOSURE - PIPIN		0	36734	23416	0	17985	78135
992311019	LINAC TUNNEL/ENCLOSU							
		1JAN90 TO 31DEC90	0	2418	6449	0	1241	10108
		1JAN91 TO 31DEC91	0	1838	5514	0	1029	8382
23110.19	**TOTAL** LINAC TUNNEL/ENCLOSURE - BACKF		0	4256	11963	0	2271	18490
992311020	LINAC TUNNEL/ENCLOSU							
		1JAN91 TO 31DEC91	0	0	0	8176	2044	10220
23110.20	**TOTAL** LINAC TUNNEL/ENCLOSURE - REVEG		0	0	0	8176	2044	10220
992315016	LINAC - ELECTRICAL							
		1JAN89 TO 31DEC89	123183	35100	2645	45270	0	206198
23150.16	**TOTAL** LINAC - ELECTRICAL		123183	35100	2645	45270	0	206198
992316015	LINAC MECHANICAL - M							
		1JAN89 TO 31DEC89	176517	30755	3112	8218	8417	227019
23160.15	**TOTAL** LINAC MECHANICAL - MECHANICAL		176517	30755	3112	8218	8417	227019
992321018	LEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	3134	8358	0	1609	13102

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN91 TO 31DEC91	0	50380	151141	0	28213	229734
23210.18	**TOTAL** LEB TUNNEL/ENCLOSURE - BACK FI		0	53515	159499	0	29822	242836
992321019	LEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	60826	38773	0	29782	129381
23210.19	**TOTAL** LEB TUNNEL/ENCLOSURE - PIPING		0	60826	38773	0	29782	129381
992321020	LEB TUNNEL/ENCLOSURE							
		1JAN91 TO 31DEC91	0	0	0	13541	3385	16926
23210.20	**TOTAL** LEB TUNNEL/ENCLOSURE - REVEGET		0	0	0	13541	3385	16926
992323030	SHAFT MOBILIZATION							
		1JAN91 TO 31DEC91	0	8978	233475	303690	189390	735533
23230.30	**TOTAL** SHAFT MOBILIZATION		0	8978	233475	303690	189390	735533
992323031	SHAFT SET UP							
		1JAN91 TO 31DEC91	0	260400	0	0	0	260400
23230.31	**TOTAL** SHAFT SET UP		0	260400	0	0	0	260400
992323033	SHAFT COLLAR							
		1JAN91 TO 31DEC91	0	417060	0	438755	99775	955590
23230.33	**TOTAL** SHAFT COLLAR		0	417060	0	438755	99775	955590
992323034	SHAFT SINKING							
		1JAN91 TO 31DEC91	0	1714650	0	267969	10725	1993344
23230.34	**TOTAL** SHAFT SINKING		0	1714650	0	267969	10725	1993344
992323035	SHAFT FURNISHING							
		1JAN91 TO 31DEC91	0	163300	0	14820	8732	186852
		1JAN92 TO 31DEC92	0	40825	0	3705	2183	46713
23230.35	**TOTAL** SHAFT FURNISHING		0	204125	0	18525	10915	233565
992323036	SHAFT CLEAN UP & DEM							
		1JAN91 TO 31DEC91	0	210504	0	90188	61644	362336
		1JAN92 TO 31DEC92	0	52626	0	22547	15411	90584
23230.36	**TOTAL** SHAFT CLEAN UP & DEMOB		0	263130	0	112735	77055	452920
992323037	SHAFT MANWAY/DRIFT							
		1JAN91 TO 31DEC91	0	269724	0	649542	90813	1010079

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		1JAN92 TO 31DEC92	0	14196	0	46396	6487	67079
23230.37	**TOTAL** SHAFT MANWAY/DRIFT		0	283920	0	695938	97300	1077158
992324101	LEB PS BUILD - COMPO							
		1JAN91 TO 31DEC91	481140	0	0	0	0	481140
		1JAN92 TO 31DEC92	139725	0	0	0	0	139725
23241.01	**TOTAL** LEB PS BUILD - COMPOSITE		620865	0	0	0	0	620865
992325016	LEB ELECTRICAL - ELE							
		1JAN89 TO 31DEC89	247373	76770	5779	89589	0	419511
23250.16	**TOTAL** LEB ELECTRICAL - ELECTRICAL		247373	76770	5779	89589	0	419511
992326015	LEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	50333	8821	949	0	2247	62350
23260.15	**TOTAL** LEB MECHANICAL - MECHANICAL		50333	8821	949	0	2247	62350
992331017	MEB TUNNEL/ENCLOSURE							
		1JAN89 TO 31DEC89	0	31081	393688	0	59468	484236
		1JAN90 TO 31DEC90	0	30009	380113	0	57417	467539
23310.17	**TOTAL** MEB TUNNEL/ENCLOSURE - EXCAV		0	61090	773801	0	116885	951775
992331018	MEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	91518	266596	0	50136	408250
		1JAN91 TO 31DEC91	0	125631	376892	0	70353	572876
23310.18	**TOTAL** MEB TUNNEL/ENCLOSURE - BFILL		0	217148	643488	0	120489	981126
992331019	MEB TUNNEL/ENCLOSURE							
		1JAN90 TO 31DEC90	0	463412	295397	0	226893	985702
23310.19	**TOTAL** MEB TUNNEL/ENCLOSURE - PIPE		0	463412	295397	0	226893	985702
992331020	MEB TUNNEL/ENCLOSURE							
		1JAN91 TO 31DEC91	0	0	0	103139	25785	128923
23310.20	**TOTAL** MEB TUNNEL/ENCLOSURE - REVEG		0	0	0	103139	25785	128923
992332017	MEB TO HEB TUNNEL -							
		1JAN89 TO 31DEC89	0	18508	234433	0	35412	288353
23320.17	**TOTAL** MEB TO HEB TUNNEL - EXCAVATION		0	18508	234433	0	35412	288353

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992332018 MEB TO HEB TUNNEL -							
	1JAN89 TO 31DEC89	0	739	1970	0	379	3089
	1JAN90 TO 31DEC90	0	67961	199733	0	37477	305171
23320.18 **TOTAL** MEB TO HEB TUNNEL - BACK FILL		0	68700	201704	0	37856	306260
992332019 MEB TO HEB TUNNEL -							
	1JAN89 TO 31DEC89	0	240183	153102	0	117597	510882
23320.19 **TOTAL** MEB TO HEB TUNNEL - PIPING		0	240183	153102	0	117597	510882
992332020 MEB TO HEB TUNNEL -							
	1JAN90 TO 31DEC90	0	0	0	53458	13365	66823
23320.20 **TOTAL** MEB TO HEB TUNNEL - REVEG		0	0	0	53458	13365	66823
992333030 SHAFT MOBILIZATION							
	1JAN91 TO 31DEC91	0	10773	280170	364428	227268	882639
23330.30 **TOTAL** SHAFT MOBILIZATION		0	10773	280170	364428	227268	882639
992333031 SHAFT SET UP							
	1JAN91 TO 31DEC91	0	312480	0	0	0	312480
23330.31 **TOTAL** SHAFT SET UP		0	312480	0	0	0	312480
992333033 SHAFT COLLAR							
	1JAN91 TO 31DEC91	0	500472	0	526506	119730	1146708
23330.33 **TOTAL** SHAFT COLLAR		0	500472	0	526506	119730	1146708
992333034 SHAFT SINKING							
	1JAN91 TO 31DEC91	0	1935105	0	302223	12104	2249432
	1JAN92 TO 31DEC92	0	122475	0	19030	766	142271
23330.34 **TOTAL** SHAFT SINKING		0	2057580	0	321252	12870	2391702
992333035 SHAFT FURNISHING							
	1JAN91 TO 31DEC91	0	163300	0	14820	8732	186852
	1JAN92 TO 31DEC92	0	81650	0	7410	4366	93426
23330.35 **TOTAL** SHAFT FURNISHING		0	244950	0	22230	13098	280278
992333036 SHAFT CLEAN UP & DEM							
	1JAN91 TO 31DEC91	0	210504	0	90188	61644	362336
	1JAN92 TO 31DEC92	0	105252	0	45094	30822	181168

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WBS NUMBER / DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
23330.36 **TOTAL** SHAFT CLEAN UP & DEMOB		0	315756	0	135282	92466	543504
992333037 SHAFT MANWAY/DRIFT							
	1JAN91 TO 31DEC91	0	269724	0	649542	90813	1010079
	1JAN92 TO 31DEC92	0	70980	0	185583	25947	282510
23330.37 **TOTAL** SHAFT MANWAY/DRIFT		0	340704	0	835126	116760	1292590
992334100 MEB SURFACE BUILDING							
	1JAN91 TO 31DEC91	434988	0	0	0	0	434988
	1JAN92 TO 31DEC92	246168	0	0	0	0	246168
23341.00 **TOTAL** MEB SURFACE BUILDINGS		681156	0	0	0	0	681156
992335016 MEB ELECTRICAL - ELE							
	1JAN89 TO 31DEC89	879387	336600	25389	310453	0	1551829
23350.16 **TOTAL** MEB ELECTRICAL - ELECTRICAL		879387	336600	25389	310453	0	1551829
992336003 MEB MECHANICAL - MEC							
	1JAN89 TO 31DEC89	2718	1463	280	800	509	5770
23360.03 **TOTAL** MEB MECHANICAL - MECHANICAL		2718	1463	280	800	509	5770
992336015 MEB MECHANICAL - MEC							
	1JAN89 TO 31DEC89	3747644	1158505	145323	903419	441449	6396340
23360.15 **TOTAL** MEB MECHANICAL - MECHANICAL		3747644	1158505	145323	903419	441449	6396340
992341017 HEB TUNNEL/ENCLOSURE							
	1JAN89 TO 31DEC89	0	69670	882483	0	133301	1085455
23410.17 **TOTAL** HEB TUNNEL/ENCLOSURE - EXCAVAT		0	69670	882483	0	133301	1085455
992341018 HEB TUNNEL/ENCLOSURE							
	1JAN90 TO 31DEC90	0	274909	799606	0	150432	1224946
23410.18 **TOTAL** HEB TUNNEL/ENCLOSURE - EXCAVAT		0	274909	799606	0	150432	1224946
992341019 HEB TUNNEL/ENCLOSURE							
	1JAN90 TO 31DEC90	0	1462512	932263	0	716068	3110844
23410.19 **TOTAL** HEB TUNNEL/ENCLOSURE - BACK FI		0	1462512	932263	0	716068	3110844
992341020 HEB TUNNEL/ENCLOSURE							
	1JAN91 TO 31DEC91	0	0	0	325510	81378	406888

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23410.20	**TOTAL** HEB TUNNEL/ENCLOSURE - REVEG		0	0	0	325510	81378	406888
992342117	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	35573	450593	0	68063	554230
23421.17	**TOTAL** HEB TO COL TUNNEL - EXCAVATION		0	35573	450593	0	68063	554230
992342118	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	1977	5272	0	1015	8264
		1JAN90 TO 31DEC90	0	140878	412252	0	77438	630568
23421.18	**TOTAL** HEB TO COL TUNNEL - BACKFILL		0	142855	417524	0	78453	638832
992342119	HEB TO COL TUNNEL -							
		1JAN89 TO 31DEC89	0	642917	409820	0	314782	1367519
23421.19	**TOTAL** HEB TO COL TUNNEL - PIPING		0	642917	409820	0	314782	1367519
992342120	HEB TO COL TUNNEL -							
		1JAN90 TO 31DEC90	0	0	0	143091	35773	178864
23421.20	**TOTAL** HEB TO COL TUNNEL - REVEG		0	0	0	143091	35773	178864
992342121	HEB TO COL TUNNEL -							
		1JAN90 TO 31DEC90	2966376	0	0	0	0	2966376
23421.21	**TOTAL** HEB TO COL TUNNEL - SURF BUILD		2966376	0	0	0	0	2966376
992343031	SHAFT SET UP							
		1JAN90 TO 31DEC90	0	355965	233475	303690	189390	1082520
23430.31	**TOTAL** SHAFT SET UP		0	355965	233475	303690	189390	1082520
992343033	SHAFT COLLAR							
		1JAN90 TO 31DEC90	0	384224	46695	588343	155077	1174339
		1JAN91 TO 31DEC91	0	64560	0	46645	8712	119917
23430.33	**TOTAL** SHAFT COLLAR		0	448784	46695	634988	163789	1294256
992343034	SHAFT SINKING							
		1JAN90 TO 31DEC90	0	465405	0	224494	9570	699469
		1JAN91 TO 31DEC91	0	287055	0	290169	117204	694428
23430.34	**TOTAL** SHAFT SINKING		0	752460	0	514664	126774	1393898
992343035	SHAFT FURNISHING							
		1JAN90 TO 31DEC90	0	65320	0	14820	8732	88872

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		1JAN91 TO 31DEC91	0	25526	0	19815	9691	55032
23430.35	**TOTAL** SHAFT FURNISHING		0	90846	0	34635	18423	143904
992343036	SHAFT CLEAN UP & DEM							
		1JAN90 TO 31DEC90	0	210504	0	90188	61644	362336
		1JAN91 TO 31DEC91	0	105252	0	45097	30822	181171
23430.36	**TOTAL** SHAFT CLEAN UP & DEMOB		0	315756	0	135285	92466	543507
992343037	SHAFT MANWAY/DRIFT							
		1JAN90 TO 31DEC90	0	851760	0	556750	77840	1486350
		1JAN91 TO 31DEC91	0	425880	0	338810	75360	840050
23430.37	**TOTAL** SHAFT MANWAY/DRIFT		0	1277640	0	895560	153200	2326400
992344101	HEB EXIT BUILD - COM							
		1JAN90 TO 31DEC90	909637	0	0	0	0	909637
		1JAN91 TO 31DEC91	662213	0	0	0	0	662213
23441.01	**TOTAL** HEB EXIT BUILD - COMPOSITE		1571850	0	0	0	0	1571850
992346016	HEB ELECTRICAL - ELE							
		1JAN89 TO 31DEC89	2076195	886500	66866	732840	0	3762401
23460.16	**TOTAL** HEB ELECTRICAL - ELECTRICAL		2076195	886500	66866	732840	0	3762401
992347015	HEB MECHANICAL - MEC							
		1JAN89 TO 31DEC89	870081	110514	11547	14184	29974	1036300
23470.15	**TOTAL** HEB MECHANICAL - MECHANICAL		870081	110514	11547	14184	29974	1036300
992411300	N ARC SEC A SHAFT -							
		1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24113.00	**TOTAL** N ARC SEC A SHAFT - SURF BUILD		46620	0	0	0	0	46620
992411314	N ARC SEC A SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24113.14	**TOTAL** N ARC SEC A SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992411515	N ARC SEC A MECHANIC							
		1JAN89 TO 31DEC89	90756	24305	48066	6645	10272	180044
24115.15	**TOTAL** N ARC SEC A MECHANICAL - MECHA		90756	24305	48066	6645	10272	180044

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992412314	N ARC SEC B SHAFT -	1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24123.14	**TOTAL** N ARC SEC B SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992412416	N ARC SEC B ELECTRIC	1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24124.16	**TOTAL** N ARC SEC B ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992412515	N ARC SEC B MECHANIC	1JAN89 TO 31DEC89	115093	65379	65379	6646	16488	268985
24125.15	**TOTAL** N ARC SEC B MECHANICAL - MECHA		115093	65379	65379	6646	16488	268985
992413300	N ARC SEC C SHAFT -	1JAN89 TO 31DEC89	27750	0	0	0	0	27750
		1JAN90 TO 31DEC90	18870	0	0	0	0	18870
24133.00	**TOTAL** N ARC SEC C SHAFT - SURF BUILD		46620	0	0	0	0	46620
992413314	N ARC SEC C SHAFT -	1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24133.14	**TOTAL** N ARC SEC C SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992413416	N ARC SEC C ELECTRIC	1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24134.16	**TOTAL** N ARC SEC C ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992413515	N ARC SEC C MECHANIC	1JAN89 TO 31DEC89	115091	28568	65738	6645	12114	228156
24135.15	**TOTAL** N ARC SEC C MECHANICAL - MECHA		115091	28568	65738	6645	12114	228156
992414300	N ARC SEC D SHAFT -	1JAN90 TO 31DEC90	93240	0	0	0	0	93240
24143.00	**TOTAL** N ARC SEC D SHAFT - SURF BUILD		93240	0	0	0	0	93240
992414314	N ARC SEC D SHAFT -	1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24143.14	**TOTAL** N ARC SEC D SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992414416	N ARC SEC D ELECTRIC	1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
24144.16	**TOTAL** N ARC SEC D ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992414515	N ARC SEC D MECHANIC	1JAN89 TO 31DEC89	195153	46710	114417	10764	20627	387671
24145.15	**TOTAL** N ARC SEC D MECHANICAL - MECHA		195153	46710	114417	10764	20627	387671
992421300	S ARC SEC E SHAFT -	1JAN89 TO 31DEC89	74370	0	0	0	0	74370
		1JAN90 TO 31DEC90	18870	0	0	0	0	18870
24213.00	**TOTAL** S ARC SEC E SHAFT - SITEWORK		93240	0	0	0	0	93240
992421314	S ARC SEC E SHAFT -	1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24213.14	**TOTAL** S ARC SEC E SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992421515	S ARC SEC E MECHANIC	1JAN89 TO 31DEC89	120512	31397	66168	7671	13681	233429
24215.15	**TOTAL** S ARC SEC E MECHANICAL - MECHA		120512	31397	66168	7671	13681	239429
992421516	MECH SYS - ELECTRICA	1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24215.16	**TOTAL** MECH SYS - ELECTRICAL		5506327	2302602	313727	1872422	0	9995078
992422300	S ARC SEC F SHAFT -	1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24223.00	**TOTAL** S ARC SEC F SHAFT - SURF BUILD		46620	0	0	0	0	46620
992422314	S ARC SEC F SHAFT -	1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24223.14	**TOTAL** S ARC SEC F SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992422416	S ARC SEC F ELECTRIC	1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24224.16	**TOTAL** S ARC SEC F ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992422515	S ARC SEC F MECHANIC	1JAN89 TO 31DEC89	129804	36248	66903	9430	14636	257021
24225.15	**TOTAL** S ARC SEC F MECHANICAL - MECHA		129804	36248	66903	9430	14636	257021

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992423300	S ARC SEC G SHAFT -							
		1JAN90 TO 31DEC90	46620	0	0	0	0	46620
24233.00	**TOTAL** S ARC SEC G SHAFT - SURF BUILD		46620	0	0	0	0	46620
992423314	S ARC SEC G SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24233.14	**TOTAL** S ARC SEC G SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992423416	S ARC SEC G ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24234.16	**TOTAL** S ARC SEC G ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992423515	S ARC SEC G MECHANIC							
		1JAN89 TO 31DEC89	127868	35237	66750	9064	14437	253356
24235.15	**TOTAL** S ARC SEC G MECHANICAL - MECHA		127868	35237	66750	9064	14437	253356
992424300	S ARC SEC H SHAFT -							
		1JAN89 TO 31DEC89	12210	0	0	0	0	12210
		1JAN90 TO 31DEC90	34410	0	0	0	0	34410
24243.00	**TOTAL** S ARC SEC H SHAFT - SURF BUILD		46620	0	0	0	0	46620
992424314	S ARC SEC H SHAFT -							
		1JAN89 TO 31DEC89	0	14460	60000	16000	9540	100000
24243.14	**TOTAL** S ARC SEC H SHAFT - CONVEYING		0	14460	60000	16000	9540	100000
992424416	S ARC SEC H ELECTRIC							
		1JAN89 TO 31DEC89	5506327	2302602	313727	1872422	0	9995078
24244.16	**TOTAL** S ARC SEC H ELECTRICAL - ELECT		5506327	2302602	313727	1872422	0	9995078
992424515	S ARC SEC H MECHANIC							
		1JAN89 TO 31DEC89	202897	50753	114850	12229	21340	402069
24245.15	**TOTAL** S ARC SEC H MECHANICAL - MECHA		202897	50753	114850	12229	21340	402069
992431416	E CONNEC V ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24314.16	**TOTAL** E CONNEC V ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992432416	E CONNEC X ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
24324.16	**TOTAL** E CONNEC X ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992432515	E CONNEC X MECHANICA							
		1JAN89 TO 31DEC89	36364	11097	17415	2746	4376	71998
24325.15	**TOTAL** E CONNEC X MECHANICAL - MECHAN		36364	11097	17415	2746	4376	71998
992433416	E CONNEC Y ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24334.16	**TOTAL** E CONNEC Y ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992434416	E CONNEC Z ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24344.16	**TOTAL** E CONNEC Z ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992441616	W CONNEC Q ELECTRICA							
		1JAN89 TO 31DEC89	1708854	703889	93229	598234	0	3104206
24416.16	**TOTAL** W CONNEC Q ELECTRICAL - ELECTR		1708854	703889	93229	598234	0	3104206
992441715	W CONNEC Q MECHANICA							
		1JAN89 TO 31DEC89	758519	164629	254741	243556	79551	1500996
24417.15	**TOTAL** W CONNEC Q MECHANICAL - MECHAN		758519	164629	254741	243556	79551	1500996
992442616	W CONNEC R ELECTRICA							
		1JAN89 TO 31DEC89	1614594	673686	90412	551888	0	2930580
24426.16	**TOTAL** W CONNEC R ELECTRICAL - ELECTR		1614594	673686	90412	551888	0	2930580
992442715	W CONNEC R MECHANICA							
		1JAN89 TO 31DEC89	758517	164627	254742	243549	86179	1507614
24427.15	**TOTAL** W CONNEC R MECHANICAL - MECHAN		758517	164627	254742	243549	86179	1507614
992443416	W CONNEC S ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24434.16	**TOTAL** W CONNEC S ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116
992444416	W CONNEC T ELECTRICA							
		1JAN89 TO 31DEC89	1590541	665258	90315	541002	0	2887116
24444.16	**TOTAL** W CONNEC T ELECTRICAL - ELECTR		1590541	665258	90315	541002	0	2887116

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
992461101	A40 PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	2285472	0	0	0	0	2285472
24611.01	**TOTAL** A40 PUMP/COMPRES - COMPOSITE		2285472	0	0	0	0	2285472
992462101	E40 PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	1754916	0	0	0	0	1754916
		1JAN91 TO 31DEC91	530556	0	0	0	0	530556
24621.01	**TOTAL** E40 PUMP/COMPRES - COMPOSITE		2285472	0	0	0	0	2285472
992463101	XR PUMP/COMPRES - CO							
		1JAN90 TO 31DEC90	495300	0	0	0	0	495300
		1JAN91 TO 31DEC91	336804	0	0	0	0	336804
24631.01	**TOTAL** XR PUMP/COMPRES - COMPOSITE		832104	0	0	0	0	832104
992464101	RR PUMP/COMPRES - C							
		1JAN90 TO 31DEC90	832104	0	0	0	0	832104
24641.01	**TOTAL** RR PUMP/COMPRES - COMPOSITE		832104	0	0	0	0	832104
992513102	HALL Y TYPE B - SITE							
		1JAN89 TO 31DEC89	9366132	0	0	0	0	9366132
		1JAN90 TO 31DEC90	3968700	0	0	0	0	3968700
25131.02	**TOTAL** HALL Y TYPE B - SITE WORK		13334832	0	0	0	0	13334832
992513716	HALL Y ELE SYS - ELE							
		1JAN89 TO 31DEC89	788358	365771	27529	142697	0	1324555
25137.16	**TOTAL** HALL Y ELE SYS - ELECTRICAL		788358	365771	27529	142897	0	1324555
992513815	HALL Y MEC SYS - MEC							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25138.15	**TOTAL** HALL Y MEC SYS - MECHANICAL		629992	248536	29554	70908	73290	1052280
992514101	HALL Z - COMPOSITE							
		1JAN89 TO 31DEC89	9366132	0	0	0	0	9366132
		1JAN90 TO 31DEC90	3968700	0	0	0	0	3968700
25141.01	**TOTAL** HALL Z - COMPOSITE		13334832	0	0	0	0	13334832
992514716	HALL Z ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561

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WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
25147.16	**TOTAL** HALL Z ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992514815	HALL Z MECH SYSTEM							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25148.15	**TOTAL** HALL Z MECH SYSTEM		629992	248536	29554	70908	73290	1052280
992521102	HALL S TYPE A - SITE							
		1JAN89 TO 31DEC89	8651766	0	0	0	0	8651766
		1JAN90 TO 31DEC90	4683066	0	0	0	0	4683066
25211.02	**TOTAL** HALL S TYPE A - SITE WORK		13334832	0	0	0	0	13334832
992521716	HALL S ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561
25217.16	**TOTAL** HALL S ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992521815	HALL S MECH SYS - ME							
		1JAN89 TO 31DEC89	629992	248536	29554	70908	73290	1052280
25218.15	**TOTAL** HALL S MECH SYS - MECHANICAL		629992	248536	29554	70908	73290	1052280
992522101	HALL T TYPE A - COMP							
		1JAN89 TO 31DEC89	8651766	0	0	0	0	8651766
		1JAN90 TO 31DEC90	4683066	0	0	0	0	4683066
25221.01	**TOTAL** HALL T TYPE A - COMPOSITE		13334832	0	0	0	0	13334832
992522716	HALL T ELEC SYS - EL							
		1JAN89 TO 31DEC89	788362	365773	27530	142896	0	1324561
25227.16	**TOTAL** HALL T ELEC SYS - ELECTRICAL		788362	365773	27530	142896	0	1324561
992522815	HALL T MECH SYS - ME							
		1JAN89 TO 31DEC89	630342	248746	29587	70936	73346	1052957
25228.15	**TOTAL** HALL T MECH SYS - MECHANICAL		630342	248746	29587	70936	73346	1052957
	TOTAL ARIZONA SSC		********	92158508	64596459	70613420	44314923	504867894

2.2 Total Project Costs Summarized by Facility, Work Breakdown Structure Level 7

This report details the total cost of Conventional Facilities Construction using the Central Design Group's Work Breakdown Structure. Costs are summarized by facility. These are the summary costs referred to in Volume 3.

1+21 Site and Infrastructure
1+22 Campus
1+23 Injector Complex
1+24 Collider Ring
1+25 Experimental Facilities

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
21210.00	CONSTRUCTION SUPPORT	964000	---------	---------	---------	---------	964000
1+2122__	**TOTAL** CONTRACTOR YARDS	964000	---------	---------	---------	---------	964000
1+212___	**TOTAL** CONSTRUCTION SUPPORT	964000					964000
21310.00	MAIN CAMPUS UTILITIES	472042	---------	---------	---------	---------	472042
1+2131__	**TOTAL** CAMPUS	472042	---------	---------	---------	---------	472042
1+213___	**TOTAL** SITE PREPARATION	472042					472042
21420.00	ELECTRICAL DISTRIBUTION	39270000	---------	---------	---------	---------	39270000
1+2142__	**TOTAL** TRANSMISSION/SWITCHING	39270000	---------	---------	---------	---------	39270000
1+214___	**TOTAL** ELECTRICAL	39270000					39270000
21511.00	WATER/WASTE WATER DISTRIBUTION	5575000	---------	---------	---------	---------	5575000
1+21511_	**TOTAL** WATER SOURCE	5575000	---------	---------	---------	---------	5575000
1+2151__	**TOTAL** POTABLE WATER	5575000	---------	---------	---------	---------	5575000
1+215___	**TOTAL** WATER & WASTE SYSTEMS	5575000					5575000

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WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
21710.00	AUX SYSTEMS GENERAL	10245000	---------	---------	---------	---------	10245000
1+2171__	**TOTAL** DATA/VOICE NETWORK	10245000	---------	---------	---------	---------	10245000
1+217___	**TOTAL** COMMUNICATIONS	10245000					10245000
21811.00	SITE WORK - CAMPUS ROADS	12882000	---------	---------	---------	---------	12882000
1+21811_	**TOTAL** CAMPUS ROADS	12882000	---------	---------	---------	---------	12882000
1+2181__	**TOTAL** ROADS & PARKING	12882000	---------	---------	---------	---------	12882000
1+218___	**TOTAL** ROADS & PARKING	12882000	---------	---------	---------	---------	12882000
1+21____	**TOTAL** SITE AND INFRASTRUCTURE	69408042					69408042
22100.00	LAB BUILDING	18799830	---------	---------	---------	---------	18799830
1+221___	**TOTAL** LABORATORY BUILDING	18799830					18799830
22210.00	HVY WORKS BUILD I - GENERAL	1399923	---------	---------	---------	---------	1399923
1+2221__	**TOTAL** HEAVY WORKS BUILDING I	1399923					1399923
22220.00	HVY WORKS BUILD II - GENERAL	1399923	---------	---------	---------	---------	1399923
1+2222__	**TOTAL** HEAVY WORKS BUILDING II	1399923					1399923

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WBS LEVEL 7 ESTIMATE
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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		SURFACE					
22230.00	HVY WORKS BUILD III - GENERAL	899976					899976
1+2223__	**TOTAL** HEAVY WORKS BUILDING III	899976					899976
22240.00	HVY WORKS BUILD IV - GENERAL	899976					899976
1+2224__	**TOTAL** HEAVY WORKS BUILDING IV	899976					899976
22250.00	HVY WORKS BUILD V - GENERAL	899976					899976
1+2225__	**TOTAL** HEAVY WORKS BUILDING V	899976					899976
22260.00	HVY WORKS BUILD VI - GENERAL	899976					899976
1+2226__	**TOTAL** HEAVY WORKS BUILDING VI	899976					899976
1+222___	**TOTAL** HEAVY WORKS BUILDING	6399750					6399750
22310.00	SHOP BUILD I - GENERAL	499968					499968
1+2231__	**TOTAL** SHOP BUILDING I	499968					499968
22320.00	SHOP BUILD II - GENERAL	400050					400050
1+2232__	**TOTAL** SHOP BUILDING II	400050					400050
22330.00	SHOP BUILD III - GENERAL	400050					400050
1+2233__	**TOTAL** SHOP BUILDING III	400050					400050
1+223___	**TOTAL** SHOP BUILDINGS	1300068					1300068
1+22____	**TOTAL** CAMPUS	26499648					26499648
22410.00	WAREHOUSE I - GENERAL	1399923					1399923

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WBS LEVEL 7 ESTIMATE
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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		SURFACE					
1+2241__	**TOTAL** WAREHOUSE I	1399923					1399923
22420.00	WAREHOUSE II - GENERAL	1399923					1399923
1+2242__	**TOTAL** WAREHOUSE II	1399923					1399923
22430.00	FIRE/SITE/RESCUE - GENERAL	400008					400008
1+2243__	**TOTAL** FIRE/SITE PATROL/RESCUE	400008					400008
22440.00	VEHICLE SERVICE - GENERAL	299964					299964
1+2244__	**TOTAL** VEHICLE KIOSK	299964					299964
22460.00	HELIPAD - GENERAL	34020					34020
1+2246__	**TOTAL** HELIPAD	34020					34020
1+224___	**TOTAL** SUPPORT BUILDINGS	3533838					3533838
23110.17	LINAC TUNNEL/ENCLOSURE - EXCAV		915	11592		1751	14258
23110.18	LINAC TUNNEL/ENCLOSURE - PIPIN		36734	23416		17985	78135
23110.19	LINAC TUNNEL/ENCLOSURE - BACKF		4256	11963		2271	18490
23110.20	LINAC TUNNEL/ENCLOSURE - REVEG				8176	2044	10220
1+2311__	**TOTAL** LINAC TUNNEL/ENCLOSURE		41905	46971	8176	24051	121103
24123.14	N ARC SEC B SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+2313__	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		14460	60000	16000	9540	100000
23150.16	LINAC - ELECTRICAL	123183	35100	2645	45270		206198
1+2315__	**TOTAL** ELECTRICAL	123183	35100	2645	45270		206198
23160.15	LINAC MECHANICAL - MECHANICAL	176517	30755	3112	8218	8417	227019
1+2316__	**TOTAL** MECHANICAL	176517	30755	3112	8218	8417	227019
1+231___	**TOTAL** LINAC	299700	122220	112728	77664	42008	654320

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WBS LEVEL 7 ESTIMATE
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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
23210.18	LEB TUNNEL/ENCLOSURE - BACK FI		53515	159499		29822	242836
23210.19	LEB TUNNEL/ENCLOSURE - PIPING		60826	38773		29782	129381
23210.20	LEB TUNNEL/ENCLOSURE - REVEGET				13541	3385	16926
1+2321__	**TOTAL** LEB TUNNEL/ENCLOSURE		114341	198272	13541	62989	389143
23230.30	SHAFT MOBILIZATION		8978	233475	303690	189390	735533
23230.31	SHAFT SET UP		260400				260400
23230.33	SHAFT COLLAR		417060		438755	99775	955590
23230.34	SHAFT SINKING		1714650		267969	10725	1993344
23230.35	SHAFT FURNISHING		204125		18525	10915	233565
23230.36	SHAFT CLEAN UP & DEMOB		263130		112735	77055	452920
23230.37	SHAFT MANWAY/DRIFT		283920		695938	97300	1077158
1+2323__	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		3152263	233475	1837612	485160	5708510
23241.01	LEB PS BUILD - COMPOSITE	620865					620865
1+23241_	**TOTAL** POWER SUPPLY BUILDINGS	620865					620865
1+2324__	**TOTAL** SURFACE BUILDINGS	620865					620865
23250.16	LEB ELECTRICAL - ELECTRICAL	247373	76770	5779	89589		419511
1+2325__	**TOTAL** ELECTRICAL	247373	76770	5779	89589		419511
23260.15	LEB MECHANICAL - MECHANICAL	50333	8821	949		2247	62350
1+2326__	**TOTAL** MECHANICAL	50333	8821	949		2247	62350
1+232___	**TOTAL** LOW ENERGY BOOSTER	918571	3352195	438475	1940742	550396	7200378
23310.17	MEB TUNNEL/ENCLOSURE - EXCAV		61090	773801		116885	951775
23310.18	MEB TUNNEL/ENCLOSURE - BFILL		217148	643488		120489	981126
23310.19	MEB TUNNEL/ENCLOSURE - PIPE		463412	295397		226893	985702

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
23310.20	MEB TUNNEL/ENCLOSURE - REVEG				103139	25785	128923
1+2331__	**TOTAL** MEB TUNNEL/ENCLOSURE		741649	1712686	103139	490052	3047526
23320.17	MEB TO HEB TUNNEL - EXCAVATION		18508	234433		35412	288353
23320.18	MEB TO HEB TUNNEL - BACK FILL		68700	201704		37856	308260
23320.19	MEB TO HEB TUNNEL - PIPING		240183	153102		117597	510882
23320.20	MEB TO HEB TUNNEL - REVEG				53458	13365	66823
1+2332__	**TOTAL** MEB TO HEB TRANSFER		327390	589239	53458	204230	1174318
23330.30	SHAFT MOBILIZATION		10773	280170	364428	227268	882639
23330.31	SHAFT SET UP		312480				312480
23330.33	SHAFT COLLAR		500472		526506	119730	1146708
23330.34	SHAFT SINKING		2057580		321252	12870	2331702
23330.35	SHAFT FURNISHING		244950		22230	13098	280278
23330.36	SHAFT CLEAN UP & DEMOB		315756		135282	92466	543504
23330.37	SHAFT MANWAY/DRIFT		340704		835126	116760	1292590
1+2333__	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		3782715	280170	2204824	582192	6849901
23341.00	MEB SURFACE BUILDINGS	681156					681156
1+23341_	**TOTAL** EXIT/VENT BUILDINGS	681156					681156
1+2334__	**TOTAL** SURFACE BUILDINGS	681156					681156
23350.16	MEB ELECTRICAL - ELECTRICAL	879387	336600	25389	310453		1551829
1+2335__	**TOTAL** ELECTRICAL	879387	336600	25389	310453		1551829
23360.03	MEB MECHANICAL - MECHANICAL	2718	1463	280	800	509	5770
23360.15	MEB MECHANICAL - MECHANICAL	3747644	1158505	145323	903419	441449	6396340
1+2336__	**TOTAL** MECHANICAL	3750362	1159968	145603	904219	441958	6402110
1+233___	**TOTAL** MEDIUM ENERGY BOOSTER	5310905	6348323	2753087	3576093	1718432	19706840

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
23410.17	HEB TUNNEL/ENCLOSURE - EXCAVAT		69670	882483		133301	1085455
23410.18	HEB TUNNEL/ENCLOSURE - EXCAVAT		274909	799606		150432	1224946
23410.19	HEB TUNNEL/ENCLOSURE - BACK FI		1462512	932263		716068	3110844
23410.20	HEB TUNNEL/ENCLOSURE - REVEG				325510	81378	406888
1+2341__	**TOTAL** HEB TUNNEL/ENCLOSURE		1807091	2614352	325510	1081179	5828132
23421.17	HEB TO COL TUNNEL - EXCAVATION		35573	450593		68063	554230
23421.18	HEB TO COL TUNNEL - BACKFILL		142855	417524		78453	638832
23421.19	HEB TO COL TUNNEL - PIPING		642917	409820		314782	1367519
23421.20	HEB TO COL TUNNEL - REVEG				143091	35773	178864
23421.21	HEB TO COL TUNNEL - SURF BUILD	2966376					2966376
1+23421_	**TOTAL** HEB TO COLLIDER	2966376	821345	1277937	143091	497071	5705820
1+2342__	**TOTAL** TRANSFER TUNNELS	2966376	821345	1277937	143091	497071	5705820
23430.31	SHAFT SET UP		355965	233475	303690	189390	1082520
23430.33	SHAFT COLLAR		448784	46695	634988	163789	1294256
23430.34	SHAFT SINKING		752460		514664	126774	1393898
23430.35	SHAFT FURNISHING		90846		34635	18423	143904
23430.36	SHAFT CLEAN UP & DEMOB		315756		135285	92466	543507
23430.37	SHAFT MANWAY/DRIFT		1277640		895560	153200	2326400
1+2343__	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		3241451	280170	2518822	744042	6784485
23441.01	HEB EXIT BUILD - COMPOSITE	1571850					1571850
1+23441_	**TOTAL** EXIT/VENT & INJECT/EJECT BUILD	1571850					1571850
1+2344__	**TOTAL** SURFACE BUILDINGS	1571850					1571850
23460.16	HEB ELECTRICAL - ELECTRICAL	2076195	886500	66866	732840		3762401
1+2346__	**TOTAL** ELECTRICAL	2076195	886500	66866	732840		3762401
23470.15	HEB MECHANICAL - MECHANICAL	870081	110514	11547	14184	29974	1036300
1+2347__	**TOTAL** MECHANICAL	870081	110514	11547	14184	29974	1036300

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
1+234___	**TOTAL** HIGH ENERGY BOOSTER	7484502	6866901	4250873	3734447	2352265	24688988
1+23____	**TOTAL** INJECTOR	17547516	16689639	7555163	9328946	4663101	55784364
912411X	CUT & COVER TUNNEL EXCAVATION		58645	742836		112207	913688
912411Y	CUT & COVER TUNNEL BACKFILL		252759	724561		136825	1114145
912411Z	CUT & COVER TUNNEL PIPE		1963104	1251360		961165	4175629
912411W	CUT & COVER REVEGETATION				436920	109230	546150
1+24111_	**TOTAL** TUNNEL		2274508	2718758	436920	1319427	6749613
924113A	SHAFT MOBILIZATION		3591	93390	121476	75756	294213
924113B	SHAFT SET UP		108144				108144
924113D	SHAFT COLLAR		161880		410870	81091	653841
924113E	SHAFT SINKING		262477		444080	168654	875211
924113F	SHAFT FURNISHING		32588		12517	5214	50319
924113G	SHAFT CLEAN UP & DEMOB		121572		41634	30822	194028
924113H	SHAFT MANWAY/DRIFT		302745		377409	102928	783082
24113.00	N ARC SEC A SHAFT - SURF BUILD	46620					46620
24113.14	N ARC SEC A SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24113_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	46620	1007457	153390	1423985	474005	3105457
24115.15	N ARC SEC A MECHANICAL - MECHA	90756	24305	48066	6645	10272	180044
1+24115_	**TOTAL** MECHANICAL	90756	24305	48066	6645	10272	180044
1+2411__	**TOTAL** SECTOR A - MILEPOST 10.01-05.0	137376	3306270	2920214	1867550	1803704	10035114
912412B	TBM SET UP CHAMBER		101439		11401		112840
912412C	TBM TUNNEL EXCAVATION		2393207		495874	4123944	7013025

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
912412D	TBM TUNNEL SUPPORT		639644		3101984		3741628
912412E	TBM TUNNEL FIT AND COMMISSION		376827		23919		400746
1+24121_	**TOTAL** TUNNEL		3511117		3633178	4123944	11268239
922412A	ELECTRON SHIELDING NICHE		392154		36666		428820
932412A	POWER ALCOVE		261436		59444		320880
1+24122_	**TOTAL** NICHES/ALCOVES/CHAMBERS		653590		96110		749700
24124.16	N ARC SEC B ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24124_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078
24125.15	N ARC SEC B MECHANICAL - MECHA	115093	65379	65379	6646	16488	268985
1+24125_	**TOTAL** MECHANICAL	115093	65379	65379	6646	16488	268985
1+2412__	**TOTAL** SECTOR B - MILEPOST 05.01-00.0	5621420	6532688	379106	5608356	4140432	22282002
912413C	TBM TUNNEL EXCAVATION		325596		60946	494873	881415
912413D	TBM TUNNEL SUPPORT		73705		372205		445910
912413E	TBM TUNNEL FIT AND COMMISSION		43020		2730		45750
1+24131_	**TOTAL** TUNNEL		442321		435881	494873	1373075
922413A	ELECTRON SHIELDING NICHE		499002		43146		542148
932413A	POWER ALCOVE		332668		63764		396432
1+24132_	**TOTAL** NICHES/ALCOVES/CHAMBERS		831670		106910		938580
924133A	SHAFT MOBILIZATION		34115	93390	143781	97398	368684
924133B	SHAFT SET UP		136176				136176
924133C	SHAFT PRE-GROUT		920				920
924133D	SHAFT COLLAR		161880		270870	46091	478841
924133E	SHAFT SINKING		1697586		926690	330822	2955098
924133F	SHAFT FURNISHING		93712		52364	26537	172613
924133G	SHAFT CLEAN UP & DEMOB		105252		50180	32276	187708
924133H	SHAFT MANWAY/DRIFT		250935		377121	71634	699690
24133.00	N ARC SEC C SHAFT - SURF BUILD	46620					46620

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
24133.14	N ARC SEC C SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24133_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	46620	2495036	153390	1839005	614298	5148348
24134.16	N ARC SEC C ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24134_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078
24135.15	N ARC SEC C MECHANICAL - MECHA	115091	28568	65738	6645	12114	228156
1+24135_	**TOTAL** MECHANICAL	115091	28568	65738	6645	12114	228156
1+2413__	**TOTAL** SECTOR C - MILEPOST 51.54-46.5	5668038	6100197	532855	4260863	1121285	17683237
912414C	TBM TUNNEL EXCAVATION		1062354		218603	2074270	3355227
912414D	TBM TUNNEL SUPPORT		265338		1364478		1629816
912414E	TBM TUNNEL FIT AND COMMISSION		172080		10920		183000
1+24141_	**TOTAL** TUNNEL		1499772		1594001	2074270	5168043
922414A	ELECTRON SHIELDING NICHE		463386		40986		504372
932414A	POWER ALCOVE		327598		66570		394168
1+24142_	**TOTAL** NICHES/ALCOVES/CHAMBERS		790984		107556		898540
924143A	SHAFT MOBILIZATION		66434	140085	227503	152262	586284
924143B	SHAFT SET UP		214296				214296
924143C	SHAFT PRE-GROUT		1840				1840
924143D	SHAFT COLLAR		233376		374262	66046	673684
924143E	SHAFT SINKING		2057580		2007187	663025	4727792
924143F	SHAFT FURNISHING		185816		79416	43794	309026
924143G	SHAFT CLEAN UP & DEMOB		157878		70997	47686	276561
924143H	SHAFT MANWAY/DRIFT		261048		515206	88979	865233
24143.00	N ARC SEC D SHAFT - SURF BUILD	93240					93240
24143.14	N ARC SEC D SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24143_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	93240	3192728	200085	3290571	1071332	7847955
24144.16	N ARC SEC D ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24144_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
24145.15	N ARC SEC D MECHANICAL - MECHA	195153	46710	114417	10764	20627	387671
1+24145_	**TOTAL** MECHANICAL	195153	46710	114417	10764	20627	387671
1+2414__	**TOTAL** SECTOR D - MILEPOST 46.52-41.5	5794720	7832796	628229	6875313	3166229	24297287
1+241___	**TOTAL** NORTH ARC - MP 41.52-10.01	17221554	23771950	4460404	18612082	10231651	74297640
912421C	TBM TUNNEL EXCAVATION		2410352		496165	3779160	6685677
912421D	TBM TUNNEL SUPPORT		574899		3099759		3674658
912421E	TBM TUNNEL FIT AND COMMISSION		376827		23919		400746
1+24211_	**TOTAL** TUNNEL		3362078		3619843	3779160	10761081
922421A	ELECTRON SHIELDING NICHE		392154		36666		428820
932421A	POWER ALCOVE		242762		55198		297960
1+24212_	**TOTAL** NICHES/ALCOVES/CHAMBERS		634916		91864		726780
924213A	SHAFT MOBILIZATION		3591	93390	121476	75756	294213
924213B	SHAFT SET UP		160224				160224
924213D	SHAFT COLLAR		235172	46695	686735	182674	1151275
924213E	SHAFT SINKING		1207887		786268	331820	2325975
924213F	SHAFT FURNISHING		91654		76976	34446	203076
924213G	SHAFT CLEAN UP & DEMOB		157878		66414	46233	270525
924213H	SHAFT MANWAY/DRIFT		210966		943361	210570	1364897
24213.00	S ARC SEC E SHAFT - SITEWORK	93240					93240
24213.14	S ARC SEC E SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24213_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	93240	2081832	200085	2697230	891039	5963426
24215.15	S ARC SEC E MECHANICAL - MECHA	120512	31397	66268	7671	13681	239429
24215.16	MECH SYS - ELECTRICAL	5506327	2302602	313727	1872422		9995078
1+24215_	**TOTAL** MECHANICAL	5626839	2333999	379895	1880093	13681	10234507
1+2421__	**TOTAL** SECTOR E - MILEPOST 35.78-30.7	5720079	8412825	579960	8289030	4683880	27685793

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	SURFACE						
912422B	TBM SET UP CHAMBER		233870		25285		259155
912422C	TBM TUNNEL EXCAVATION		3283922		1120903	10172722	14577546
912422D	TBM TUNNEL SUPPORT		1825009		5688649		7513658
912422E	TBM TUNNEL FIT AND COMMISSION		990983		64059		1055042
1+24221_	**TOTAL** TUNNEL		6333784		6898896	10172722	23405401
922422A	ELECTRON SHIELDING NICHE		1049082		96138		1145220
932422A	POWER ALCOVE		726554		159262		885816
1+24222_	**TOTAL** NICHES/ALCOVES/CHAMBERS		1775636		255400		2031036
924223A	SHAFT MOBILIZATION		1796	46695	60738	37878	147107
924223B	SHAFT SET UP		95136				95136
924223C	SHAFT PRE-GROUT		920				920
924223D	SHAFT COLLAR		194199	46695	481622	140610	863126
924223E	SHAFT SINKING		1770988		1155636	473476	3400100
924223F	SHAFT FURNISHING		53590		36811	16536	106937
924223G	SHAFT CLEAN UP & DEMOB		105252		45404	31502	182158
924223H	SHAFT MANWAY/DRIFT		126336		457438	105610	689384
24223.00	S ARC SEC F SHAFT - SURF BUILD	46620					46620
24223.14	S ARC SEC F SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24223_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	46620	2362677	153390	2253648	815152	5631487
24224.16	S ARC SEC F ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24224_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078
24225.15	S ARC SEC F MECHANICAL - MECHA	129804	36248	66903	9430	14636	257021
1+24225_	**TOTAL** MECHANICAL	129804	36248	66903	9430	14636	257021
1+2422__	**TOTAL** SECTOR F - MILEPOST 30.77-25.7	5682751	12810947	534020	11289796	11002509	41320023
912423C	TBM TUNNEL EXCAVATION		468920		119489	923995	1512404
912423D	TBM TUNNEL SUPPORT		158319		683307		841626
912423E	TBM TUNNEL FIT AND COMMISSION		91978		6420		98398
1+24231_	**TOTAL** TUNNEL		719217		809216	923995	2452428

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
922423A	ELECTRON SHIELDING NICHE		516810		44226		561036
932423A	POWER ALCOVE		319930		59878		379808
1+24232_	**TOTAL** NICHES/ALCOVES/CHAMBERS		836740		104104		940844
924233A	SHAFT MOBILIZATION		34115	93390	143781	95418	366704
924233B	SHAFT SET UP		136176				136176
924233C	SHAFT PRE-GROUT		920				920
924233D	SHAFT COLLAR		161880		254879	46091	462850
924233E	SHAFT SINKING		1378653		1111739	362139	2852531
924233F	SHAFT FURNISHING		96001		49365	25221	170587
924233G	SHAFT CLEAN UP & DEMOB		105252		50180	32275	187707
924233H	SHAFT MANWAY/DRIFT		241332		378962	69519	689813
24233.00	S ARC SEC G SHAFT - SURF BUILD	46620					46620
24233.14	S ARC SEC G SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24233_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	46620	2168789	153390	2004906	640203	5013907
24234.16	S ARC SEC G ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24234_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078
24235.15	S ARC SEC G MECHANICAL - MECHA	127868	35237	66750	9064	14437	253356
1+24235_	**TOTAL** MECHANICAL	127868	35237	66750	9064	14437	253356
1+2423__	**TOTAL** SECTOR G - MILEPOST 25.76-20.7	5680815	6062585	533867	4799712	1578635	18655613
912424C	TBM TUNNEL EXCAVATION		2084756		427780	3440110	5952646
912424D	TBM TUNNEL SUPPORT		501194		2666114		3167308
912424E	TBM TUNNEL FIT AND COMMISSION		333807		21189		354996
1+24241_	**TOTAL** TUNNEL		2919757		3115083	3440110	9474950
922424A	ELECTRON SHIELDING NICHE		398090		37026		435116
932424A	POWER ALCOVE		267372		59804		327176
1+24242_	**TOTAL** NICHES/ALCOVES/CHAMBERS		665462		96830		762292
924243A	SHAFT MOBILIZATION		3591	93390	121476	73776	292233

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WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
924243B	SHAFT SET UP		56752				56752
924243C	SHAFT PRE-GROUT		1840				1840
924243D	SHAFT COLLAR		161880		569879	124841	856600
924243E	SHAFT SINKING		376395		420833	134490	931718
924243F	SHAFT FURNISHING		61279		60747	23529	145555
924243G	SHAFT CLEAN UP & DEMOB		105252		41634	30776	177662
924243H	SHAFT MANWAY/DRIFT		269724		880510	198606	1348840
24243.00	S ARC SEC H SHAFT - SURF BUILD	46620					46620
24243.14	S ARC SEC H SHAFT - CONVEYING		14460	60000	16000	9540	100000
1+24243_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES	46620	1051173	153390	2111076	595558	3957819
24244.16	S ARC SEC H ELECTRICAL - ELECT	5506327	2302602	313727	1872422		9995078
1+24244_	**TOTAL** ELECTRICAL	5506327	2302602	313727	1872422		9995078
24245.15	S ARC SEC H MECHANICAL - MECHA	202897	50753	114850	12229	21340	402069
1+24245_	**TOTAL** MECHANICAL	202897	50753	114850	12229	21340	402069
1+2424__	**TOTAL** SECTOR H - MILEPOST 20.76-15.7	5755844	6989747	581967	7207642	4057008	24592207
1+242___	**TOTAL** SOUTH ARC - MP 15.75-35.78	22839489	34276103	2229834	31586179	21322031	112253636
912431C	TBM TUNNEL EXCAVATION		239871		49591	471425	760887
912431D	TBM TUNNEL SUPPORT		58964		310064		369028
912431E	TBM TUNNEL FIT AND COMMISSION		43020		2730		45750
912431X	CUT & COVER TUNNEL EXCAVATION		4438	56215		8491	69144
912431Y	CUT & COVER TUNNEL BACKFILL		18237	52687		9929	80853
912431Z	CUT & COVER TUNNEL PIPE		117786	75082		57670	250538
912431W	CUT & COVER REVEGETATION				26214	6553	32767
1+24311_	**TOTAL** TUNNEL		482316	183983	388598	554069	1608967
922431A	ELECTRON SHIELDING NICHE		93370		8730		102100
932431A	POWER ALCOVE		74696		16984		91680

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
1+24312_	**TOTAL** NICHES/ALCOVES/CHAMBERS		168066		25714		193780
24314.16	E CONNEC V ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24314_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
1+2431__	**TOTAL** CONNECTOR V - MILEPOST 41.52-4	1590541	1315640	274298	955314	554069	4689863
912432X	CUT & COVER TUNNEL EXCAVATION		17430	220782		33350	271562
912432Y	CUT & COVER TUNNEL BACKFILL		75284	215738		40743	331765
912432Z	CUT & COVER TUNNEL PIPE		588931	375408		288350	1252689
912432W	CUT & COVER REVEGETATION				131076	32769	163645
1+24321_	**TOTAL** TUNNEL		681645	811928	131076	395211	2019861
924323B	SHAFT SET UP		56064				56064
924323D	SHAFT COLLAR		92180	46695	196233	64014	399122
924323E	SHAFT SINKING		156332		72619	40386	269337
924323F	SHAFT FURNISHING		9196		7045	3284	19525
924323G	SHAFT CLEAN UP & DEMOB		52626		21320	15411	89357
924323H	SHAFT MANWAY/DRIFT		83202		197250	55900	336352
1+24323_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		449600	46695	494467	178995	1169757
24324.16	E CONNEC X ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24324_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
24325.15	E CONNEC X MECHANICAL - MECHAN	36364	11097	17415	2746	4376	71998
1+24325_	**TOTAL** MECHANICAL	36364	11097	17415	2746	4376	71998
1+2432__	**TOTAL** CONNECTOR X - MILEPOST 40.25-3	1626905	1807600	966353	1169291	578582	6148731
912433X	CUT & COVER TUNNEL EXCAVATION		23386	296219		44745	364349
912433Y	CUT & COVER TUNNEL BACKFILL		96280	278051		52406	426737
912433Z	CUT & COVER TUNNEL PIPE		628193	400435		307573	1336201
912433W	CUT & COVER REVEGETATION				139815	34954	174769
1+24331_	**TOTAL** TUNNEL		747859	974705	139815	439678	2302057

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
24334.16	E CONNEC Y ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24334_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
1+2433__	**TOTAL** CONNECTOR Y - MILEPOST 38.65-3	1590541	1413117	1065020	680817	439678	5189173
912434B	TBM SET UP CHAMBER		101439		11401		112840
912434C	TBM TUNNEL EXCAVATION		422645		88791	680249	1191685
912434D	TBM TUNNEL SUPPORT		153191		559631		712822
912434E	TBM TUNNEL FIT AND COMMISSION		75687		4809		80496
912434X	CUT & COVER TUNNEL EXCAVATION		15632	198007		29909	243548
912434Y	CUT & COVER TUNNEL BACKFILL		60126	175656		33009	268791
912434Z	CUT & COVER TUNNEL PIPE		274835	175190		134563	584588
912434W	CUT & COVER REVEGETATION				61170	15293	76463
1+24341_	**TOTAL** TUNNEL		1103554	548853	725802	893024	3271233
922434A	ELECTRON SHIELDING NICHE		74696		6984		81680
932434A	POWER ALCOVE		37348		8492		45840
1+24342_	**TOTAL** NICHES/ALCOVES/CHAMBERS		112044		15476		127520
24344.16	E CONNEC Z ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24344_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
1+2434__	**TOTAL** CONNECTOR Z - MILEPOST 37.22-3	1590541	1880856	639168	1282280	893024	6285869
1+243___	**TOTAL** EAST CLUSTER - MP 10.01-15.75	6398528	6417213	2944840	4087703	2465352	22313636
912441B	TBM SET UP CHAMBER		101439		11401		112840
912441C	TBM TUNNEL EXCAVATION		782531		144130	1360023	2286684
912441D	TBM TUNNEL SUPPORT		262159		870979		1133138
912441E	TBM TUNNEL FIT AND COMMISSION		108354		6888		115242
1+24412_	**TOTAL** TUNNEL		1254483		1033398	1360023	3647904

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
922441A	ELECTRON SHIELDING NICHE		130718		12222		142940
932441A	POWER ALCOVE		93370		21230		114600
1+24414_	**TOTAL** NICHES/ALCOVES/CHAMBERS		224088		33452		257540
24416.16	W CONNEC Q ELECTRICAL - ELECTR	1708854	703889	93229	598234		3104206
1+24416_	**TOTAL** ELECTRICAL	1708854	703889	93229	598234		3104206
24417.15	W CONNEC Q MECHANICAL - MECHAN	758519	164629	254741	243556	79551	1500996
1+24417_	**TOTAL** MECHANICAL	758519	164629	254741	243556	79551	1500996
1+2441__	**TOTAL** CONNECTOR Q - MILEPOST 15.75-1	2467373	2347089	347970	1908640	1439574	8510647
912442C	TBM TUNNEL EXCAVATION		1096644		175211	2239987	3511642
912442D	TBM TUNNEL SUPPORT		191633		992273		1183906
912442E	TBM TUNNEL FIT AND COMMISSION		118707		7539		126246
1+24422_	**TOTAL** TUNNEL		1406984		1175023	2239987	4821994
922442A	ELECTRON SHIELDING NICHE		130718		12222		142940
932442A	POWER ALCOVE		93370		21230		114600
1+24424_	**TOTAL** NICHES/ALCOVES/CHAMBERS		224088		33452		257540
924425A	SHAFT MOBILIZATION		1796	46695	60738	37878	147107
924425B	SHAFT SET UP		56064				56064
924425D	SHAFT COLLAR		90384		135495	26136	252015
924425E	SHAFT SINKING		51520				51520
924425F	SHAFT FURNISHING		27588		24135	11274	62997
924425G	SHAFT CLEAN UP & DEMOB		13800				13800
924425H	SHAFT MANWAY/DRIFT		141302		289387	52174	482863
1+24425_	**TOTAL** SHAFTS/EXITS/STAIRS/HATCHES		382454	46695	509755	127462	1066366
24426.16	W CONNEC R ELECTRICAL - ELECTR	1614594	673686	90412	551888		2930580
1+24426_	**TOTAL** ELECTRICAL	1614594	673686	90412	551888		2930580
24427.15	W CONNEC R MECHANICAL - MECHAN	758517	164627	254742	243549	86179	1507614
1+24427_	**TOTAL** MECHANICAL	758517	164627	254742	243549	86179	1507614

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
1+2442__	**TOTAL** CONNECTOR R - MILEPOST 14.31-1	2373111	2851839	391849	2513667	2453628	10584094
912443B	TBM SET UP CHAMBER		101439		11401		112840
912443C	TBM TUNNEL EXCAVATION		331258		54331	699996	1085585
912443D	TBM TUNNEL SUPPORT		183974		313874		497848
912443E	TBM TUNNEL FIT AND COMMISSION		43020		2730		45750
912443X	CUT & COVER TUNNEL EXCAVATION		18101	229275		34633	282008
912443Y	CUT & COVER TUNNEL BACKFILL		74081	214153		40353	328587
912443Z	CUT & COVER TUNNEL PIPE		471145	300326		230680	1002151
912443W	CUT & COVER REVEGETATION				104818	26205	131023
1+24431_	**TOTAL** TUNNEL		1223018	743754	487154	1031866	3485791
922443A	ELECTRON SHIELDING NICHE		37348		3492		40840
932443A	POWER ALCOVE		37348		8492		45840
1+24432_	**TOTAL** NICHES/ALCOVES/CHAMBERS		74696		11984		66680
24434.16	W CONNEC S ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24434_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
1+2443__	**TOTAL** CONNECTOR S - MILEPOST 12.88-1	1590541	1962972	834069	1040140	1031866	6459587
912444X	CUT & COVER TUNNEL EXCAVATION		16726	211865		32003	260594
912444Y	CUT & COVER TUNNEL BACKFILL		74082	211458		39976	325516
912444Z	CUT & COVER TUNNEL PIPE		628193	400435		307573	1336201
912444W	CUT & COVER REVEGETATION				139815	34954	174769
1+24441_	**TOTAL** TUNNEL		719002	823758	139815	414505	2097080
24444.16	W CONNEC T ELECTRICAL - ELECTR	1590541	665258	90315	541002		2887116
1+24444_	**TOTAL** ELECTRICAL	1590541	665258	90315	541002		2887116
1+2444__	**TOTAL** CONNECTOR T - MILEPOST 11.45-1	1590541	1384260	914073	680817	414505	4984196
1+244___	**TOTAL** WEST CLUSTER - MP 35.78-41.52	8021566	8546159	2487961	6143265	5339573	30538524

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
24611.01	A40 PUMP/COMPRES - COMPOSITE	2285472					2285472
1+24611_	**TOTAL** A40 PUMP/COMPRESSOR BUILDING	2285472					2285472
1+2461__	**TOTAL** NORTH ARC CRYO FAC	2285472					2285472
24621.01	E40 PUMP/COMPRES - COMPOSITE	2285472					2285472
1+24621_	**TOTAL** E40 PUMP/COMPRESSOR BUILDING	2285472					2285472
1+2462__	**TOTAL** SOUTH ARC CRYO FAC	2285472					2285472
24631.01	XR PUMP/COMPRES - COMPOSITE	832104					832104
1+24631_	**TOTAL** XR PUMP/COMPRESSOR BUILDING	832104					832104
1+2463__	**TOTAL** EAST CLUSTER CRYO FAC	832104					832104
24641.01	RR PUMP/COMPRES - COMPOSITE	832104					832104
1+24641_	**TOTAL** RR PUMP/COMPRESSOR BUILDING	832104					832104
1+2464__	**TOTAL** WEST CLUSTER CRYO FAC	832104					832104
1+246___	**TOTAL** CRYOGENIC FACILITIES	6235152					6235152
1+24____	**TOTAL** COLLIDER RING	60716289	73011425	12123038	60429229	39358607	245638586
25131.02	HALL Y TYPE B - SITE WORK	13334832					13334832
1+25131_	**TOTAL** COLLISION HALL	13334832					13334832

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
	SURFACE						
25137.16	HALL Y ELE SYS - ELECTRICAL	788358	365771	27529	142897		1324555
1+25137_	**TOTAL** ELECTRICAL SYSTEM	788358	365771	27529	142897		1324555
25138.15	HALL Y MEC SYS - MECHANICAL	629992	248536	29554	70908	73290	1052280
1+25138_	**TOTAL** MECHANICAL SYSTEM	629992	248536	29554	70908	73290	1052280
1+2513__	**TOTAL** FUTURE COLLISION/ACCESS HALL Y	14753182	614307	57083	213805	73290	15711667
25141.01	HALL Z - COMPOSITE	13334832					13334832
1+25141_	**TOTAL** COLLISION HALL	13334832					13334832
25147.16	HALL Z ELEC SYS - ELECTRICAL	788362	365773	27530	142896		1324561
1+25147_	**TOTAL** ELECTRICAL SYSTEM	788362	365773	27530	142896		1324561
25148.15	HALL Z MECH SYSTEM	629992	248536	29554	70908	73290	1052280
1+25148_	**TOTAL** MECHANICAL SYSTEM	629992	248536	29554	70908	73290	1052280
1+2514__	**TOTAL** FUTURE COLLISION/ACCESS HALL Z	14753186	614309	57084	213804	73290	15711673
1+251___	**TOTAL** EAST CLUSTER - EXP FACILITIES	29506368	1228616	114167	427609	146579	31423339
25211.02	HALL S TYPE A - SITE WORK	13334832					13334832
1+25211_	**TOTAL** COLLISION HALL	13334832					13334832
25217.16	HALL S ELEC SYS - ELECTRICAL	788362	365773	27530	142896		1324561
1+25217_	**TOTAL** ELECTRICAL SYSTEM	788362	365773	27530	142896		1324561
25218.15	HALL S MECH SYS - MECHANICAL	629992	248536	29554	70908	73290	1052280
1+25218_	**TOTAL** MECHANICAL SYSTEM	629992	248536	29554	70908	73290	1052280
1+2521__	**TOTAL** FUTURE COLLISION/ACCESS HALL S	14753186	614309	57084	213804	73290	15711673

ARIZONA SSC PROJECT
MARICOPA SITE
WBS LEVEL 7 ESTIMATE
SUMMARY COSTS

WBS NUMBER	DESCRIPTION	BUILDINGS	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
		SURFACE					
25221.01	HALL T TYPE A - COMPOSITE	13334832					13334832
1+25221_	**TOTAL** COLLISION HALL	13334832					13334832
25227.16	HALL T ELEC SYS - ELECTRICAL	788362	365773	27530	142896		1324561
1+25227_	**TOTAL** ELECTRICAL SYSTEM	788362	365773	27530	142896		1324561
25228.15	HALL T MECH SYS - MECHANICAL	630342	248746	29587	70936	73346	1052957
1+25228_	**TOTAL** MECHANICAL SYSTEM	630342	248746	29587	70936	73346	1052957
1+2522__	**TOTAL** FUTURE COLLISION/ACCESS HALL T	14753536	614519	57117	213832	73346	15712350
1+252___	**TOTAL** WEST CLUSTER - EXP FACILITIES	29506722	1228828	114201	427636	146636	31424023
1+25____	**TOTAL** EXPERIMENTAL FACILITIES	59013090	2457444	228368	855245	293215	62847362

SYSTEM : 'P/2 ' RELEASE

THIS RUN HAS BEEN FULLY ACCOUNTED FOR 'UNIOFAZ '

18JUL87 OVERALL ENTRY 1096 MONTH ENTRY 221 TIME =16:41.23

	CPU SECONDS RUN	LAST INTERVAL
EXECUTION	543.95	543.95

2.3 Total Yearly Project Costs Summarized by Facility, Work Breakdown Structure Level 7

This report details the total cost of Conventional Facilities Construction using the Central Design Group's Work Breakdown Structure. Costs are detailed by year and summarized by facility. This report can be used to develop annual project costs for comparison with DOE funding levels.

1+21 Site and Infrastructure
1+22 Campus
1+23 Injector Complex
1+24 Collider Ring
1+25 Experimental Facilities

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
1210000	SITE AND INFRASTRUCT							
902121000	CONSTRUCTION SUPPORT							
		1JAN89 TO 31DEC89	964000	0	0	0	0	964000
21210.00	**TOTAL** CONSTRUCTION SUPPORT		964000	0	0	0	0	964000
992131000	MAIN CAMPUS UTILITIE							
		1JAN89 TO 31DEC89	157347	0	0	0	0	157347
		1JAN90 TO 31DEC90	314695	0	0	0	0	314695
21310.00	**TOTAL** MAIN CAMPUS UTILITIES		472042	0	0	0	0	472042
992142000	ELECTRICAL DISTRIBUT							
		1JAN89 TO 31DEC89	19635000	0	0	0	0	19635000
		1JAN90 TO 31DEC90	19635000	0	0	0	0	19635000
21420.00	**TOTAL** ELECTRICAL DISTRIBUTION		39270000	0	0	0	0	39270000
992151100	WATER/WASTE WATER DI							
		1JAN89 TO 31DEC89	1393750	0	0	0	0	1393750
		1JAN90 TO 31DEC90	4181250	0	0	0	0	4181250
21511.00	**TOTAL** WATER/WASTE WATER DISTRIBUTION		5575000	0	0	0	0	5575000
992171000	AUX SYSTEMS GENERAL							
		1JAN90 TO 31DEC90	10245000	0	0	0	0	10245000
21710.00	**TOTAL** AUX SYSTEMS GENERAL		10245000	0	0	0	0	10245000
992181100	SITE WORK - CAMPUS R							
		1JAN90 TO 31DEC90	12882000	0	0	0	0	12882000
21811.00	**TOTAL** SITE WORK - CAMPUS ROADS		12882000	0	0	0	0	12882000
1+21	**TOTAL** SITE AND INFRASTRUCTURE		69408042	0	0	0	0	69408042
1220000	CAMPUS							
992210000	LAB BUILDING							
		1JAN89 TO 31DEC89	12632690	0	0	0	0	12632690
		1JAN90 TO 31DEC90	6167140	0	0	0	0	6167140
22100.00	**TOTAL** LAB BUILDING		18799830	0	0	0	0	18799830
992221000	HVY WORKS BUILD I -							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923

ARIZONA SSC PROJECT
MARICOPA SITE
FACILITIES ESTIMATE
YEARLY COST SUMMARY

WBS NUMBER	DESCRIPTION	ACC PER	SURFACE BUILD	LABOR	EQUIPMENT	MATERIAL	OVERHEAD & PROFIT	TOTAL DOLLARS
22210.00	**TOTAL** HVY WORKS BUILD I - GENERAL		1399923	0	0	0	0	1399923
992222000	HVY WORKS BUILD II -							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923
22220.00	**TOTAL** HVY WORKS BUILD II - GENERAL		1399923	0	0	0	0	1399923
992223000	HVY WORKS BUILD III							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22230.00	**TOTAL** HVY WORKS BUILD III - GENERAL		899976	0	0	0	0	899976
992224000	HVY WORKS BUILD IV -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22240.00	**TOTAL** HVY WORKS BUILD IV - GENERAL		899976	0	0	0	0	899976
992225000	HVY WORKS BUILD V -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22250.00	**TOTAL** HVY WORKS BUILD V - GENERAL		899976	0	0	0	0	899976
992226000	HVY WORKS BUILD VI -							
		1JAN89 TO 31DEC89	899976	0	0	0	0	899976
22260.00	**TOTAL** HVY WORKS BUILD VI - GENERAL		899976	0	0	0	0	899976
992231000	SHOP BUILD I - GENER							
		1JAN89 TO 31DEC89	499968	0	0	0	0	499968
22310.00	**TOTAL** SHOP BUILD I - GENERAL		499968	0	0	0	0	499968
992232000	SHOP BUILD II - GENE							
		1JAN89 TO 31DEC89	400050	0	0	0	0	400050
22320.00	**TOTAL** SHOP BUILD II - GENERAL		400050	0	0	0	0	400050
992233000	SHOP BUILD III - GEN							
		1JAN89 TO 31DEC89	400050	0	0	0	0	400050
22330.00	**TOTAL** SHOP BUILD III - GENERAL		400050	0	0	0	0	400050
1+22	**TOTAL** CAMPUS		26499648	0	0	0	0	26499648
1230000	INJECTOR							
992241000	WAREHOUSE I - GENERA							
		1JAN89 TO 31DEC89	1399923	0	0	0	0	1399923

PROJECT MIFP2
PLOT MIFP2
PAGE 1 SHEET 3

START 3JAN89
FINISH 17JAN92
DATA DATE 2JAN89

RUN 10JUL87 06:51
PROJECT/2
SCHEDULE BAR CHART

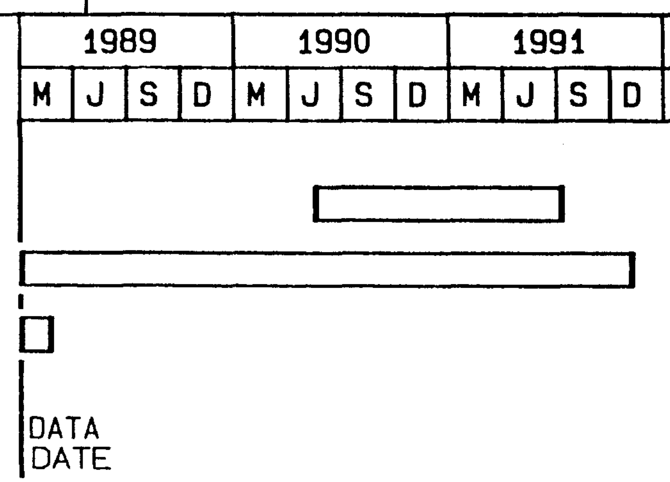
ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
WORK PACKAGE DETAILS

MODE C/FE
INTERVAL: 3 MONTH(S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON SCHEDULE ACTIVITIES

520 EXCAV & SUPPORT POWER ALCOVES
600 SURFACE FACILITIES CONSTRUCTION
810 EXCAVATE CHAMBERS



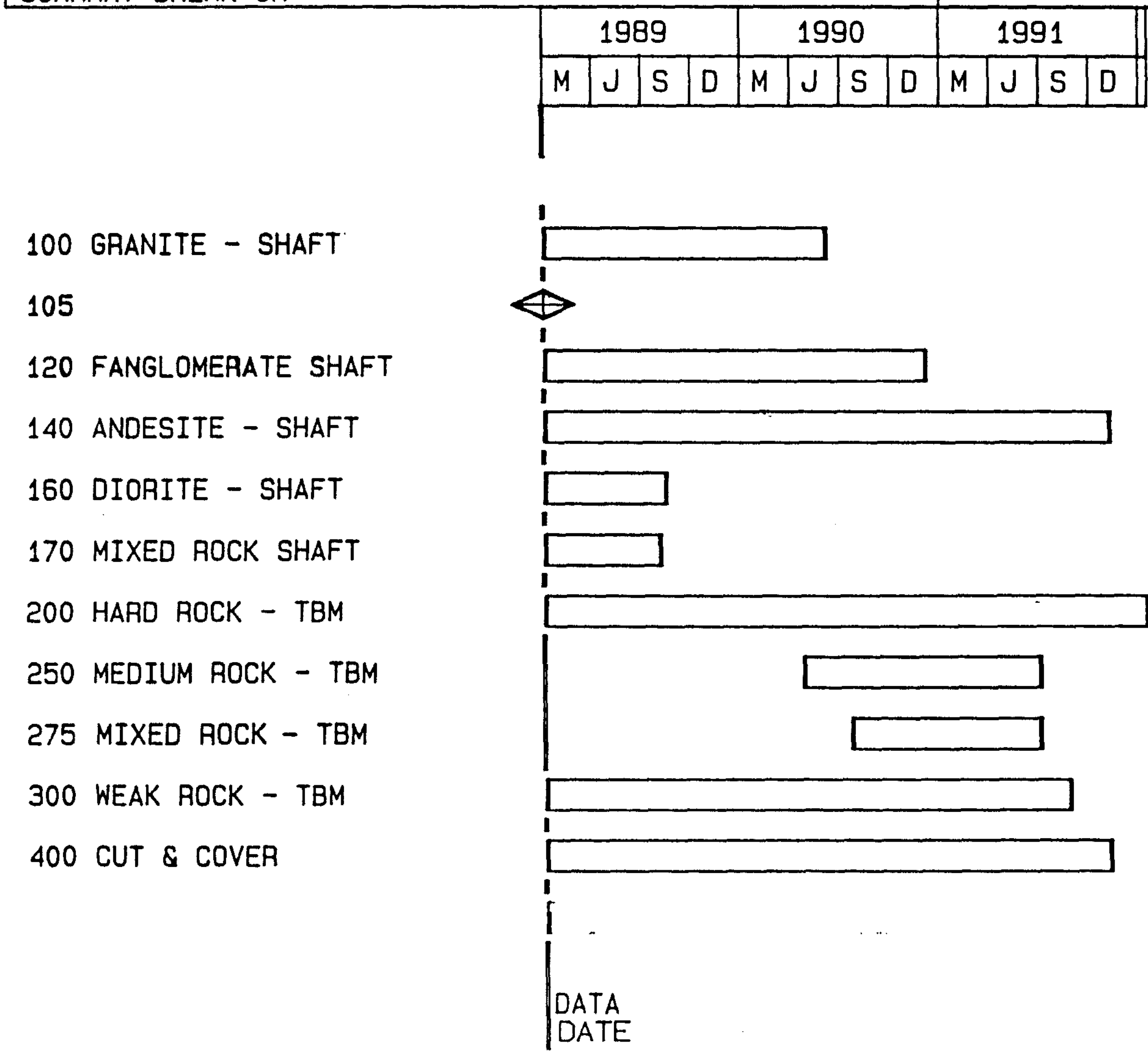
PROJECT SIFP2 PLOT MGEOL PAGE 1 SHEET 1	START 3JAN89 FINISH 17JAN92 DATA DATE 2JAN89		RUN 23JUL87 07: 23 PROJECT/2 SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
GEOLOGY SUMMARY

MODE C/FE
INTERVAL: 3 MONTH (S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON



3.2 INDIVIDUAL SCHEDULES

In this section examples of schedule details are displayed. Construction Unit 6 is used to present the details of a typical Weak Rock Tunnel Contract. Construction Unit 4 is used to present the details of a typical Cut and Fill Contract. Construction Unit 9 is used to present the details of a typical Hard Rock Tunnel Contract. Shaft E5 represents shaft development contracts. The Injection Complex construction is summarized. Finally, Shaft Construction is summarized by sector.

Individual schedules are presented in the following order:

Weak Rock Tunnel Contract #6
Cut-and-Fill Contract #2
Hard Rock Tunnel Contract #9
Shaft E5 Construction
Injector Complex Summary
Shaft Contract Summary

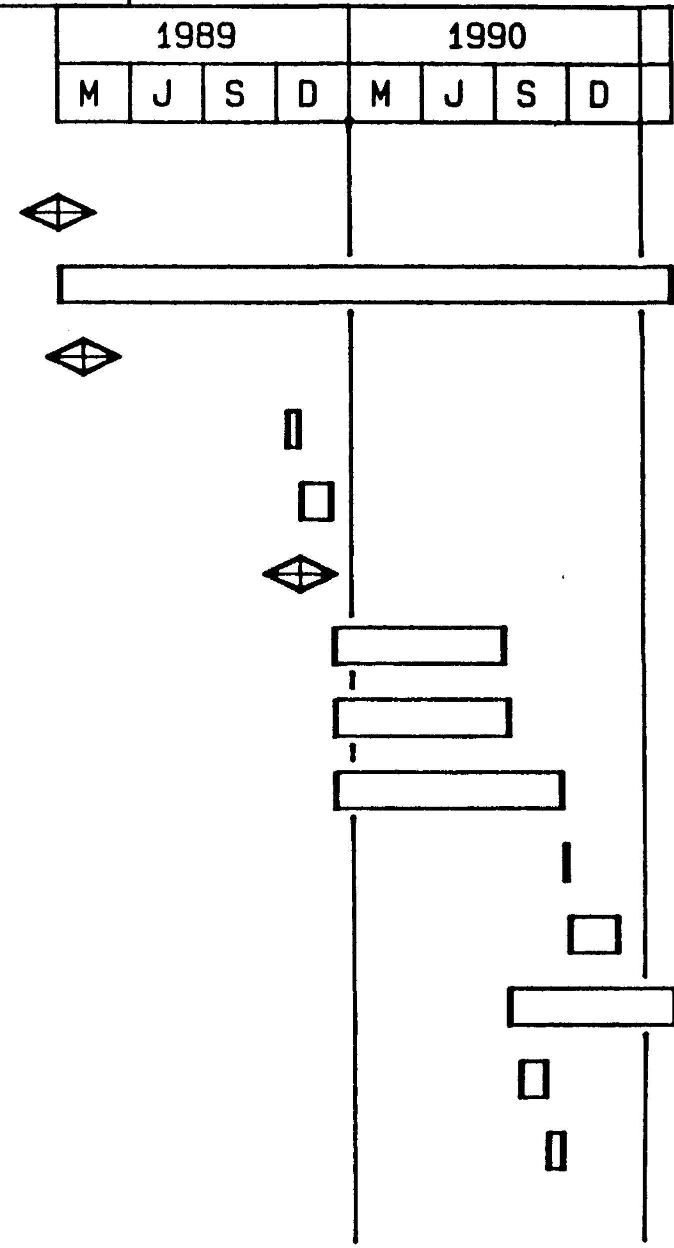
MARICOPA SITE
WEAK ROCK TUNNEL CONTRACT #1 : MP 5.

SUMMARY W O R K I N G SCHEDULE

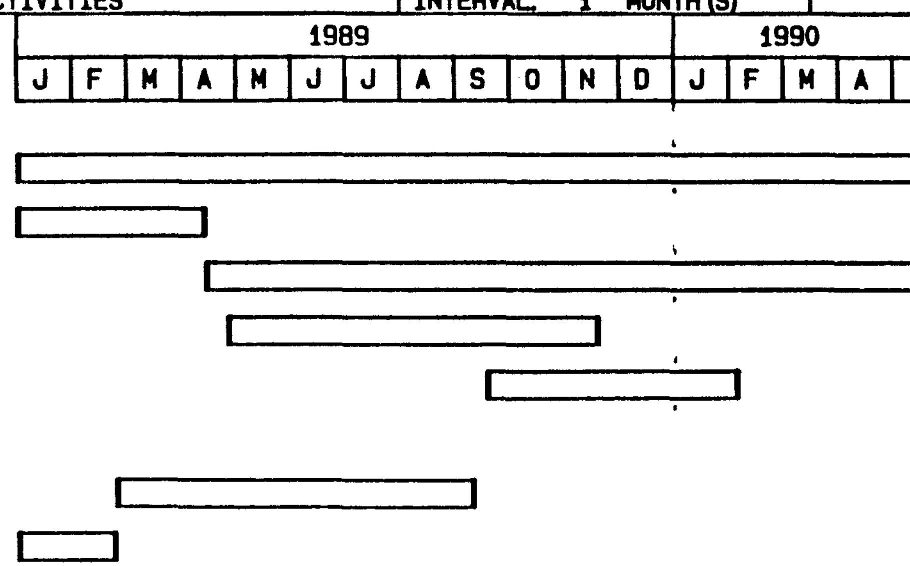
SUMMARY BREAK ON SCHEDULE ACTIVITIES

MODE O/FE
INTERVAL: 3 MONTH(S)

0 MODULE LINK
300 GENERAL TUNNEL DEVELOPMENT
320 SET UP TUNNEL DEVELOPMENT EQUIPMENT
321 EXCAVATE AND SUPPORT STARTING CHAMBE
322 ERECT TUNNEL BORING MACHINE
323 EXCAVATE & SUPPORT TAIL TUNNEL
330 SATURDAY MAINTENANCE
331 EXCAVATE TUNNEL
350 INSTALL FINAL LINER / CONCRETE
351 PLACE SHOTCRETE
352 PLACE INVERT PAVING
380 REMOVE TRAILING FLOOR, FANLINES, & T
510 EXCAV & SUPPORT ELECTRON SHIELDING N
520 EXCAV & SUPPORT POWER ALCOVES



PROJECT MCUT2A PLOT MCUT2A PAGE 1 SHEET 1	ARIZONA SSC PROJECT MARICOPA SITE CUT AND COVER CONTRACT #2 : MP 5.0 -		RUN 10JUL87 06:52 PROJECT/2 SCHEDULE BAR CHART
START 2JAN89 FINISH 14MAY90	SUMMARY W O R K I N G SCHEDULE SUMMARY BREAK ON SCHEDULE ACTIVITIES	MODE 0/FE INTERVAL: 1 MONTH(S)	



400 CUT AND COVER - GENERAL

420 CUT TRENCH

430 STABILIZE TRENCH BOTTOM

440 PLACE CAST IN PLACE PIPE AND STABILI

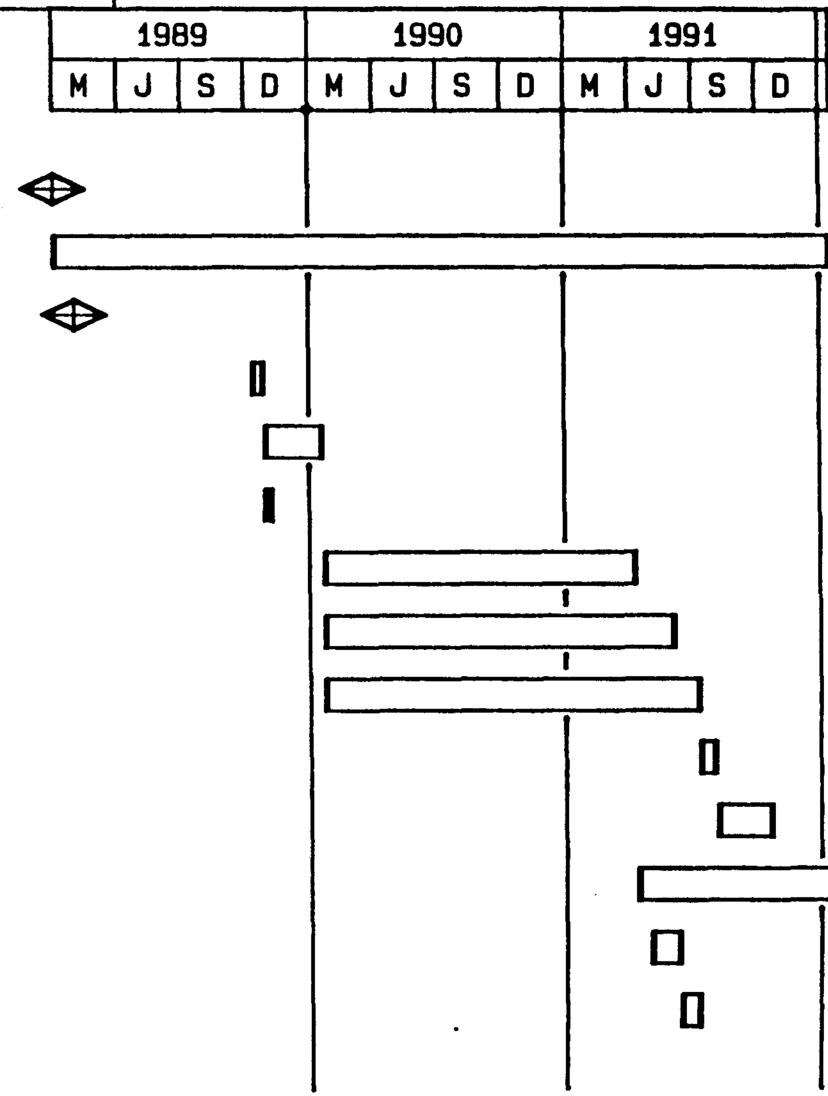
445 PLACE CAST IN PLACE PIPE INVERT

600 SURFACE FACILITIES CONSTRUCTION

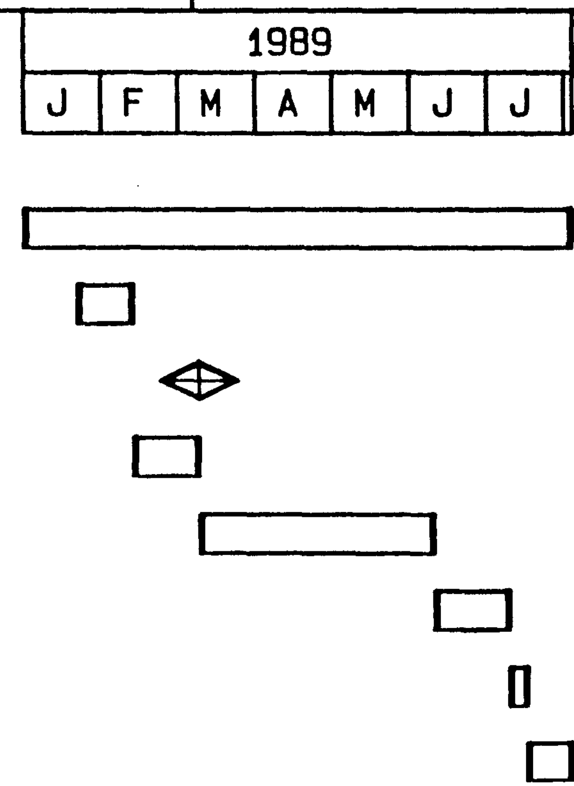
810 EXCAVATE CHAMBERS

PROJECT MTBM9 PLOT MTBM9 PAGE 1 SHEET 1	START 2JAN89 FINISH 16JAN92		RUN 10JUL87 06:54 PROJECT/2 SCHEDULE BAR CHART
ARIZONA SSC PROJECT MARICOPA SITE HARD ROCK TUNNEL CONTRACT #9 : MP 45	MODE O/FE INTERVAL: 3 MONTH(S)		
SUMMARY W O R K I N G SCHEDULE SUMMARY BREAK ON SCHEDULE ACTIVITIES			

0 MODULE LINK
300 GENERAL TUNNEL DEVELOPMENT
320 SET UP TUNNEL DEVELOPMENT EQUIPMENT
321 EXCAVATE AND SUPPORT STARTING CHAMBE
322 ERECT TUNNEL BORING MACHINE
323 EXCAVATE & SUPPORT TAIL TUNNEL
330 SATURDAY MAINTENANCE
331 EXCAVATE TUNNEL
350 INSTALL FINAL LINER / CONCRETE
351 PLACE SHOTCRETE
352 PLACE INVERT PAVING
380 REMOVE TRAILING FLOOR, FANLINES, & T
510 EXCAV & SUPPORT ELECTRON SHIELDING N
520 EXCAV & SUPPORT POWER ALCOVES



PROJECT MSHAFTS PLOT F4 PAGE 1 SHEET 1	START 2JAN89 FINISH 4OCT90		RUN 10JUL87 06:49 PROJECT/2 SCHEDULE BAR CHART
ARIZONA SSC PROJECT MARICOPA SITE SHAFT F4 CONSTRUCTION 320 FEET			MODE O/FE INTERVAL: 1 MONTH (S)
SUMMARY W O R K I N G SCHEDULE			
SUMMARY BREAK ON SCHEDULE ACTIVITIES			



200 SHAFT MOBILIZATION

201 SET UP FOR EXCAVATION

210 SHAFT PRE GROUTING

220 SPUD / COLLAR SHAFT

230 SINK SHAFT

260 MAN WAY FROM SHAFT

270 FURNISH SHAFT / COMMISSION, TEST

280 CLEAR SHAFT & DEMOBILIZE

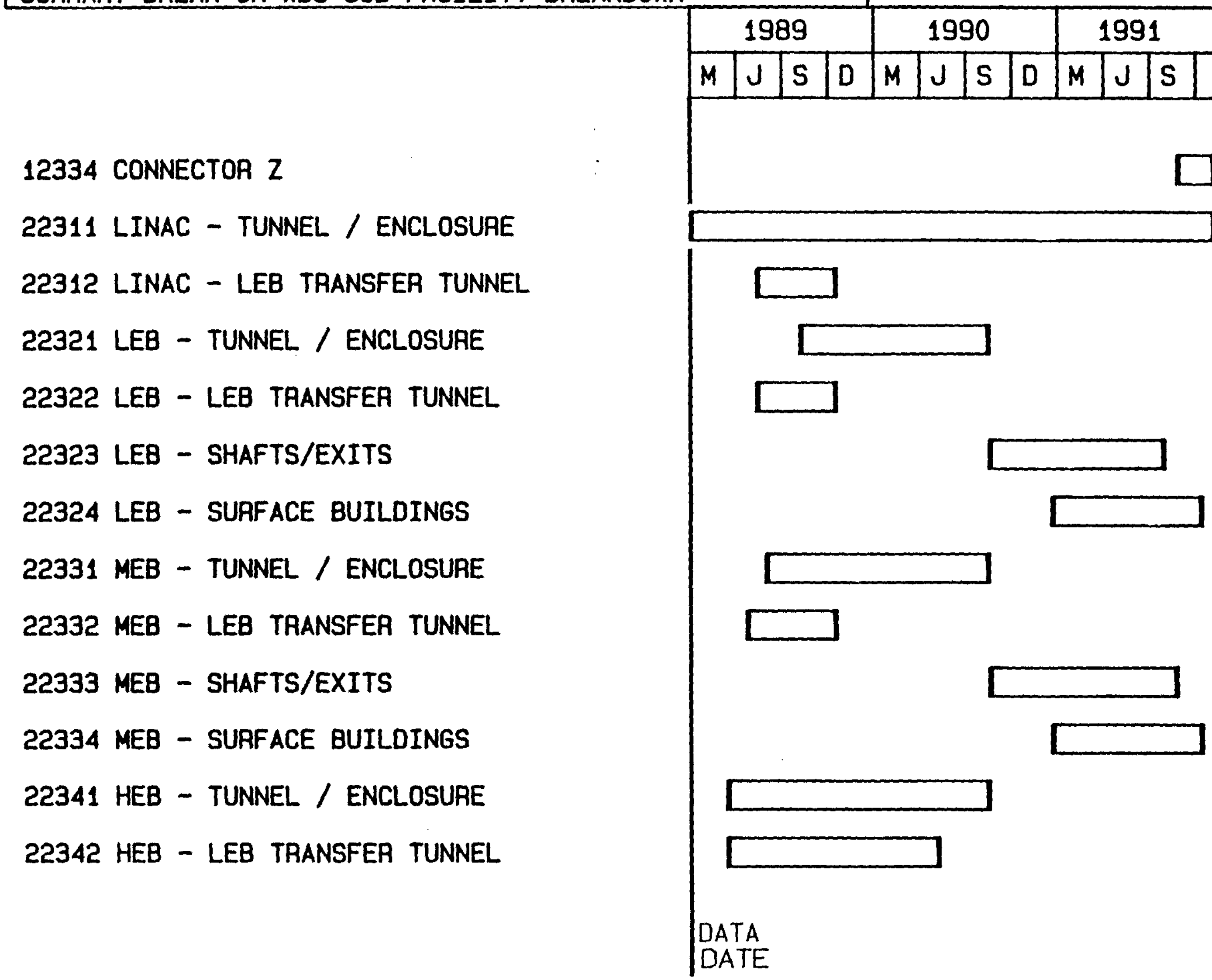
PROJECT SIFP2 PLOT MINJ PAGE 1 SHEET 1	START 3JAN89 FINISH 17JAN92 DATA DATE 2JAN89		RUN 24JUL87 05: 46 PROJECT/2 SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
INJECTOR COMPLEX SUMMARY

MODE C/FE
INTERVAL: 3 MONTH (S)

SUMMARY W O R K I N G SCHEDULE

SUMMARY BREAK ON WBS SUB FACILITY BREAKDOWN



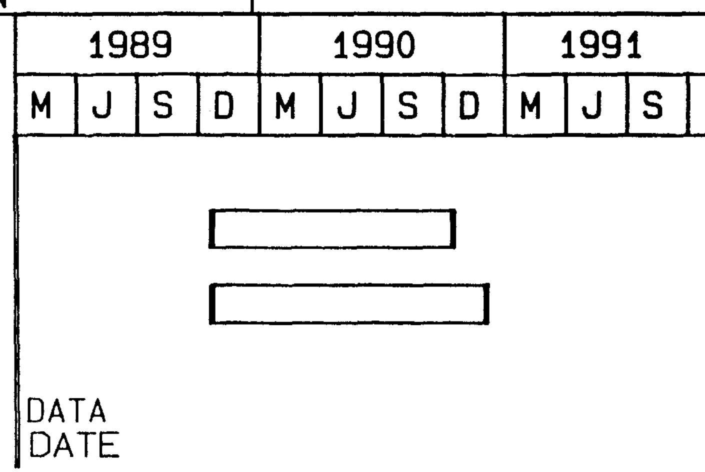
PROJECT SIFP2 PLOT MINJ PAGE 1 SHEET 2	START 3JAN89 FINISH 17JAN92 DATA DATE 2JAN89		RUN 24JUL87 05: 46 PROJECT/2 SCHEDULE BAR CHART

ARIZONA SSC PROJECT
MARICOPA GUNG HO RING SCHEDULE
INJECTOR COMPLEX SUMMARY

MODE C/FE
INTERVAL: 3 MONTH (S)

SUMMARY W O R K I N G SCHEDULE

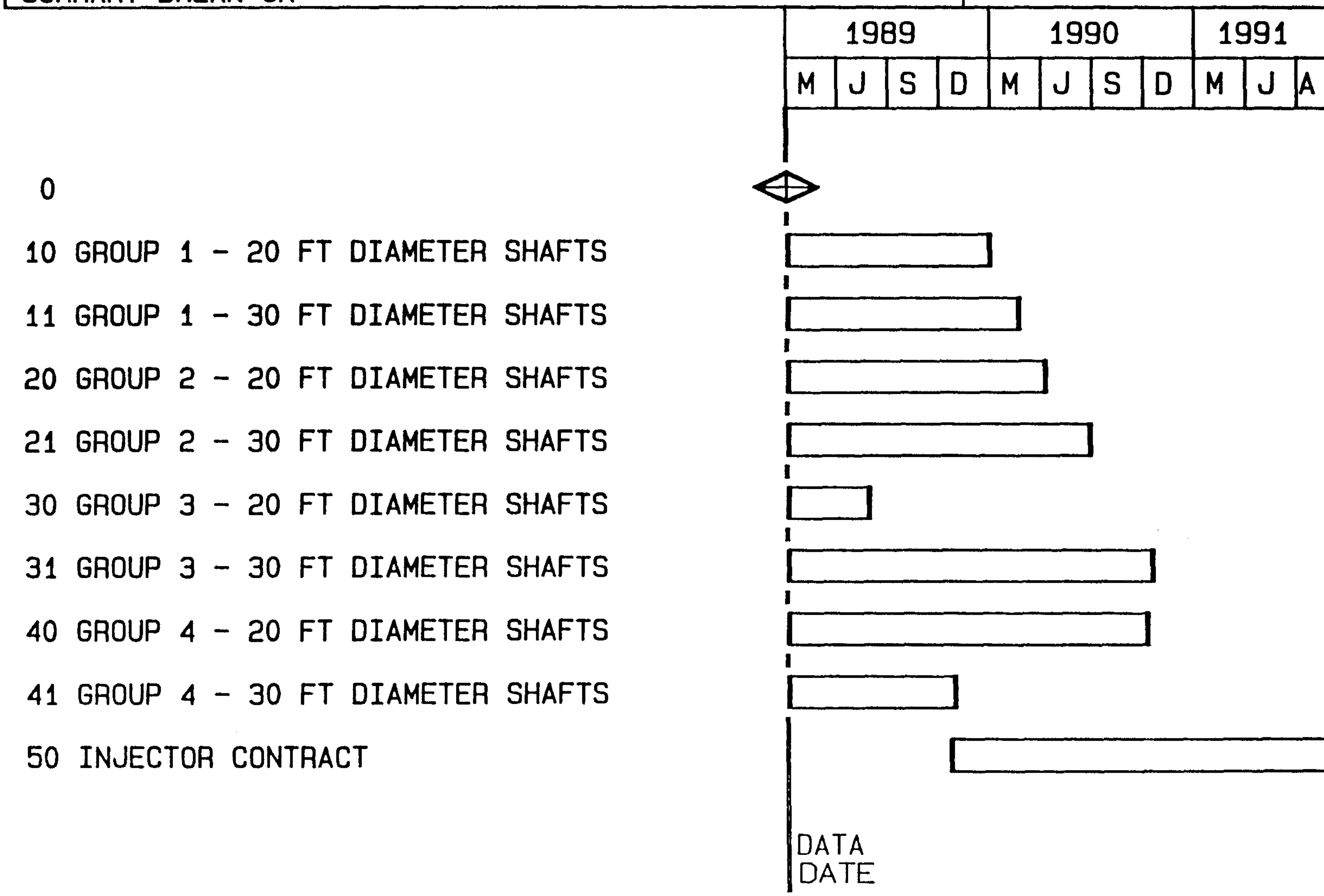
SUMMARY BREAK ON WBS SUB FACILITY BREAKDOWN



22343 HEB - SHAFTS/EXITS

22344 HEB - SURFACE BUILDINGS

PROJECT SIFP2 PLOT MSHAFT PAGE 1 SHEET 1	START 3JAN89 FINISH 17JAN92 DATA DATE 2JAN89		RUN 23JUL87 07:24 PROJECT/2 SCHEDULE BAR CHART
ARIZONA SSC PROJECT MARICOPA GUNG HO RING SCHEDULE SHAFT SUMMARY		MODE C/FE INTERVAL: 3 MONTH(S)	
SUMMARY W O R K I N G SCHEDULE			
SUMMARY BREAK ON			



4.0 TUNNEL COST ESTIMATE

This section gives an example of the Tunnel Construction Cost estimating process. The basis of estimate is presented followed by detailed background calculations for each of the major sections of the estimate for Construction Unit 3.

Tunnel cost estimates are presented in the following order:

4.1 Basis of Tunneling Estimate

4.2 Background Calculations:
Rock Support
TBM Penetration Rate
Ventilation Calculation
Haulage Assumptions
Takeoffs
Locomotive Calculations
Haulage Calculations by Construction Unit
TBM Excavation Progress by Construction Unit
Excavation Summary
Calculated Durations by Construction Unit
Cost Input Sheet
Cost Estimate for Construction Unit #3

Maricopa Site ...... BASIS OF ESTIMATE

See Excavation Summary sheets for method of construction access, direction of tunnel excavation, tunnel length and size, and excavation and support methods for each site.

Finished diameter of tunnels is 10'-0". Excavated diameter of tunnels in soft rock is 11'-0"; tunnels in hard rock are excavated 11'-0" when anticipated to require steel set supports, otherwise they are excavated 10'-0".

Except for short stretches, the tunnels all are on curve.

The first 300' of every tunnel is excavated by conventional methods to provide a starting chamber for the tunneling machine. With shaft access, a 200' long tail tunnel is also excavated conventionally. These footages are not deducted from the tunnel boring machine footages.

Hard and medium rock TBM <u>penetration</u> is based on tests and advice from The Robbins Company. Soft rock TBM penetration is calculated from recent research findings at the Colorado School of Mines presented at the 1987 RETC.

TBM <u>production</u> is calculated using delay factors based on personal experience while Project Manager at River Mountains and Navajo 3 tunnels as well as on analysis of data from Patricia N. Nelson thesis.

Hard rock tunnels are unlined, except in fault zones, which are supported with steel sets; a final lining of shotcrete is added to steel set supported sections after excavation is complete.

Soft rock tunnels are supported with precast, expanded concrete segments, which form the final lining. Segments are erected under a 240 degree tail shield.

Muck haulage is by rail. Locomotive size and horsepower calculations are made for each tunnel. AP type bearings, providing muck car rolling resistance of 10 #/Ton are used. This type of bearing is provided on ASEA cars and is currently in use at the Henderson Molybdenum Mine and the Foundation-Atlas-Healy contract for the East end of the Selkirk Tunnel in Alberta. These bearings were used by Healy on their large TARP tunnel.

Muck removal at tunnel access:

Box Portals: Rotary dump in 200' long open cut. Dumps into surge hopper over apron feeder that feeds belt conveyor to large storage pile. Loaded into trucks by FEL.

Shaft: Lift boxes off muck cars with Card type skip cartridge and headframe and hoist. Dump into large storage pile. Loaded into trucks by FEL.

Groundwater inflow is 1 GPM per 100 feet of tunnel in medium and hard rock.

The inflow is not concentrated enough in any one area to require grouting. The tunnels in soft rock (cemented alluvium above the water table) are dry.

An intermediate shaft is assumed to be available for ventilation exhaust on the longer contracts.

The cost of excavation and support of electron shielding nitches, power alcoves is included in these estimates, as well as the final, 7 foot wide, concrete invert with drainage gutter.

All underground work is scheduled for three shifts a day, at eight hours a shift, five days a week, plus a Saturday maintenance shift.

Labor cost, based on the current Union Contract covering Mine Development and including fringe benefits, portal pay, insurance, taxes, incidental overtime, and contractor's markup (50% of total labor): $308.00 per man-shift.

The following classifications will not be required by the labor agreement: compressor, man-elevator and pump operators, operator foreman and crane and hoist oilers.

Estimates are based on June, 1987 costs. Equipment and spare parts prices are factored to a projected BLS Construction Machinery Index of 371. No escalation is included in these costs.

Muck disposal is sub-contracted at $4.00 per solid cubic yard for truck haul to disposal within 10 miles.

Five inch thick, precast concrete segments for the soft rock tunnels are fabricated on site by a sub-contractor for $100 per foot of tunnel. These segments have plain joints. There are no connections between segments.

For safety, a continuous 6 foot wide strip of #11 gage chain link fabric is secured along the back of all unlined rock tunnels.

Material prices:

chain link fabric	$ .35 per SF
chain link fabric bolts	2.00 per each
shotcrete materials	80.00 per CY
resin anchor rock bolts	1.50 per LF
steel sets	.55 per lb
transit mix concrete	60.00 per CY

3000 KVA of electric power at 15,000 volts is provided by others at each tunnel portal. Cost is $0.04 per kwh.

Construction access roads to each site are provided by others.

Water, for construction use, is provided by others at each work site.

Material and parts and supplies prices include freight. Freight is added as a separate item to Plant & Equipment costs.

No state sales tax is included.

Public Liability and Property Damage insurance cost is not included. This is covered elsewhere as Wrap-up insurance.

Contingencies suggested to be added to these estimated costs at this time are:

	Maricopa	Sierrita
Bidding Contingency	10%	10%
Specification "	0	0
Design "	0	0
Supply-Demand "	5	5
Geotechnical "	5 to 20	5 to 30
Total Contingency	20 to 35%	20 to 45%

See the Rock Support and Final Lining tabulation for suggested Geotechnical Contingency for each contract.

P. E. Sperry
June 3, 1987

CONTRACT NUMBER	EXCAVATED DIAMETER feet	MAXIMUM COVER feet	LENGTH MEDIUM ROCK feet	HARD ROCK feet	WATER TABLE BELOW TUNNEL	GEOTECH CONTIN-GENCY percent	ROCK CLASSIFICATION PERCENT III	IV	FOOTAGE I bald feet	II spot bolts feet	III pattern bolts & CLF feet	rows	IV sets feet	each	TOTALS feet	ROUNDED LENGTH OF FINAL LINING CLASS III & IV feet	STARTING CHAMBER feet	TAIL TUNNEL feet	TOTAL feet
MARICOPA																			
1 soft	11	250			Yes	10											300		300
2 cut & cover					Yes	0													0
3 soft +	11	200		7,392	Yes	15	5.0	1.0	6,948		370	92	74	18	7,392	440	300		740
4 soft +	11	300		3,696	Yes	15	5.0	2.0	3,437		185	46	74	18	3,696	260	300		560
5 soft +	11	550	10,824		Yes	20	3.0	1.0		10,391	325	81	108	27	10,824	430	300	200	930
6 soft	11	300			Yes	5						0		0	0	0	300		300
7 cut & cover					Yes							0		0	0	0			0
8 soft +	11	250		4,224	Yes	15	5.0	2.0	3,928		211	53	84	21	4,224	300	300		600
9 all hard	10	1,100		38,016	Yes	10	2.0	0.0	37,256		760	190	0	0	38,016	760	300	200	1260
												0		0	0				0
TOTALS			13,850	53,328			2.9	0.5	51,570	10,391	1,851	463	341	85	64,152	2,190	2,100	400	4,690

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ROCK CLASSIFICATION	ROCK SUPPORTS
I bald	1 rock bolt every 250'. All medium rock except shears and faults.
II spot bolts	1 rock bolt every 25'. All hard rock except shears and faults.
III shear zone	Split sets & clf + shotcrete final lining.
IV fault zone	Sets with structural fabric + shotcrete final lining.

NOTE: All tunnels supported with steel sets must be excavated 11' diameter to provide a 10' final lining.

ROCK	HORSEPOWER-HOUR PER TON	ROCK	#/TON	ROCK	#/TON
COLORADO SCHOOL OF MINES	1.5	CALICHE	2430	SHALE	4450
NEVADA TEST SITE TUFF	2.5	POTASH	3700	QUARTZITE	4520
SOFT ROCK	4.0 - 5.0	CONGLOMERATE	3720	GRANITE	4540
MEDIUM ROCK	5.0 - 6.0	RHYOLITE	4050	GNEISS	4550
HARD ROCK	6.0 - 8.0	CHALK	4060	DOLOMITE	4870
		LIMESTONE	4380	DIORITE	5220

ARIZONA HARD ROCK TBM diameter: 11.0 feet

WEIGHT OF ROCK	#/Ton	5220	5220	5220	5220	5220	5220
TBM HORSEPOWER	HP	700	800	800	900	900	900
HP-HR/TON	HP-hr/Ton	8.0	7.0	8.0	7.0	7.5	8.0
PENETRATION	feet/hour	7.1	9.3	8.2	10.5	9.8	9.2

ARIZONA HARD ROCK TBM diameter: 10.0 feet

WEIGHT OF ROCK	#/Ton	5220	5220	5220	5220	5220	5220
TBM HORSEPOWER	HP	700	800	800	900	900	900
HP-HR/TON	HP-hr/Ton	8.0	7.0	8.0	7.0	7.5	8.0
PENETRATION	feet/hour	8.6	11.3	9.9	12.7	11.8	11.1

ARIZONA MEDIUM ROCK TBM diameter: 11.0 feet

WEIGHT OF ROCK	#/Ton	4400	4400	4400	4400	4400	4400	4400
TBM HORSEPOWER	HP	700	800	800	800	900	900	900
HP-HR/TON	HP-hr/Ton	5.0	5.5	6.0	6.0	5.5	6.0	7.0
PENETRATION	feet/hour	13.6	14.1	12.9	12.9	15.8	14.5	12.4

ARIZONA MEDIUM ROCK TBM diameter: 10.0 feet

WEIGHT OF ROCK	#/Ton	4400	4400	4400	4400	4400	4400	4400
TBM HORSEPOWER	HP	700	800	800	800	900	900	900
HP-HR/TON	HP-hr/Ton	5.0	5.5	6.0	6.0	5.5	6.0	7.0
PENETRATION	feet/hour	16.4	17.0	15.6	15.6	19.2	17.6	15.1

ARIZONA SOFT ROCK TBM diameter: 11.0 feet

WEIGHT OF ROCK	#/Ton	3000	3000	3000	3000	3000	3000	3000
TBM HORSEPOWER	HP	600	600	600	700	700	700	700
HP-HR/TON	HP-hr/Ton	1.5	2.0	2.4	2.5	2.8	3.0	3.5

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PENETRATION	feet/hour	56.8	42.6	35.0	39.8	35.5	33.1	28.4

ARIZONA SOFT ROCK TBM diameter: 11.0 feet

WEIGHT OF ROCK	#/Ton	3500	3500	3500	3500	3500	3500	3500	3500
TBM HORSEPOWER	HP	600	600	700	700	700	700	800	800
HP-HR/TON	HP-hr/Ton	1.5	2.1	1.5	2.0	2.4	2.5	3.0	3.5
PENETRATION	feet/hour	48.7	35.0	56.8	42.6	35.5	34.1	32.5	27.8

A	B	C	D	E	F	G	H
2							
3 VENTILATION CALCULATION							
4							
5 FORMULA ASSUMPTIONS							
6 minimum of 2 locomotives operate in tunnel.							
7 air velocity in fanline is 3500 FPM							
8							
9		AVAILABLE ENGINES	------------	------------	------------	------------	------------
10 LOCOMOTIVE ENGINE MAKE		DEUTZ	DEUTZ	CAT	CAT	CAT	CAT
11 LOCOMOTIVE ENGINE MODEL		F4L912W	F6L912W	3304NA	3304NA	3304NA	3304NA
12						TANDEM	
13 LOCOMOTIVE HORSEPOWER:		51	80	110	110	220	110
14							
15 MAX. # OF LOCOMOTIVES OPERATING:		2	2	2	2	2	3
16 PERSONNEL IN TUNNEL. EA		15	15	15	15	15	15
17							
18 VENT REQ'D FOR PERSONNEL, CFM		3000	3000	3000	3000	3000	3000
19 VENT REQ'D 1st LOCO, CFM		6120	9600	9020	9020	18040	9020
20 VENT REQ'D FOR 2nd LOCO, CFM		4590	7200	6765	6765	13530	6765
21 VENT REQ'D FOR ADDL LOCOS, CFM		0	0	0	0	0	4510
22							
23 TOTAL VENT REQ'D, CFM		13710	19800	18785	18785	34570	23295
24							
25 FANLINE DIAMETER - INCHES:		28	34	32	34	40	36
26 FRICTION/100' OF FANLINE		0.47	0.38	0.44	0.32	0.45	0.36
27 FAN SPACING - FEET:		3000	3000	3000	3000	3000	3000
28 WATER GAGE		14.10	11.40	13.20	9.60	13.50	10.80
29							
30 FAN DIAMETER		23.0	36.0	25.0	36.0	38.0	36.0
31 FAN SIZE		17.5	26.5	17.5	26.5	26.5	26.5
32 BLADE SETTING		4	6	2	8	0	4
33 FAN HORSEPOWER		60	50	90	50	120	60
34				---------			
35							

36 NOTES

37

38 Choose fanline diameter from Trane Ductulator @ calc volume at 3500 FPM duct velocity.

39

40 Determine friction from Ductulator @ fanline diameter & calculate volume.

41

42 Choose fan @ volume, water gage and mid-horsepower range for the blade setting.

HAULAGE ASSUMPTIONS

1. Average haul speed MPH

	loaded	empty
maximum with adverse grade	12	15
maximum with flat grade	13	15
maximum with favorable grade	15	15

2. Haulage is designed to not delay TBM.
3. TBM production calculations are based on TBM being delayed by haulage 20 minutes a day.
4. Haulage based on use of trailing floor, with car shifter, pulled behind TBM.
5. Rolloing resistance of train based on use of AP bearings in muck cars.
6. California switches are set so empty train always waits for loaded train on California switch.
7. Haulage steps with increasing length of haul.

SUMMARY OF HAULAGE STEPS

	Locos	Car Mover	Trains	Calif Switch
1. One locomotive and two trains.	1		2	
2. Add car mover at shaft/portal and 3rd train.	1	X	3	
3. Add 2nd loco and 1st Calif. switch, delete car mover. Add delay to dump cars and to pass on California.	2		3	1
4. Add car mover at shaft/portal and 4th train.	2	X	4	1
5. Add 3rd loco and 2nd Calif. switch, delete car mover. Add delay to dump cars and to pass on California.	3		4	2
6. Add car mover at shaft/portal and 5th train.	3	X	5	2
7. Add 4th loco and 3rd Calif. switch, delete car mover. Add delay to dump cars and to pass on California.	4		5	3

CONTRACT NUMBER	MILE POST	CUT & COVER	SOFT ROCK TBM	MED ROCK TBM	HARD ROCK TBM	TOTAL LENGTH OF CONTR	WORK SHAFT DEPTH FEET	EXCAV UP OR DOWN GRADE	MAX GRADE %	LOADED HAUL	CUT & COVER	SOFT ROCK TBM	MED ROCK TBM	HARD ROCK TBM	TOTAL LENGTH OF CONTR
		LENGTH IN MILES									LENGTH IN FEET				
1	52.20							/\			0	0	0	0	0
	52.80		0.60			0.60		|			0	3,168	0	0	3,168
	0.00							|			0	0	0	0	0
	5.00		5.00			5.00	BOX	DOWN	0.47	ADVERSE	0	26,400	0	0	26,400
	TOTALS		5.60		0.00	5.60					0	29,568	0	0	29,568
	%	0	100	0	0	100									
2	5.00						CUT & COVER								
	12.80	7.80				7.80					41,184	0	0	0	41,184
	%	100	0	0	0	100									
3	12.80						BOX	UP	0.28	FAVORABLE					
	14.20				1.40	1.40		|			0	0	0	7,392	7,392
	15.30		1.10			1.10		|			0	5,808	0	0	5,808
	TOTALS		1.10		1.40	2.50		\/			0	5,808	0	7,392	13,200
	%	0	44	0	56	100									
4	15.30						BOX	UP	0.28	FAVORABLE					
	16.30		1.00			1.00		|			0	5,280	0	0	5,280
	17.00				0.70	0.70		|			0	0	0	3,696	3,696
	21.30		4.30			4.30		|			0	22,704	0	0	22,704
	TOTALS	0.00	5.30	0.00	0.70	6.00		\/			0	27,984	0	3,696	31,680
	%	0	88	0	12	100									
5	21.30							/\							
	25.40		2.05	2.05		4.10	350'	|			0	10,824	10,824	0	21,648
	28.80		3.40			3.40	SHAFT	UP	0.42	FAVORABLE	0	17,952	0	0	17,952
	TOTALS	0.00	5.45	2.05	0.00	7.50					0	28,776	10,824	0	39,600
	%	0	73	27	0	100									
6	28.80							/\							

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TAKEOFF

CONTRACT NUMBER	MILE POST	CUT & COVER	SOFT ROCK TBM	MED ROCK TBM	HARD ROCK TBM	TOTAL LENGTH OF CONTR	WORK SHAFT DEPTH FEET	EXCAV UP OR DOWN GRADE	MAX GRADE %	LOADED HAUL	CUT & COVER	SOFT ROCK TBM	MED ROCK TBM	HARD ROCK TBM	TOTAL LENGTH OF CONTR
	37.40		8.60			8.60	BOX	UP	0.42	FAVORABLE	0	45,408	0	0	45,408
	%	0	100	0	0	100									
7	37.40														
	41.50	4.10				4.10	CUT & COVER				21,648	0	0	0	21,648
	%	100	0	0	0	100									
8	41.50						BOX	DOWN	0.28	ADVERSE					
	42.30				0.80	0.80		|			0	0	0	4,224	4,224
	45.00		2.70			2.70		\/			0	14,256	0	0	14,256
	TOTALS	0.00	2.70	0.00	0.80	3.50					0	14,256	0	4,224	18,480
	%	0	77	0	23	100									
9	45.00						350'	FLAT	0.09	ADVERSE					
	52.20				7.20	7.20	SHAFT	\/			0	0	0	38,016	38,016
	%	0	0	0	100	100									
GRAND TOTAL		11.90	28.75	2.05	10.10	52.80					62,832	151,800	10,824	53,328	278,784
										PERCENT	23	54	4	19	100

A	B	C	D	E	F	G	H	I	J	K
2										
3		LOCOMOTIVE CALCULATIONS								
4										
5		CONTRACT NUMBER		1	3	4	5	6	8	9
6		ROCK TYPE AT MAXIMUM HAUL		SOFT	SOFT	SOFT	SOFT	SOFT	SOFT	HARD
7		MUCK REMOVAL VIA		BOX	BOX	BOX	350'	BOX	BOX	350'
8				PORTAL	PORTAL	PORTAL	SHAFT	PORTAL	PORTAL	SHAFT
9										
10	*	EXCAVATED DIAMETER	FEET	11.0	11.0	11.0	11.0	11.0	11.0	10.0
11	*	WEIGHT OF ROCK AT MAXIMUM HAUL	#/SCY	3500	3500	3500	3500	3500	3500	5220
12	*	SWELL FACTOR	%	80	80	80	80	80	80	80
13		LOOSE MUCK PER TUNNEL FOOT	LCY/TF	6.3	6.3	6.3	6.3	6.3	6.3	5.2
14										
15	*	STROKE OF TBM	FEET	4.0	4.0	5.0	5.0	4.0	5.0	5.0
16		UTILIZED STROKE OF TBM @ MAX HAUL	FEET	3.50	3.50	3.50	3.50	3.50	3.50	4.75
17		LOOSE MUCK PER STROKE	LCY	22.2	22.2	22.2	22.2	22.2	22.2	24.9
18	*	TBM STROKES PER TRAIN	EA	2	2	2	2	2	2	2
19										
20		MUCK CAR TYPE		ROTARY	ROTARY	ROTARY	LIFTOFF	ROTARY	ROTARY	LIFTOFF
21	*			DUMP	DUMP	DUMP		DUMP	DUMP	
22	*	MUCK CAR WT PER CY	TONS	0.35	0.35	0.35	0.35	0.35	0.35	0.35
23	*	MUCK CAR CAPACITY	CY	14.6	14.6	14.6	8.8	14.6	14.6	8.8
24		MUCK CARS REQUIRED PER STROKE	EA	1.5	1.5	1.5	2.5	1.5	1.5	2.8
25	*	MUCK CARS PROVIDED PER STROKE	EA	1.5	1.5	1.5	2.5	1.5	1.5	3.0
26	*	SUPPLY CARS REQUIRED PER STROKE	EA	1	1	1	1	1	1	0
27		SUPPLY CAR WEIGHT EMPTY	TONS	1.0	1.0	1.0	1.0	1.0	1.0	1.0
28	*	SUPPLY CAR LOAD	TONS	3.5	3.5	3.5	3.5	3.5	3.5	3.5
29										
30		EMPTY TRAILING TRAIN WEIGHT	TONS	24.3	24.3	24.3	24.4	24.3	24.3	18.5
31		LOADED TRAILING TRAIN WEIGHT	TONS	67.5	67.5	67.5	67.5	67.5	67.5	90.6
32										
33	*	MAXIMUM EMPTY ADVERSE GRADE OR FLAT	%	0.00	0.28	0.28	0.42	0.42	0.00	0.21
34	*	MAXIMUM LOADED ADVERSE GRADE OR FLAT	%	0.47	0.00	0.00	0.00	0.00	0.28	0.09
35										
36	*	DRAW BAR PULL (see table below)	%	480	480	480	480	480	480	480
37	*	ACCELERATION FACTOR		0.20	0.20	0.20	0.20	0.20	0.20	0.20

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\LOCO

A	B	C	D	E	F	G	H	I	J	K
38										
39		CALC LOCO WT - EMPTY	TONS	2.1	2.4	2.4	2.6	2.5	2.1	1.7
40		CALC LOCO WT - LOADED	TONS	7.2	5.7	5.7	5.7	5.7	6.6	8.1
41		LOCO WEIGHT PROVIDED	TONS	10.0	8.0	8.0	8.0	8.0	8.0	10.0
42										
43	*	ROLLING RESISTANCE	#/Ton	10	10	10	10	10	10	10
44	*	DESIGN SPEED	MPH	17.0	18.0	18.0	18.0	18.0	18.0	18.0
45										
46		CALC LOCO HORSEPOWER - EMPTY	HP	19	30	30	36	36	19	24
47		CALC LOCO HORSEPOWER - LOADED	HP	85	45	45	45	45	71	71
48		REQUIRED LOCO HP (calc x 1.15)	HP	98	52	52	52	52	81	82
49		LOCO HORSEPOWER PROVIDED	HP	110	110	110	110	110	110	110
50										
51		LOCO ENGINE PROVIDED	CAT	3304NA	3304NA	3304NA	3304NA	3304NA	3304NA	3304NA
52		REQUIRED VENTILATION PER LOCO	CFM	9000	9000	9000	9000	9000	9000	9000
53										
54										
55		COEFICIENT OF ADHESION	DRAWBAR PULL							
56		20% (wet track)	380 #/T							
57		25% (dry track)	480 #/T							
58		30% (sanded track)	580 #/T	Rolling resistance based on AP bearings in muck cars.						

HAULAGE CALCULATION — CONTRACT #1

SOFT ROCK WITH BOX PORTAL ACCESS

GRADE ADVERSE	0.47 percent		TRAVEL SPEED LOADED (OUT)	12 MPH
TOTAL LENGTH OF HEADING	29,568 feet		EMPTY (IN)	15 MPH
TBM PENETRATION RATE	35.0 FPH		MUCK CARS PER TRAIN	3 each
TBM EFFECTIVE STROKE	3.5 feet		INBOUND WAIT TO PASS ON SWITCH	5 min
TBM REGRIP TIME	2.5 min		ROTARY DUMP CYCLE	3 min/car
TBM STROKES PER TRAIN	2 each		SWITCH TIME AT PORTAL	
SEGMENT DELAY PER RING	5 min		ONLY SUPPLY CARS	3 min
SWITCH AT HEADING	2 min		MUCK & SUPPLY CARS	5 min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	6	9	9	12	12	15	15
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0
MAXIMUM LENGTH OF HEADING	feet	6,460	12,930	19,400	25,900	29,568		
TUNNEL BORING MACHINE CYCLE		min	min	min	min	min		
REGRIP TWICE		5.0	5.0	5.0	5.0	5.0		
EXCAVATE		12.0	12.0	12.0	12.0	12.0		
SET SEGMENT DELAY		10.0	10.0	10.0	10.0	10.0		
TOTAL		27.0	27.0	27.0	27.0	27.0		
HAULAGE CYCLE								
SWITCH AT HEADING		2.0	2.0	2.0	2.0	2.0		
TRAVEL OUT		6.1	12.2	18.4	24.5	28.0		
DUMP CARS		9.0	0.0	9.0	0.0	9.0		
SWITCH AT PORTAL		5.0	3.0	5.0	3.0	5.0		
TRAVEL IN		4.9	9.8	14.7	19.6	22.4		
WAIT ON CALIFORNIA SWITCH		0.0	0.0	5.0	5.0	10.0		
TOTAL		27.0	27.0	54.1	54.1	76.4		

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TOTAL PER TRAIN	27.0	27.0	27.0	27.1	25.5
DELAY	0	0	0	0	-2

EQUIPMENT TO PURCHASE	
SPARE MUCK CARS	1
SPARE SUPPLY CARS	1
SPARE LOCOMOTIVES	2
TOTAL MUCK CARS	13
TOTAL SUPPLY CARS	9
TOTAL LOCOMOTIVES	5

AVERAGE NUMBER OF MOTORMEN & LOCOS	1.69
AVERAGE NUMBER OF CAR MOVER OPERATORS	0.44
AVERAGE NUMBER OF MUCK CARS IN USE	9.38

HAULAGE CALCULATION CONTRACT # 3

SOFT ROCK WITH BOX PORTAL ACCESS

GRADE FAVORABLE	0.28 percent	TRAVEL SPEED LOADED (OUT)		15 MPH
TOTAL LENGTH OF HEADING	13,200 feet		EMPTY (IN)	15 MPH
TBM PENETRATION RATE	35.0 FPH	MUCK CARS PER TRAIN		3 each
TBM EFFECTIVE STROKE	3.5 feet	INBOUND WAIT TO PASS ON SWITCH		5 min
TBM REGRIP TIME	2.5 min	DUMP CYCLE	ROTARY	3 min/car
TBM STROKES PER TRAIN	2 each	SWITCH TIME AT PORTAL/SHAFT		
SEGMENT DELAY PER RING	5 min		ONLY SUPPLY CARS	3 min
SWITCH AT HEADING	2 min		MUCK & SUPPLY CARS	5 min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	6	9	9	12	12	15	15
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0
MAXIMUM LENGTH OF HEADING	feet	7,270	13,200					
TUNNEL BORING MACHINE CYCLE		min	min					
REGRIP TWICE		5.0	5.0					
EXCAVATE		12.0	12.0					
SET SEGMENT DELAY		10.0	10.0					
TOTAL		27.0	27.0					
HAULAGE CYCLE								
SWITCH AT HEADING		2.0	2.0					
TRAVEL OUT		5.5	10.0					
DUMP CARS		9.0	0.0					
SWITCH AT PORTAL/SHAFT		5.0	3.0					
TRAVEL IN		5.5	10.0					
WAIT ON CALIFORNIA SWITCH		0.0	0.0					
TOTAL		27.0	25.0					

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TOTAL PER TRAIN		27.0	25.0
DELAY		0	-2

EQUIPMENT TO PURCHASE		AVERAGE NUMBER OF MOTORMEN & LOCOS	1.00
SPARE MUCK CARS	1	AVERAGE NUMBER OF CAR MOVER OPERATORS	0.45
SPARE SUPPLY CARS	1	AVERAGE NUMBER OF MUCK CARS IN USE	7.35
SPARE LOCOMOTIVES	2		
TOTAL MUCK CARS	10		
TOTAL SUPPLY CARS	7		
TOTAL LOCOMOTIVES	3		

HAULAGE CALCULATION — CONTRACT # 4

SOFT ROCK WITH BOX PORTAL ACCESS

GRADE FAVORABLE	0.28	percent
TOTAL LENGTH OF HEADING	31,680	feet
TBM PENETRATION RATE	35.0	FPH
TBM EFFECTIVE STROKE	3.5	feet
TBM REGRIP TIME	2.5	min
TBM STROKES PER TRAIN	2	each
SEGMENT DELAY PER RING	5	min
SWITCH AT HEADING	2	min

TRAVEL SPEED LOADED (OUT)	15	MPH
EMPTY (IN)	15	MPH
MUCK CARS PER TRAIN	3	each
INBOUND WAIT TO PASS ON SWITCH	5	min
ROTARY DUMP CYCLE	3	min/car
SWITCH TIME AT PORTAL		
ONLY SUPPLY CARS	3	min
MUCK & SUPPLY CARS	5	min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	6	9	9	12	12	15	15
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0
MAXIMUM LENGTH OF HEADING	feet	7,270	14,550	21,780	29,040	31,680		
TUNNEL BORING MACHINE CYCLE		min	min	min	min	min		
REGRIP TWICE		5.0	5.0	5.0	5.0	5.0		
EXCAVATE		12.0	12.0	12.0	12.0	12.0		
SET SEGMENT DELAY		10.0	10.0	10.0	10.0	10.0		
TOTAL		27.0	27.0	27.0	27.0	27.0		
HAULAGE CYCLE								
SWITCH AT HEADING		2.0	2.0	2.0	2.0	2.0		
TRAVEL OUT		5.5	11.0	16.5	22.0	24.0		
DUMP CARS		9.0	0.0	9.0	0.0	9.0		
SWITCH AT PORTAL		5.0	3.0	5.0	3.0	5.0		
TRAVEL IN		5.5	11.0	16.5	22.0	24.0		
WAIT ON CALIFORNIA SWITCH		0.0	0.0	5.0	5.0	10.0		
TOTAL		27.0	27.0	54.0	54.0	74.0		

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	1	2	3	4	5
TOTAL PER TRAIN	27.0	27.0	27.0	27.0	24.7
DELAY	0	0	0	0	-2

EQUIPMENT TO PURCHASE	
SPARE MUCK CARS	1
SPARE SUPPLY CARS	1
SPARE LOCOMOTIVES	2
TOTAL MUCK CARS	13
TOTAL SUPPLY CARS	9
TOTAL LOCOMOTIVES	5

AVERAGE NUMBER OF MOTORMEN & LOCOS	1.62
AVERAGE NUMBER OF CAR MOVER OPERATORS	0.46
AVERAGE NUMBER OF MUCK CARS IN USE	9.25

HAULAGE CALCULATION CONTRACT # 5

SOFT ROCK WITH 350' SHAFT ACCESS

GRADE FAVORABLE	0.42	percent	TRAVEL SPEED LOADED (OUT)	15	MPH
TOTAL LENGTH OF HEADING	39,600	feet	EMPTY (IN)	15	MPH
TBM PENETRATION RATE	35.0	FPH	MUCK CARS PER TRAIN	5	each
TBM EFFECTIVE STROKE	3.5	feet	INBOUND WAIT TO PASS ON SWITCH	5	min
TBM REGRIP TIME	2.5	min	DUMP CYCLE	5	min/car
TBM STROKES PER TRAIN	2	each	SWITCH TIME AT PORTAL/SHAFT		
SEGMENT DELAY PER RING	5	min	ONLY SUPPLY CARS	3	min
SWITCH AT HEADING	2	min	MUCK & SUPPLY CARS	5	min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	10	15	15	20	20	25	25
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0

MAXIMUM LENGTH OF HEADING	feet	14,550	29,050	39,600
TUNNEL BORING MACHINE CYCLE		min	min	min
REGRIP TWICE		5.0	5.0	5.0
EXCAVATE		12.0	12.0	12.0
SET SEGMENT DELAY		10.0	10.0	10.0
TOTAL		27.0	27.0	27.0
HAULAGE CYCLE				
SWITCH AT HEADING		2.0	2.0	2.0
TRAVEL OUT		11.0	22.0	30.0
DUMP CARS		0.0	0.0	0.0
SWITCH AT PORTAL/SHAFT		3.0	3.0	3.0
TRAVEL IN		11.0	22.0	30.0
WAIT ON CALIFORNIA SWITCH		0.0	5.0	10.0
TOTAL		27.0	54.0	75.0

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TOTAL PER TRAIN	27.0	27.0	25.0
DELAY	0	0	-2

EQUIPMENT TO PURCHASE

SPARE MUCK CARS	1
SPARE SUPPLY CARS	1
SPARE LOCOMOTIVES	2
TOTAL MUCK CARS	26
TOTAL SUPPLY CARS	11
TOTAL LOCOMOTIVES	5

AVERAGE NUMBER OF MOTORMEN & LOCOS	1.90
AVERAGE NUMBER OF CAR MOVER OPERATORS	1.00
AVERAGE NUMBER OF MUCK CARS IN USE	19.49

HAULAGE CALCULATION   CONTRACT # 6

SOFT ROCK WITH BOX PORTAL ACCESS

GRADE	FAVORABLE	0.42 percent	TRAVEL SPEED LOADED (OUT)		15 MPH
TOTAL LENGTH OF HEADING		45,408 feet		EMPTY (IN)	15 MPH
TBM PENETRATION RATE		35.0 FPH	MUCK CARS PER TRAIN		3 each
TBM EFFECTIVE STROKE		3.5 feet	INBOUND WAIT TO PASS ON SWITCH		5 min
TBM REGRIP TIME		2.5 min	ROTARY DUMP CYCLE		3 min/car
TBM STROKES PER TRAIN		2 each	SWITCH TIME AT PORTAL		
SEGMENT DELAY PER RING		5 min		ONLY SUPPLY CARS	3 min
SWITCH AT HEADING		2 min		MUCK & SUPPLY CARS	5 min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	6	9	9	12	12	15	15
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0
MAXIMUM LENGTH OF HEADING	feet	7,270	14,530	21,800	29,050	36,300	43,600	45,408
TUNNEL BORING MACHINE CYCLE		min	min	min	min	min	min	min
REGRIP TWICE		5.0	5.0	5.0	5.0	5.0	5.0	5.0
EXCAVATE		12.0	12.0	12.0	12.0	12.0	12.0	12.0
SET SEGMENT DELAY		10.0	10.0	10.0	10.0	10.0	10.0	10.0
TOTAL		27.0	27.0	27.0	27.0	27.0	27.0	27.0
HAULAGE CYCLE								
SWITCH AT HEADING		2.0	2.0	2.0	2.0	2.0	2.0	2.0
TRAVEL OUT		5.5	11.0	16.5	22.0	27.5	33.0	34.4
DUMP CARS		9.0	0.0	9.0	0.0	9.0	0.0	9.0
SWITCH AT PORTAL		5.0	3.0	5.0	3.0	5.0	3.0	5.0
TRAVEL IN		5.5	11.0	16.5	22.0	27.5	33.0	34.4
WAIT ON CALIFORNIA SWITCH		0.0	0.0	5.0	5.0	10.0	10.0	15.0
TOTAL		27.0	27.0	54.0	54.0	81.0	81.1	99.8

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TOTAL PER TRAIN	27.0	27.0	27.0	27.0	27.0	27.0	25.0
DELAY	0	0	0	0	0	0	-2

EQUIPMENT TO PURCHASE		AVERAGE NUMBER OF MOTORMEN & LOCOS	2.08
SPARE MUCK CARS	1	AVERAGE NUMBER OF CAR MOVER OPERATORS	0.48
SPARE SUPPLY CARS	1	AVERAGE NUMBER OF MUCK CARS IN USE	10.68
SPARE LOCOMOTIVES	2		
TOTAL MUCK CARS	16		
TOTAL SUPPLY CARS	11		
TOTAL LOCOMOTIVES	6		

HAULAGE CALCULATION CONTRACT # 8

SOFT ROCK WITH BOX PORTAL ACCESS

GRADE ADVERSE	0.28 percent	TRAVEL SPEED LOADED (OUT)	12 MPH
TOTAL LENGTH OF HEADING	18,480 feet	EMPTY (IN)	15 MPH
TBM PENETRATION RATE	35.0 FPH	MUCK CARS PER TRAIN	3 each
TBM EFFECTIVE STROKE	3.5 feet	INBOUND WAIT TO PASS ON SWITCH	5 min
TBM REGRIP TIME	2.5 min	ROTARY DUMP CYCLE	3 min/car
TBM STROKES PER TRAIN	2 each	SWITCH TIME AT PORTAL	
SEGMENT DELAY PER RING	5 min	ONLY SUPPLY CARS	3 min
SWITCH AT HEADING	2 min	MUCK & SUPPLY CARS	5 min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	6	9	9	12	12	15	15
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0
MAXIMUM LENGTH OF HEADING	feet	6,460	12,930	18,480				
TUNNEL BORING MACHINE CYCLE		min	min	min				
REGRIP TWICE		5.0	5.0	5.0				
EXCAVATE		12.0	12.0	12.0				
SET SEGMENT DELAY		10.0	10.0	10.0				
TOTAL		27.0	27.0	27.0				
HAULAGE CYCLE								
SWITCH AT HEADING		2.0	2.0	2.0				
TRAVEL OUT		6.1	12.2	17.5				
DUMP CARS		9.0	0.0	9.0				
SWITCH AT PORTAL		5.0	3.0	5.0				
TRAVEL IN		4.9	9.8	14.0				
WAIT ON CALIFORNIA SWITCH		0.0	0.0	5.0				
TOTAL		27.0	27.0	52.5				

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\HAUL-8

TOTAL PER TRAIN	27.0	27.0	26.3
DELAY	0	0	-1

EQUIPMENT TO PURCHASE

SPARE MUCK CARS	1
SPARE SUPPLY CARS	1
SPARE LOCOMOTIVES	2
TOTAL MUCK CARS	10
TOTAL SUPPLY CARS	7
TOTAL LOCOMOTIVES	4

AVERAGE NUMBER OF MOTORMEN & LOCOS	1.30
AVERAGE NUMBER OF CAR MOVER OPERATORS	0.35
AVERAGE NUMBER OF MUCK CARS IN USE	7.95

HAULAGE CALCULATION CONTRACT # 9

HARD ROCK WITH 320' SHAFT ACCESS

GRADE FLAT	0 percent	TRAVEL SPEED LOADED (OUT)		12 MPH
TOTAL LENGTH OF HEADING	38,016 feet		EMPTY (IN)	15 MPH
TBM PENETRATION RATE	12.7 FPH	MUCK CARS PER TRAIN		6 each
TBM EFFECTIVE STROKE	4.75 feet	INBOUND WAIT TO PASS ON SWITCH		5 min
TBM REGRIP TIME	2.5 min	DUMP CYCLE	HOIST	5 min/car
TBM STROKES PER TRAIN	2 each	SWITCH TIME AT PORTAL/SHAFT		
SEGMENT DELAY PER RING	0 min		ONLY SUPPLY CARS	3 min
SWITCH AT HEADING	2 min		MUCK & SUPPLY CARS	5 min

HAULAGE STEP		1	2	3	4	5	6	7
MAIN HAUL LOCOMOTIVES	each	1	1	2	2	3	3	4
TRAINS	each	2	3	3	4	4	5	5
TOTAL MUCK CARS IN USE	each	12	18	18	24	24	30	30
CALIFORNIA SWITCHES	each	0	0	1	1	2	2	3
CAR MOVER AT PORTAL	each	0	1		1	0	1	0

MAXIMUM LENGTH OF HEADING	feet	10,500	26,350	36,900	38,016
TUNNEL BORING MACHINE CYCLE		min	min	min	min
REGRIP TWICE		5.0	5.0	5.0	5.0
EXCAVATE		44.9	44.9	44.9	44.9
SET SEGMENT DELAY		0.0	0.0	0.0	0.0
TOTAL		49.9	49.9	49.9	49.9
HAULAGE CYCLE					
SWITCH AT HEADING		2.0	2.0	2.0	2.0
TRAVEL OUT		9.9	25.0	34.9	36.0
DUMP CARS		30.0	0.0	30.0	0.0
SWITCH AT PORTAL/SHAFT		0.0	3.0	0.0	3.0
TRAVEL IN		8.0	20.0	28.0	28.8
WAIT ON CALIFORNIA SWITCH		0.0	0.0	5.0	5.0
TOTAL		49.9	49.9	99.9	74.8

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\HAUL-9

TOTAL PER TRAIN	49.9	49.9	49.9	37.4
DELAY	0	0	0	-12

EQUIPMENT TO PURCHASE	
SPARE MUCK CARS	1
SPARE SUPPLY CARS	1
SPARE LOCOMOTIVES	2
TOTAL MUCK CARS	25
TOTAL SUPPLY CARS	1
TOTAL LOCOMOTIVES	4

AVERAGE NUMBER OF MOTORMEN & LOCOS	1.31
AVERAGE NUMBER OF CAR MOVER OPERATORS	0.45
AVERAGE NUMBER OF MUCK CARS IN USE	16.52

Item	Quantity	Unit	Rate	Unit	HOURS	TOTAL HOURS
PRODUCTION						
MOLING HARD	0	feet at	10.5	FPH	0	
MEDIUM	0	feet at	14.1	FPH	0	
SOFT	29,568	feet at	35.0	FPH	845	845
total	29,568	feet				
RESET (1)	4.75	ft/stroke at	2.5	min/stroke		0
RESET (2)	3.50	ft/stroke at	2.5	min/stroke		352
TOTAL PRODUCTION TIME						1197
DELAYS						
ROCK SUPPORT						
ERECT SEGMENTS	8448	rings at	3.5	ft wide		
	10	min per ring	50	% delay	704	
SPOT BOLTS	0	each at	5	min/each	0	
SPLIT SETS & CLF	0	rows at	20	min/each	0	
STEEL SETS	0	each at	60	min/each	0	
CRIB GRIPPERS					30	
MUCK FALLOUT					296	1029
HAULAGE						
TRAIN CHANGE	0	min/tunnel foot			0	
WAIT FOR TRAINS	20	min/working day			49	
DERAILMENTS	10	min/working day			25	74
HOISTING	10	min/working day				25
VENTILATION	6	min/section	20	ft/section		148
POWER						
ADD CABLE	4	hrs/1000 feet of tunnel x 80%			91	
OUTAGES	4	hrs/outage	5	outages	18	109
CUTTERS	2	cutters/week	1.5	hrs/cutter		88

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	BOX PORTAL	
TUNNEL BORING MACHINE:	SOFT ROCK	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	11.0'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	147.1	working days
	7.00	months
PRODUCTION	201.0	feet per working day
MOLING TIME	5.7	hours per working day
MOLE UTILIZATION	34	percent

AZ SSC MARICOPA　　P. E. Sperry　18-Jul-87　\AZFM-CAL\TBM-1

Item	Quantity	Unit	HOURS	TOTAL HOURS
EQUIPMENT REPAIR				
TBM	30.0	% of moling	253	
TRAILING FLOOR	0.5	min/tunnel foot	246	
SEGMENT ERECTOR	5	% of segment erection time	70	
DRILLS	use	handheld - no delay	0	
OTHER	1	% of moling	8	579
OTHER				
SHIFT CHANGE	15	min/shift	110	
LUNCH	0	min/working day	0	
STARTUP	5	working days	120	
SURVEY			7	
CURVES			44	282
TOTAL DELAY TIME				2333
TOTAL TIME REQUIRED				3530

MOLE AVAILABILITY　90　percent

B C D E F G H I J K L M N O

Item		Quantity	Unit	Rate	Rate unit	HOURS	TOTAL HOURS
PRODUCTION							
MOLING	HARD	7,392	feet at	12.7	FPH	582	
	MEDIUM	0	feet at	14.1	FPH	0	
	SOFT	5,808	feet at	35.0	FPH	166	748
	total	13,200	feet				
RESET (1)		4.75	ft/stroke at	2.5	min/stroke		65
RESET (2)		3.50	ft/stroke at	2.5	min/stroke		69
TOTAL PRODUCTION TIME							882
DELAYS							
ROCK SUPPORT							
ERECT SEGMENTS		1659	rings at	3.5	ft wide		
		10	min per ring	50	% delay	138	
SPOT BOLTS		30	each at	5	min/each	2	
SPLIT SETS & CLF		92	rows at	20	min/each	31	
STEEL SETS		18	each at	60	min/each	18	
CRIB GRIPPERS						6	
MUCK FALLOUT						58	253
HAULAGE							
TRAIN CHANGE		0	min/tunnel foot			0	
WAIT FOR TRAINS		20	min/working day			30	
DERAILMENTS		10	min/working day			15	46
HOISTING		10	min/working day				15
VENTILATION		6	min/section	20	ft/section		66
POWER							
ADD CABLE		4	hrs/1000 feet of tunnel x 80%			39	
OUTAGES		4	hrs/outage	3	outages	13	52
CUTTERS		12	cutters/week	1.5	hrs/cutter		328

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	BOX PORTAL	
TUNNEL BORING MACHINE:	COMBINATIONM	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	11.0'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	91.2	working days
	4.34	months
PRODUCTION	144.8	feet per working day
MOLING TIME	8.2	hours per working day
MOLE UTILIZATION	40	percent

AZ SSC MARICOPA   P. E. Sperry   18-Jul-87   \AZFM-CAL\TBM-3

Item	Quantity	Unit	HOURS	TOTAL HOURS
EQUIPMENT REPAIR				
TBM	27.2	% of moling	203	
TRAILING FLOOR	0.5	min/tunnel foot	110	
SEGMENT ERECTOR	5	% of segment erection time	14	
DRILLS	use	handheld - no delay	0	
OTHER	1	% of moling	7	335
OTHER				
SHIFT CHANGE	15	min/shift	68	
LUNCH	0	min/working day	0	
STARTUP	5	working days	120	
SURVEY			3	
CURVES			20	211
TOTAL DELAY TIME				1306
TOTAL TIME REQUIRED				2188

MOLE AVAILABILITY 76 percent

B C D E F G H I K L M N O

					HOURS	TOTAL HOURS
PRODUCTION						
MOLING HARD	3,696	feet at	10.5	FPH	352	
MEDIUM	0	feet at	14.1	FPH	0	
SOFT	27,984	feet at	35.0	FPH	800	1152
total	31,680	feet				
RESET (1)	4.75	ft/stroke at	2.5	min/stroke		32
RESET (2)	3.50	ft/stroke at	2.5	min/stroke		333
TOTAL PRODUCTION TIME						1517
DELAYS						
ROCK SUPPORT						
ERECT SEGMENTS	7995	rings at	3.5	ft wide		
	10	min per ring	50	% delay	666	
SPOT BOLTS	15	each at	5	min/each	1	
SPLIT SETS & CLF	46	rows at	20	min/each	15	
STEEL SETS	18	each at	60	min/each	18	
CRIB GRIPPERS					28	
MUCK FALLOUT					280	1009
HAULAGE						
TRAIN CHANGE	0	min/tunnel foot			0	
WAIT FOR TRAINS	20	min/working day			57	
DERAILMENTS	10	min/working day			29	86
HOISTING	10	min/working day				29
VENTILATION	6	min/section	20	ft/section		158
POWER						
ADD CABLE	4	hrs/1000 feet of tunnel x 80%			98	
OUTAGES	4	hrs/outage	5	outages	20	118
CUTTERS	4	cutters/week	1.5	hrs/cutter		205

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountails and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	BOX PORTAL	
TUNNEL BORING MACHINE:	COMBINATION	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	11.0'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	171.1	working days
	8.15	months
PRODUCTION	185.2	feet per working day
MOLING TIME	6.7	hours per working day
MOLE UTILIZATION	37	percent

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TBM-4

					HOURS	TOTAL HOURS
EQUIPMENT REPAIR						
TBM	29.4	% of moling			339	
TRAILING FLOOR	0.5	min/tunnel foot			264	
SEGMENT ERECTOR	5	% of segment erection time			67	
DRILLS	use	handheld - no delay			0	
OTHER	1	% of moling			12	681
OTHER						
SHIFT CHANGE	15	min/shift			128	
LUNCH	0	min/working day			0	
STARTUP	5	working days			120	
SURVEY					8	
CURVES					48	303
TOTAL DELAY TIME						2589
TOTAL TIME REQUIRED						4106

MOLE AVAILABILITY 87 percent

B C D E F G H I . K L M N O

					HOURS	TOTAL HOURS
PRODUCTION						
MOLING HARD	0	feet at	10.5	FPH	0	
MEDIUM	10,824	feet at	14.1	FPH	768	
SOFT	28,776	feet at	35.0	FPH	822	1590
total	39,600	feet				
RESET (1)	4.75	ft/stroke at	2.5	min/stroke		0
RESET (2)	3.50	ft/stroke at	2.5	min/stroke		343
TOTAL PRODUCTION TIME						1932
DELAYS						
ROCK SUPPORT						
ERECT SEGMENTS	8222	rings at	3.5	ft wide		
	10	min per ring	50	% delay	685	
SPOT BOLTS	433	each at	5	min/each	36	
SPLIT SETS & CLF	81	rows at	20	min/each	27	
STEEL SETS	27	each at	60	min/each	27	
CRIB GRIPPERS					34	
MUCK FALLOUT					301	1110
HAULAGE						
TRAIN CHANGE	0	min/tunnel foot			0	
WAIT FOR TRAINS	20	min/working day			73	
DERAILMENTS	10	min/working day			36	109
HOISTING	30	min/working day				109
VENTILATION	6	min/section	20	ft/section		198
POWER						
ADD CABLE	4	hrs/1000 feet of tunnel x 80%			124	
OUTAGES	4	hrs/outage	6	outages	25	148
CUTTERS	6	cutters/week	1.5	hrs/cutter		392

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TBM-5

EQUIPMENT REPAIR						
TBM	28.9	% of moling			459	
TRAILING FLOOR	0.5	min/tunnel foot			330	
SEGMENT ERECTOR	5	% of segment erection time			69	
DRILLS	use	handheld - no delay			0	
OTHER	1	% of moling			16	874
OTHER						
SHIFT CHANGE	15	min/shift			163	
LUNCH	0	min/working day			0	
STARTUP	5	working days			120	
SURVEY					10	
CURVES					59	352
TOTAL DELAY TIME						3292
TOTAL TIME REQUIRED						5224

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA: 350' SHAFT

TUNNEL BORING MACHINE: COMBINATION

TBM THRUST OFF: SIDES

EXCAVATED DIAMETER: 11.0'

CUTTER SIZE: 17"

SCHEDULED HOURS 24 hours per working day

ELAPSED TIME 217.7 working days

10.37 months

PRODUCTION 181.9 feet per working day

MOLING TIME 7.3 hours per working day

MOLE UTILIZATION 37 percent

MOLE AVAILABILITY 84 percent

					HOURS	TOTAL HOURS
PRODUCTION						
MOLING HARD	0	feet at	10.5	FPH	0	
MEDIUM	0	feet at	14.1	FPH	0	
SOFT	45,408	feet at	35.0	FPH	1297	1297
total	45,408	feet				
RESET (1)	4.75	ft/stroke at	2.5	min/stroke		0
RESET (2)	3.50	ft/stroke at	2.5	min/stroke		541
TOTAL PRODUCTION TIME						1838
DELAYS						
ROCK SUPPORT						
ERECT SEGMENTS	12974	rings at	3.5	ft wide		
	10	min per ring	50	% delay	1081	
SPOT BOLTS	0	each at	5	min/each	0	
SPLIT SETS & CLF	0	rows at	20	min/each	0	
STEEL SETS	0	each at	60	min/each	0	
CRIB GRIPPERS					45	
MUCK FALLOUT					454	1581
HAULAGE						
TRAIN CHANGE	0	min/tunnel foot			0	
WAIT FOR TRAINS	20	min/working day			74	
DERAILMENTS	10	min/working day			37	111
HOISTING	10	min/working day				37
VENTILATION	6	min/section	20	ft/section		227
POWER						
ADD CABLE	4	hrs/1000 feet of tunnel x 80%			142	
OUTAGES	4	hrs/outage	6	outages	25	167
CUTTERS	2	cutters/week	1.5	hrs/cutter		134

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	BOX PORTAL	
TUNNEL BORING MACHINE:	SOFT	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	11.0'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	222.9	working days
	10.62	months
PRODUCTION	203.7	feet per working day
MOLING TIME	5.8	hours per working day
MOLE UTILIZATION	34	percent

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TBM-6

				TOTAL HOURS
EQUIPMENT REPAIR				
TBM	30.0	% of moling	389	
TRAILING FLOOR	0.5	min/tunnel foot	378	
SEGMENT ERECTOR	5	% of segment erection time	108	
DRILLS	use	handheld - no delay	0	
OTHER	1	% of moling	13	889
OTHER				
SHIFT CHANGE	15	min/shift	167	
LUNCH	0	min/working day	0	
STARTUP	5	working days	120	
SURVEY			11	
CURVES			68	366
TOTAL DELAY TIME				3512
TOTAL TIME REQUIRED				5350

MOLE AVAILABILITY	90	percent

B C D E F G H I K L M N O

				HOURS	TOTAL HOURS
PRODUCTION					
MOLING HARD	4,224 feet at	10.5 FPH		402	
MEDIUM	0 feet at	14.1 FPH		0	
SOFT	14,256 feet at	35.0 FPH		407	810
total	18,480 feet				
RESET (1)	4.75 ft/stroke at	2.5 min/stroke			37
RESET (2)	3.50 ft/stroke at	2.5 min/stroke			170
TOTAL PRODUCTION TIME					1016
DELAYS					
ROCK SUPPORT					
ERECT SEGMENTS	4073 rings at	3.5 ft wide			
	10 min per ring	50 % delay		339	
SPOT BOLTS	17 each at	5 min/each		1	
SPLIT SETS & CLF	53 rows at	20 min/each		18	
STEEL SETS	21 each at	60 min/each		21	
CRIB GRIPPERS				14	
MUCK FALLOUT				143	536
HAULAGE					
TRAIN CHANGE	0 min/tunnel foot			0	
WAIT FOR TRAINS	20 min/working day			37	
DERAILMENTS	10 min/working day			18	55
HOISTING	10 min/working day				18
VENTILATION	6 min/section	20 ft/section			92
POWER					
ADD CABLE	4 hrs/1000 feet of tunnel x 80%			56	
OUTAGES	4 hrs/outage	4 outages		15	70
CUTTERS	6 cutters/week	1.5 hrs/cutter			199

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	BOX PORTAL	
TUNNEL BORING MACHINE:	COMBINATION	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	11.0'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	110.6	working days
	5.26	months
PRODUCTION	167.2	feet per working day
MOLING TIME	7.3	hours per working day
MOLE UTILIZATION	38	percent

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TBM-8

EQUIPMENT REPAIR				
TBM	28.9 % of moling		234	
TRAILING FLOOR	0.5 min/tunnel foot		154	
SEGMENT ERECTOR	5 % of segment erection time		34	
DRILLS	use handheld - no delay		0	
OTHER	1 % of moling		8	430
OTHER				
SHIFT CHANGE	15 min/shift		83	
LUNCH	0 min/working day		0	
STARTUP	5 working days		120	
SURVEY			4	
CURVES			28	235
TOTAL DELAY TIME				1637
TOTAL TIME REQUIRED				2653

MOLE AVAILABILITY	84	percent

B C D E F G H I J K L M N O

			HOURS	TOTAL HOURS
PRODUCTION				
MOLING HARD	38,016 feet at	12.7 FPH	2993	
MEDIUM	0 feet at	17.0 FPH	0	
SOFT	0 feet at	35.0 FPH	0	2993
total	38,016 feet			
RESET (1)	4.75 ft/stroke at	2.5 min/stroke		333
RESET (2)	3.50 ft/stroke at	2.5 min/stroke		0
TOTAL PRODUCTION TIME				3327
DELAYS				
ROCK SUPPORT				
ERECT SEGMENTS	0 rings at	3.5 ft wide		
	10 min per ring	50 % delay	0	
SPOT BOLTS	152 each at	5 min/each	13	
SPLIT SETS & CLF	190 rows at	20 min/each	63	
STEEL SETS	0 each at	60 min/each	0	
CRIB GRIPPERS			0	
MUCK FALLOUT			0	76
HAULAGE				
TRAIN CHANGE	0 min/tunnel foot		0	
WAIT FOR TRAINS	20 min/working day		103	
DERAILMENTS	10 min/working day		52	155
HOISTING	30 min/working day			155
VENTILATION	6 min/section	20 ft/section		190
POWER				
ADD CABLE	4 hrs/1000 feet of tunnel x 80%		118	
OUTAGES	4 hrs/outage	8 outages	33	152
CUTTERS	20 cutters/week	1.5 hrs/cutter		1856

NOTES

1. TBM production based on rock tests and advice from The Robbins Company.
2. Delay factors based on experience at River Mountains and Navajo 3 Tunnels and on analysis of data from P. N. Nelson thesis.
3. Heading mechanic operates TBM during lunch.

FOOTNOTES

(1) Hard and medium rock.
(2) Soft rock.

ACCESS VIA:	320' SHAFT	
TUNNEL BORING MACHINE:	HARD ROCK	
TBM THRUST OFF:	SIDES	
EXCAVATED DIAMETER:	10'	
CUTTER SIZE:	17"	
SCHEDULED HOURS	24	hours per working day
ELAPSED TIME	309.3	working days
	14.73	months
PRODUCTION	122.9	feet per working day
MOLING TIME	9.7	hours per working day
MOLE UTILIZATION	45	percent

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\TBM-9

			HOURS	TOTAL HOURS
EQUIPMENT REPAIR				
TBM	25.0 % of moling		748	
TRAILING FLOOR	0.5 min/tunnel foot		317	
SEGMENT ERECTOR	5 % of segment erection time		0	
DRILLS	use handheld - no delay		0	
OTHER	1 % of moling		30	1095
OTHER				
SHIFT CHANGE	15 min/shift		232	
LUNCH	0 min/working day		0	
STARTUP	5 working days		120	
SURVEY			9	
CURVES			57	418
TOTAL DELAY TIME				4096
TOTAL TIME REQUIRED				7423

MOLE AVAILABILITY 65 percent

EXCAVATION SUMMARY

CONTRACT NUMBER	1	3	4	5	6	8	9	
EXCAVATED FROM	BOX PORTAL	BOX PORTAL	BOX PORTAL	350' SHAFT	BOX PORTAL	BOX PORTAL	350' SHAFT	
PORTAL MILEPOST	5.00	12.80	15.30	28.80	37.40	41.50	45.00	
TO END MILEPOST	52.20	15.30	21.30	21.30	28.80	45.00	52.20	
MAXIMUM EXCAVATION GRADE %	adverse 0.47	favorable 0.28	favorable 0.28	favorable 0.42	favorable 0.42	adverse 0.28	adverse 0.09	TOTAL
GENERAL ROCK DESCRIPTION	SOFT	SOFT & HARD	SOFT & HARD	SOFT & MEDIUM	SOFT	SOFT & HARD	HARD	TUNNEL
HEADING LENGTH FT	29,568	13,200	31,680	39,600	45,408	18,480	38,016	215,952
TUNNEL EXCAV DIA FT	11.0	11.0	11.0	11.0	11.0	11.0	10.0	40.9
TUNNEL FINISHED DIA FT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
EXCAVATION METHOD	TBM	TBM	TBM	TBM	TBM	TBM	TBM	
HORSEPOWER	600	900	900	800	600	900	900	
ESTIMATED ADVANCE RATE ft/day	201.0	144.8	185.2	181.9	203.7	167.2	122.9	
TUNNEL EXCAVATION MONTHS	7.0	4.3	8.1	10.4	10.6	5.3	14.7	
MUCK HAULAGE	RAIL	RAIL	RAIL	RAIL	RAIL	RAIL	RAIL	
WEIGHT OF RAIL #/YD	80	80	80	80	80	80	80	
TRACK GAGE IN.	24	24	24	24	24	24	24	
TRAILING FLOOR TYPE	PASS AT HEADING	PASS AT HEADING	PASS AT HEADING	PASS AT HEADING	PASS AT HEADING	PASS AT HEADING	PASS AT HEADING	
MAXIMUM LOCOMOTIVES IN USE	3	1	3	3	4	2	2	
LOCOMOTIVE ENGINE MAKE	CAT	CAT	CAT	CAT	CAT	CAT	CAT	
ENGINE HP	110	110	110	110	110	110	110	
WEIGHT TONS	10	8	8	8	8	8	10	
WIDTH IN.	41	41	41	41	41	41	41	
HEIGHT IN.	52	52	52	52	52	52	52	
PASSING TRACKS each	2	0	2	2	3	1	1	
FANLINE DIAMETER IN.	34	34	34	34	34	34	34	
FAN SIZE HP	50	50	50	50	50	50	50	
CAPACITY CFM	19000	19000	23300	19000	19000	19000	19000	
FAN SPACING FEET	3000	3000	3000	3000	3000	3000	3000	
ACCESS SHAFT DEPTH FEET	60	50	100	350	70	70	320	
MUCK HOISTING FROM TUNNEL	CONVEYOR	CONVEYOR	CONVEYOR	MINE HOIST	CONVEYOR	CONVEYOR	MINE HOIST	
REQ'D HOISTING CAPACITY TPH	216	96	216	216	216	216	96	
SHAFT EXCAV DIA FEET				25			25	
SUPPORTED DIA FEET				24			24	
LINED DIA FEET				21			21	

AZ SSC MARICOPA P. E. Sperry 18-Jul-87 \AZFM-CAL\SUMMARY

MUCK CAR DUMP TYPE	ROTARY DUMP	ROTARY DUMP	ROTARY DUMP	LIFT OFF	ROTARY DUMP	ROTARY DUMP	LIFT OFF
MUCK CAR BOX LENGTH FT	33.0	33.0	33.0	21.0	33.0	33.0	21.0
WIDTH IN	41	41	41	41	41	41	41
HEIGHT IN	53	53	53	53	53	53	53
CAPACITY CY	14.6	14.6	14.6	8.8	14.6	14.6	8.8

ROCK TYPE		SOFT	MEDIUM	HARD
		CEMENTED ALLUVIUM	SCHIST/LATITE	DIORITE/GRANITE
WEIGHT OF ROCK #/SCY		3500	4400	5220
PENETRATION RATE FT/HR	EXCAV DIAMETER 10'		17.0	12.7
	11'	35.0	14.1	10.5
INITIAL AND FINAL SUPPORT		PRECAST SEGMENTS	SPOT BOLTS	SPOT BOLTS
		EXPANDED AT BACK	PATTERN BOLTS	PATTERN BOLTS
		5" THICK	3/4 SETS	3/4 SETS
TBM STROKE feet		4.0	5.0	5.0
CUTTER COST $/CY		0.50	4.00	4.50
THRUST TBM FROM		SIDES	SIDES	SIDES
RAIL ATTACHMENT		BOLT TO SEGMENT	BOLT TO ROCK	BOLT TO ROCK

B C D E F G H I J K L M N O P Q R S T

INPUT FACTORS TO ESTIMATE

Labor Cost, $ per man-shift:	308.00
* BLS Index:	371
* Diesel Fuel Cost $/gal:	1.00
* Power Cost $/KWH:	0.04
* Tire Index:	2.50
* Sales Tax Rate, %:	0.00
Small Tool %:	4.67
* Tunnel Length, feet:	
Location:	
Urban	
Rural	XX
Remote	
Access Via Portal	
Shaft	
Method of Tunnel Excavation	
Drill & Shoot	
Tunnel Boring Machine	XX
Roadheader	
Tunnel Digging Machine	
Shield	
Hand Mine	
Excavation Width, feet	10.0
Excavation Should be Wet	
Dry	XX
Initial Support	
Rock Bolts	XX
Steel Sets	XX
Shotcrete	
Ribs & Lagging	
Precast Segments	XX
Concrete Lining	
None	
Full Circle	
Invert then Arch	
Arch then Invert	
Invert Segments	XX

DIRECT LABOR COST CALCULATION

HOURS OF WORK/HOURS OF PAY			WORK	PAY
STRAIGHT TIME			7.50	8.00
OVERTIME		NORMAL		0.00
	0.5	LUNCH	0.25	0.38
		TRAVEL	0.75	1.13
		OTHER		
TOTALS			8.50	9.50

AVERAGE COST PER SHIFT		MINER	HEAVY DUTY MECHANIC
WAGES, UNDERGROUND DEVELOPMENT CONTRACT		13.97	15.06
TUNNEL DIFFERENTIAL			
FRINGES		2.85	2.85
OTHER			
PAID HOLIDAYS			
	TOTALS	16.82	17.91
AVERAGE WAGE WITHOUT FRINGES			$14.52
AVERAGE WAGE WITH FRINGES			$17.37

INSURANCE & TAXES	Percent		
FICA	7.15	1.04	
FUI	0.40	0.06	
SUI	3.50	0.51	
WORKMAN'S COMP	9.64	1.40	
TOTALS	20.69	3.00	3.00
TOTAL WAGES, INSURANCE & TAXES			$20.37
ADD INCIDENTAL OVERTIME	6.00%		21.59
TOTAL COST PER SHIFT			$205.11
ADD CONTRACTOR MARKUP	50.00%		$307.66
AVERAGE COST PER SHIFT			$308

SMALL TOOLS & EXPENDABLES PERCENT OF DIRECT LABOR

	% RANGE	% USE
PROTECTIVE CLOTHING	1 - 2	1.0
HAND TOOLS & SUPPLIES	3 - 5	3.0
SMALL EQUIPMENT	2 - 4	2.0
EXPENDABLE ELECT. SUPPLIES	.5 - 2	1.0
	TOTAL	7.0

MODIFIED PERCENT OF DIRECT LABOR: 4.67

SMALL TOOLS AND EXPENDABLES GUIDELINES

	percent	
PROTECTIVE CLOTHING	1.00	dry work
	2.00	wet work
HAND TOOLS & SUPPLIES	3.00	low theft; little hand labor
	5.00	high theft; much hand labor
SMALL EQUIPMENT	2.00	small equip not included in P & E
	4.00	much not covered
EXPEND ELECT SUPPLIES	0.50	no vandalism; no blasting
	2.00	vandalism and blasting

COST SUMMARY

CONTRACT NUMBER		1
ROCK TYPE		SOFT
ACCESS		PORTAL
LENGTH, feet		29,568
COST	Page Ref	$
DIRECT COST	6	9,672,893
PLANT & EQUIPMENT	15	5,255,393
INDIRECT COST	28	4,618,710
TOTALS		19,546,996
COST PER FOOT OF TUNNEL		$
DIRECT COST		327
PLANT & EQUIPMENT		178
INDIRECT COST		156
TOTALS		661

BID QUANTITY 29,568 LF 11.00 Feet Excavated Diameter 104,112 CY
Box Portal Access

PRODUCTION: 201.0 FPD (See Mole Excavation Progress calculation.)

f: TBM electrical power: 600 HP 35 FPH penetration
c: TBM parts & supply: $1.00 $/CY
b: TBM cutters: $0.50 $/CY

PURCHASE SUPPORTS				Unit Cost	Cost
Rock Support Bolts			LF	$1.50	
CLF Split Sets			EA	$0.80	
Chain Link Fabric			SF	$0.35	
Steel Sets, ea	80	40,000	#	$0.60	24,000
Blocking & Lagging		8	MBF	$400.00	3,200
Shotcrete		180	CY	$80.00	14,400
TOTAL SUPPORT COST				d	41,600

PURCHASE CONCRETE				
Precast Segments	29,568	LF	$100.00	2,956,800
Invert Paving	8,072	CY	$60.00	484,324
TOTAL CONCRETE COST			e	3,441,124

B DESCRIPTION	C	D	E F G CREW	H QUAN	I UNIT	K LABOR UNIT	L LABOR TOTAL $	N EQUIP PARTS UNIT	O EQUIP PARTS TOTAL $	P EQUIP OWNERSHIP UNIT	R EQUIP OWNERSHIP TOTAL $	T EXPEND MATLS UNIT	U EXPEND MATLS TOTAL $	W PERM MATLS UNIT	X PERM MATLS TOTAL $	Z SUBCONTRACTS UNIT	AA SUBCONTRACTS TOTAL $	AC TOTAL DIRECT COST UNIT	AD TOTAL DIRECT COST TOTAL $
Portal Excavation and Support			-	8900	CY											25	222,500		222,500
Starting Chamber Excavation and Support			DS	12	WD	7803	93,636	877	10,524					d	41,600				145,760
Tail Tunnel Excavation and Support			DS		WD														
Purchase Supports			-	-										e	3,441,124				3,441,124
TBM Excavation and Tunnel Support			TBM	147	WD	17813	2,620,372	781	114,889										2,735,261
TBM Operation			-	-				c	104,112			b	52,056						156,168
Install California Switch			TBM	4	WD	17813	71,252	400	1,600										72,852
Muck Disposal			-	104112	CY			f	15,206							4	416,448		431,654
Saturday Maintenance			SM	29	WD	5662	166,581	155	4,560										171,141
Remove Fanline, TBM & Trailing Floor	3,000	FPD	RF	10	WD	11961	117,888	777	7,658										125,546
Ex & Supt Electron Shielding Nitches	47	EA	ME	47	WD	9337	438,217	423	19,853			100	4,693	350	16,427				479,189
Excavate & Support Power Alcoves	7	EA	ME	29	WD	9337	273,866	423	12,407			300	8,799	1400	41,064				336,136
Purchase Concrete Lining Materials			-	-															
Place Shotcrete Lining 75 FPD	700	LF	SH	9	WD	12501	116,676	381	3,556										120,232
Place Invert Concrete	700	FPD	IC	44	WD	14741	652,142	701	31,012										683,154
Remove Utilities and Final Cleanup	1,000	FPD	CU	30	WD	10353	306,118	651	19,249										325,366
Small Tools and Expendables 4.67 % of Direct Labor													226,810						226,810
UNIT COST PER TUNNEL FOOT and TOTALS						164	4,856,746	12	344,626			10	292,359	120	3,540,214	22	638,948	$327	9,672,893

ARIZONA SSC MARICOPA

P. E. Sperry 30-Jun-87 \AZM1-COS\TBM

1	B	C	D	E	F	G	H	
2	CREW					RATE	COST	
3		NUMBER OF MEN				PER	PER	REMARKS
4	CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
5								
6	SHIFTER	1.0	1.0	1.0	3.0			
7								
8	MOLE OPERATOR	1.0	1.0	1.0	3.0			
9	MOLE MECHANIC	1.0	1.0	1.0	3.0			
10								
11	GREASER	1.0			1.0			
12								
13	CONVEYOR OPR	1.0	1.0	1.0	3.0			conveyor on trailing floor
14								
15	MINERS	2.0	2.0	2.0	6.0			place segments
16	TRACKMEN	3.0	3.0	3.0	9.0			help miners & lay rail & install
17	REAR MINER							utilities
18								
19	MOTORMEN	1.7	1.7	1.7	5.1			average number over job
20	BRAKEMEN	1.7	1.7	1.7	5.1			average number over job
21								
22	BULL GANG 4MAN	1.0			1.0			average number over job
23	BULL GANG LABOR	1.5			1.5			average number over job
24								
25	PUMPMAN							dry tunnel
26								
27	ELECTRICAL 4MAN							indirect cost
28	ELECTRICIAN							
29								
30	CONVEYOR OPR	1.0	1.0	1.0	3.0			stacking conveyor at portal
31	LOADER OPR	1.0			1.0			loads trucks for muck haul to disposal
32								
33	WELDER - SHOP	1.0			1.0			
34								
35								
36								
37	HOIST OPERATOR							
38	CRANE OPERATOR	1.0	1.0	1.0	3.0			load precast segments
39	OUTSIDE LABOR	2.0	2.0	2.0	6.0			load precast segments
40	CAR MOVER OPR	0.4	0.4	0.4	1.3			average number over job
41								
42	TOTALS PER DAY	22.3	16.8	16.8	56.0			
43	TOTAL LABOR MAN-SHIFTS PER DAY				57.8	308	17813	
44								
45	TUNNEL BORING MACHINE EXCAVATION CREW AND EQUIPMENT OPERATION							

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	------- PER	DAY	----------	
		UNITS		OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
VENT FAN, 50 HP	10.0	5.5	4.5	8.0	3.0	108	0.010	1	1.63	176
SCRUBBER AND 25 HP FAN	2.0	1.0	1.0	2.0	3.0	6	0.030	0	0.93	6
WELDER	1.0		1.0	1.0	3.0	3	0.005	0	0.78	2
TRAILING CONVEYOR	1.0		1.0	2.0	3.0	6			16.77	101
DRILLS, HAND HELD	3.0	2.0	1.0				0.040		1.62	
LOCOMOTIVE, 10 Tons	4.0	2.3	1.7	3.0	3.0	15	0.340	5	10.29	157
ROTARY DUMP	1.0		1.0	1.0	3.0	3	0.090	0	4.84	15
MUCK CARS	14.0	4.6	9.4	2.0	3.0	56	0.050	3	0.70	39
FLAT CARS	7.0	3.4	3.6	1.0	3.0	11	0.015	0	0.50	5
MANHAUL CAR	1.0		1.0	1.0	3.0	3	0.040	0	0.61	2
PUMPS, 1 HP				4.0	3.0		0.005		0.14	
3 HP				4.0	3.0		0.005		0.26	
5 HP				4.0	3.0		0.010		0.50	
13 HP	2.0	1.0	1.0	0.3	3.0	1	0.015	0	0.87	1
30 HP				1.0	3.0		0.020		1.61	
PORTAL FEEDER & CONVEYOR	1.0		1.0	1.0	3.0	3	0.030	0	7.33	22
FRONT END LOADER, 6 CY	1.0		1.0	7.0	1.0	7	0.350	2	24.52	172
WELDER	1.0		1.0	4.0	1.0	4	0.005	0	0.78	3
COMPRESSOR, 1200 CFM	1.0		1.0	1.0	3.0	3	0.071	0	7.75	23
BIT GRINDER							0.010		1.32	
MAN ELEVATOR							0.300		3.50	
SHAFT HOIST, 400 HP							0.550		26.46	
YARD CRANE, 25T	1.0		1.0	2.0	3.0	6	0.290	2	8.83	53
CAR MOVER	1.0	0.6	0.4	1.0	3.0	1	0.060	0	2.87	4
								15		781

ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\CLEANUP

B	C	D	E	F	G	H	REMARKS
CREW					RATE	COST	
	NUMBER OF MEN				PER	PER	REMARKS
CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
SHIFTER	1.0	1.0	1.0	3.0			OPERATIONS
MINERS	2.0	2.0	2.0	6.0			Remove power cable and lights.
							Remove air and water lines.
LABORERS	4.0	4.0	4.0	12.0			Cleanup concrete mess.
							Clean drainageway.
OPERATOR	2.0	2.0	2.0	6.0			Remove utility bolts, pins, etc.
OUTSIDE LABOR	2.0	2.0	2.0	6.0			PRODUCTION
							350'/shift = 1000'/day
TOTALS PER DAY	11.0	11.0	11.0	33.0			
TOTAL LABOR MAN-SHIFTS PER DAY 33.6					308	10353	

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	-------- PER		DAY --------	
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
VENT FANS, 50 HP	2.0		2.0	8.0	3.0	48.0	0.015	1	1.63	78
DIESEL BUGGY	2.0		2.0	7.0	3.0	42.0	0.100	4	13.63	572
								5		651

CLEANUP CREW AND EQUIPMENT OPERATION

ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\D&S

1	B	C	D	E	F	G	H	
2	CREW					RATE	COST	
3		NUMBER OF MEN				PER	PER	REMARKS
4	CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
5								
6	SHIFTER	1.0	1.0	1.0	3.0			Use this crew for tunnels up to 0.5
7	MINER	2.0	2.0	2.0	6.0			miles long.
8	CHUCKTENDER	1.0	1.0	1.0	3.0			
9								PRODUCTION:
10								
11	HEADING MECH							4 rounds @ 6' = 24'/day.
12	LHD OPERATOR	2.0	2.0	2.0	6.0			
13	MUCKER OPR							for startup allow 12'/day.
14	TRUCK DRIVERS	1.0			1.0			
15								
16								
17	POWDERMAN	1.0			1.0			
18	POWDERMAN HLPR							
19								
20								
21								
22								
23								
24								
25	BULL GANG 4MAN							
26	BULL GANG LAB							
27								
28	ELECTRICAL 4MAN							
29	ELECTRICIAN							
30								
31	DRILL DOCTOR	1.0			1.0			
32	BIT GRINDER							
33								
34								
35	COMPRESSOR OPR							
36								
37								
38								
39								
40	OUTSIDE LABOR	2.0			2.0			
41								
42	TOTALS PER DAY	11.0	6.0	6.0	23.0			
43	TOTAL LABOR MAN-SHIFTS PER DAY				25.3	308	7803	
44								
45	DRILL & SHOOT EXCAVATION CREW AND EQUIPMENT OPERATION							

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	-------- PER	DAY -------		
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
HAND HELD DRILLS	3.0	2.0	1.0	1.0	1.0	1.0	0.040	0	1.62	2
DRILL JUMBO, 2 PR-55	1.0		1.0	3.0	3.0	9.0	0.480	4	17.84	161
LHD, 2 CY	3.0	1.0	2.0	3.0	3.0	18.0	0.560	10	16.92	305
POWDER TRUCK	1.0		1.0	1.0	3.0	3.0	0.210	1	17.80	53
NIP TRUCK	1.0		1.0	3.0	3.0	9.0	0.210	2	16.80	151
AN-FO POTS										
SHOTCRETE GUN										
SHOTCRETE MIXER										
SHOTCRETE TRUCK / CAR										
VENT FANS, 50 HP	2.0	1.0	1.0	8.0	3.0	24.0	0.010	0	1.63	39
PUMP - AIR	2.0	1.0	1.0	2.0	3.0	6.0	0.025	0	1.70	10
PUMP - ELECTRIC										
BIT GRINDER	1.0		1.0	2.0	1.0	2.0	0.010	0	1.32	3
SAW	3.0	2.0	1.0	1.0	1.0	1.0	0.040	0	1.91	2
COMPRESSORS, 1200 CFM	2.0	1.0	1.0	6.0	3.0	18.0	0.056	1	7.75	140
GRADER	1.0		1.0	1.0	1.0	1.0	0.250	0	12.70	13
								19		877

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ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\INV-CONC

1	B	C	D	E	F	G	H
2	CREW					RATE	COST
3		NUMBER OF MEN				PER	PER
4	CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY
5							
6	SHIFTER	1.0	1.0	1.0	3.0		
7	PUMP OPERATOR	1.0			1.0		
8	CONVEYOR OPR	1.0			1.0		
9	SCREED OPERATOR	1.0			1.0		
10	AGITATOR TENDER	1.0			1.0		
11							
12	NOZZLEMAN	1.0			1.0		
13	VIBRATORMEN	2.0			2.0		
14	CONCRETE LABOR	1.0			1.0		
15							
16	FINISHER 4MAN	1.0	1.0		2.0		
17	FINISHERS	2.0	2.0		4.0		
18							
19	CLEANUP LABOR		3.0	3.0	6.0		
20	DOZER OPR						
21	MUCKER OPR		1.0	1.0	2.0		
22	FORM JUMBO OPR						
23	FORM LABORERS	3.0	2.0	4.0	9.0		
24	CARPENTER						
25	HEADING MECH.	1.0	1.0	1.0	3.0		
26	NIPPER						
27	TRUCK DRIVERS						
28	ELECTRICAL 4MAN						
29	ELECTRICIAN						
30	PUMPMEN	1.0			1.0		
31	TRANSIT MIX OPR						
32	MOTORMEN	2.5	1.0	1.0	4.5		
33	BRAKEMEN	1.0			1.0		
34	COMPRESSOR OPR						
35	BATCHPLANT OPR						
36	MECHANIC/OILER						
37	BATCHPLANT LAB						
38	OUTSIDE LABOR	2.0			2.0		
39	FEL OPERATOR						
40							
41							
42	TOTALS PER DAY	22.5	12.0	11.0	45.5		
43	TOTAL LABOR MAN-SHIFTS PER DAY				47.9	308	14741
44							
45	INVERT CONCRETE CREW AND EQUIPMENT OPERATION						

REMARKS

PLACE 7' WIDE FLAT INVERT WITH DRAINAGEWAY

LINED DIAMETER: 10'
CY PER FOOT OF TUNNEL: 0.26

SCHEDULE ------------------------------

DAY SHIFT
finish screed rails & place concrete
700' = 182CY/day

SWING SHIFT
cleanup and start screed rails
700'x.10CY/TF=70CY muck to remove

GRAVEYARD SHIFT
finish cleanup and set screed rails

PRODUCTION: 700 FPD

FORMS -----------------------------------

DRAINAGEWAY FORMS	
1000'x2sidesx0.5SFx$40 =	40,000
SCREED	10,000
HARDWEAR	5,000
TOTAL FORMS	$55,000

SUPPLIES ---------------------------------

FORM HARDWEAR	$5,000
SLICKLINE	6,000
SCREED RAIL	3,000
FORM OIL	600
CURING COMPOUND	500
TOTAL SUPPLIES	$9,900

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	-------- PER		DAY --------	
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
VENT FANS 50 HP	2.0		2.0	8.0	3.0	48.0	0.010	0	1.63	78
CONCRETE PUMP	1.0		1.0	4.0	1.0	4.0	0.620	2	36.04	144
WET BELT	1.0		1.0	4.0	1.0	4.0	0.025	0	1.09	4
SCREED	1.0		1.0	4.0	1.0	4.0			2.00	8
WELDER			1.0	3.0	1.0	3.0	0.005	0	0.78	2
AGITATORS, 6 CY	7.0	1.0	6.0	4.0	1.0	24.0	0.210	5	5.60	134
VIBRATORS	4.0	2.0	2.0	4.0	1.0	8.0	0.090	1	1.18	9
MUCKER, BOBCAT	1.0		1.0	6.0	2.0	12.0	0.180	2	2.57	31
PUMPS 1 HP	6.0		6.0	2.0	3.0	36.0	0.005	0	0.14	5
PUMPS 13 HP	2.0		2.0	4.0	3.0	24.0	0.015	0	0.87	21
LOCOMOTIVES	4.0	2.5	1.5	4.0	3.0	18.0	0.340	6	10.29	185
MUCK CARS			2.0	3.0	2.0	12.0	0.050	1	0.70	8
COMPRESSOR	2.0	1.0	1.0	3.0	3.0	9.0	0.071	1	7.75	70
								19		701

B	C	D	E	F	G	H
CREW					RATE	COST
	NUMBER OF MEN				PER	PER
CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY
SHIFTER	1.0	1.0	1.0	3.0		
MINER	2.0	2.0	2.0	6.0		
CHUCKTENDER	2.0	2.0	2.0	6.0		
MECH/MUCKER	1.0	1.0	1.0	3.0		
MOTORMAN	1.0	1.0	1.0	3.0		
BRAKEMAN	1.0	1.0	1.0	3.0		
BULL GANG 4MAN	1.0			1.0		
BULL GANG LAB	2.0			2.0		
ELECTRICAL 4MAN						
ELECTRICIAN						
COMPRESSOR OPR						
OUTSIDE LABOR	2.0			2.0		
TOTALS PER DAY	13.0	8.0	8.0	29.0		
TOTAL LABOR MAN-SHIFTS PER DAY				30	308	9337

REMARKS

Use this composite crew for excavation and lining of Electronic Shielding Nitches and Power Alcoves.

ELECTRONIC SHIELDING NITCHES
Nitches are on centerline in back.
Spacing: 630'.
2' diameter x 5' deep.
Excavate, place steel form, place concrete (1 CY) and strip form.

POWER ALCOVES
Enlarge tunnel on inner side of ring.
Average spacing: 4408'.
Excavated dimensions:
12' long x 14' deep x 8' high.
Excavate and shotcrete (14 CY).

DURATIONS

Nitches: 1 days.
Alcoves: 4 days.
Provide two crews; therefore schedule time is half total duration.

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	-------- PER	DAY	--------	
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
HAND HELD DRILLS	3.0	1.0	2.0	3.0	3.0	18.0	0.040	1	1.62	29
MUCKER, EIMCO 25	1.0		1.0	1.0	3.0	3.0	0.370	1	12.84	39
LOCOMOTIVE			1.0	2.0	3.0	6.0	0.340	2	10.29	62
MUCK CARS	3.0	1.0	2.0	1.0	3.0	6.0	0.050	0	0.70	4
MAN CAR	1.0		1.0	1.0	3.0	3.0	0.040	0	0.61	2
SHOTCRETE GUN			1.0	1.0	3.0	3.0	0.800	2	16.30	49
SHOTCRETE MIXER			1.0	1.0	3.0	3.0	0.500	2	9.45	28
SHOTCRETE TRUCK / CAR			1.0	1.0	3.0	3.0	0.200	1	6.03	18
VENT FANS, 50 HP	2.0	1.0	1.0	8.0	3.0	24.0	0.010	0	1.63	39
PUMP - AIR	2.0	1.0	1.0	2.0	3.0	6.0	0.025	0	1.70	10
PUMP - ELECTRIC										
BIT GRINDER	1.0		1.0	1.0	1.0	1.0	0.010	0	1.32	1
SAW	3.0	2.0	1.0	1.0	1.0	1.0	0.040	0	1.91	2
COMPRESSORS, 1200 CFM	2.0	1.0	1.0	6.0	3.0	18.0	0.071	1	7.75	140
								11		423

MISCELLANEOUS EXCAVATION CREW AND EQUIPMENT OPERATION

ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\REM-FAN

1	B	C	D	E	F	G	H	
2	CREW					RATE	COST	
3		NUMBER OF MEN				PER	PER	REMARKS
4	CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
5								
6	SHIFTER	1.0	1.0	1.0	3.0			
7								
8	MOLE OPERATOR	1.0	1.0	1.0	3.0			
9	MOLE MECHANIC	1.0	1.0	1.0	3.0			
10								
11	GREASER	1.0			1.0			
12								
13	CONVEYOR OPR							
14								
15	MINERS	2.0	2.0	2.0	6.0			
16	TRACKMEN	1.0	1.0	1.0	3.0			
17	REAR MINER							
18								
19	MOTORMEN	2.0	2.0	2.0	6.0			
20	BRAKEMEN	2.0	2.0	2.0	6.0			
21								
22	BULL GANG 4MAN	1.0			1.0			
23	BULL GANG LABOR	2.0			2.0			
24								
25	PUMPMAN							
26								
27	ELECTRICAL 4MAN							indirect cost
28	ELECTRICIAN							
29								
30	CONVEYOR OPR							
31	LOADER OPR	1.0			1.0			
32								
33	WELDER - SHOP	1.0			1.0			
34								
35								
36								
37								
38								
39								
40								
41								
42	TOTALS PER DAY	16.0	10.0	10.0	36.0			
43	TOTAL LABOR MAN-SHIFTS PER DAY				38.8	308	11961	
44								
45	REMOVE FANLINE, TUNNEL BORING MACHINE AND TRAILING FLOOR --- SHAFT							

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	------- PER	DAY	----------	
		UNITS		OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
VENT FAN, 50 HP	1.0		1.0	8.0	3.0	24	0.010	0	1.63	39
LOCOMOTIVE, 10 Tons	4.0	2.0	2.0	4.0	3.0	24	0.400	10	16.13	387
MUCK CARS	14.0		14.0	4.0	3.0	168	0.050	8	0.70	118
PUMPS 3 HP	10.0	6.0	4.0	4.0	3.0	48	0.005	0	0.26	12
13 HP	4.0	2.0	2.0	4.0	3.0	24	0.015	0	0.87	21
FRONT END LOADER, 6 CY	1.0		1.0	2.0	3.0	6	0.350	2	24.52	147
YARD CRANE, 25T	1.0		1.0	6.0	1.0	6	0.290	2	8.83	53
								23		777

ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\SHOTCRET

B	C	D	E	F	G	H	REMARKS
CREW	NUMBER OF MEN				RATE PER	COST PER	
CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
SHIFTER	1.0	1.0	1.0	3.0			
NOZZLEMAN	1.0	1.0	1.0	3.0			
HOSE TENDER	1.0	1.0	1.0	3.0			
OPERATOR, GUN	1.0	1.0	1.0	3.0			Also operates sucker for rebound cleanup.
OPERATOR, MIXER	1.0	1.0	1.0	3.0			
LABORERS	3.0	3.0	3.0	9.0			Place over steel sets to form permanent lining. Remove as much wood lagging as possible before placing shotcrete.
MOTORMAN	1.0	1.0	1.0	3.0			
BRAKEMAN	1.0	1.0	1.0	3.0			
MINERS	1.0	1.0	1.0	3.0			Remove excess lagging, retimber and cleanup.
LABORERS	2.0	2.0	2.0	6.0			
TOTALS PER DAY	13.0	13.0	13.0	39.0			
TOTAL LABOR MAN-SHIFTS PER DAY				40.6	308	12501	

Production: 4CY/hr x 4 hrs/shift = 16 CY/shift.

Assume 4" thick and 40% rebound.
In 11' tunnel = 0.6 CY/TF.

PRODUCTION: 16CY/shift / 0.6 CY/TF = 26 TF/shift

3 shifts/day = say 75 TF/WD

SHOTCRETE CREW AND EQUIPMENT OPERATION

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	--- PER DAY ---			
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
FAN, 50 HP	2.0		2.0	8.0	3.0	48.0	0.010	0	1.63	78
CONVEYOR	1.0		1.0	2.0	3.0	6.0	0.050	0	0.91	5
GUN	1.0		1.0	4.0	3.0	12.0	0.800	10	16.30	196
MIXER	1.0		1.0	2.0	3.0	6.0	0.200	1	9.45	57
LOCOMOTIVE	4.0	3.0	1.0	2.0	3.0	6.0	0.170	1	7.08	42
FLAT CAR	3.0	1.0	2.0	1.0	3.0	6.0	0.015	0	0.50	3
								13		381

SH

ARIZONA SSC

P. E. Sperry 30-Jun-87 \AZM1-COS\SATMAINT

B	C	D	E	F	G	H	
CREW					RATE	COST	
	NUMBER OF MEN				PER	PER	REMARKS
CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	DAY	
FOREMAN	1.0			1.0			
MECHANICS - TBM	2.0			2.0			tunnel boring machine
MECHS - FLOOR	2.0			2.0			floor and other equipment
TBM OPERATOR	1.0			1.0			
GREASER	1.0			1.0			
SHIFTER	1.0			1.0			
MINERS	1.0			1.0			change cutters
MINERS	2.0			2.0			cleanup
MOTORMAN	1.0			1.0			
HOIST OPR							
CRANE OPR							
ELECTRICAL 4MAN							
ELECTRICIAN							
TOTALS PER DAY	12.0			12.0			
TOTAL LABOR MAN-SHIFTS PER DAY	12.3				462	5662	

SATURDAY MAINTENANCE -- TUNNEL BORING MACHINE -- PORTAL ACCESS

L	M	N	O	Q	R	S	T	U	V	W
EQUIPMENT OPERATION				HR	SH	HR	-------- PER		DAY --------	
	UNITS			OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPP	
DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
				SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
VENT FAN			8.0	1.0	8.0	64.0	0.010	1	1.63	104
WELDERS			2.0	6.0	1.0	12.0	0.005	0	0.78	9
LOCOMOTIVE			1.0	4.0	1.0	4.0	0.340	1	10.29	41
								2		155

SUMMARY

DATA

Location of project site ----------------	ARIZONA
Urban (1), rural (2), or remote (3) -----	2
Rock type -------------------------------	SOFT
Method of tunnel excavation -------------	TBM
Tunnel access via portal (1) or shaft (2)	1
Tunnel should be wet (1) or dry (2)------	1
Haulageway width	10.0 feet
Tunnel length	29,568 feet

D E F G H	I	J	K	L	M	N	O	P	Q	R	S	T	U
DESCRIPTION	PURCHASE	SALVAGE	DEPRECIATE	RENT	FREIGHT IN	ASSEMBLE LABOR	ASSEMBLE OTHER	DISASSEMBLE LABOR	DISASSEMBLE OTHER	SALES TAX	OTHER	FREIGHT OUT	JOB CHARGE
BUILDINGS & YARD	121,754	35,685	86,069		200	17,864	93,662	2,680	512			1,000	201,987
UTILITIES	997,313	231,121	766,192	600	16,000	20,020	27,382	6,037	1,732			7,500	845,463
HOISTING AND CRANES	69,178	32,375	36,803	14,574	2,200	4,928	2,870	1,971	1,148			1,500	65,993
HAUL - RUBBER	243,230	53,088	190,142		1,000	15,400	8,916	6,160	871			2,500	224,989
HAUL - RAIL	1,336,552	516,879	819,674		57,600	47,432	12,760	18,788	2,921			21,500	980,674
SURFACE EXCAVATION EQUIPMENT	131,900	51,441	80,459		100							500	81,059
ROCK DRILLS AND EQUIPMENT	5,719	777	4,942										4,942
TUNNEL & SHAFT MUCKERS	40,070	13,735	26,335	9,962	3,500							2,650	42,446
TUNNEL & SHAFT MACHINES	3,242,427	1,076,129	2,166,298		31,200	58,520	4,612	23,408	1,845			6,500	2,292,383
CONCRETE & SHOTCRETE	547,534	307,644	239,890		21,600	1,540	512	308	102			4,500	268,453
GENERAL PLANT & EQUIPMENT	317,053	72,290	244,763		100	1,232	410					500	247,005
TOTAL PLANT AND EQUIPMENT COST	7,052,730	2,391,164	4,661,566	25,135	133,500	166,936	151,124	59,352	9,132			48,650	5,255,393

ARIZONA SSC P. E. Sperry 30-Jun-87 \AZM1-COS\P&E

BUILDINGS	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
DESCRIPTION	IND	SIZE		QUANTITY	UNIT	PURCHASE	SALVAGE	DEPRECIATE	RENT	FREIGHT IN	ASSEMBLE LABOR	ASSEMBLE OTHER	DISASSEMBLE LABOR	DISASSEMBLE OTHER	SALES TAX	OTHER	FREIGHT OUT	JOB CHARGE
SITEWORK																		
CLEAR & GRUBB	S	1 #		5	A							14,604						14,604
SITE GRADING	S			2,000	CY							3,075						3,075
FENCING	S	1 #			LF													
ACCESS ROADS	S	3 #		1,000	LF							2,562						2,562
SURFACING	S			1,000	SY							1,978						1,978
SIGNS & BARRICADES	A			1	LS						1,540	1,025						2,565
STAIRWAYS & LADDERS	A			60	VF						3,696	922						4,618
RESTORATION	S			1,000	SY							1,445						1,445
SURFACE RAILROAD	A			150	LF						3,696	307						4,003
OFFICES																		
JOB	PAD			2,500	SF	57,648	17,986	39,662			1,540	1,281	770					43,253
FIELD	P				SF													
OWNER'S	PAD			500	SF	11,530	3,597	7,932			308	256	154					8,651
FIRST AID	PAD			500	SF	11,530	3,597	7,932			308	256	0					8,497
SHOPS																		
EQUIPMENT	S			2,000	SF							40,994						40,994
CARPENTER	A			200	SF						1,232	2,050						3,282
ELECTRICAL	PA			2	VAN	7,379	1,727	5,652			1,232	1,025						7,909
CUTTER	S			100	SF							1,537						1,537
STORAGE																		
WAREHOUSE	S			1,000	SF							15,373						15,373
CEMENT, SACK	PA				VAN													
POWDER & CAPS	RAD				LS													
FUEL	AD			1	LS						3,080	4,099	1,232	512				8,924
OFFSITE YARD	R				MO													
MISCELLANEOUS																		
CHANGEHOUSE	PAD			60	MAN	22,137	5,180	16,957			924	615	370					18,865
LIVING TRAILERS	PAD			500	SF	11,530	3,597	7,932			308	256	154					8,651
FREIGHT ON PURCHASES				2.0	LOADS					200							1,000	1,200
				TOTALS		121,754	35,685	86,069	.	200	17,864	93,662	2,680	512			1,000	201,987

UTILITIES ONE	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
SANITARY																		
HOOK TO CITY SEWER	S				LF													
SEPTIC TANKS	S			1	LS							5,124						5,124
TILE FIELDS	S			1	LS							4,169						4,169
SEWER LINES	S			200	LF							2,050						2,050
TREATMENT PLANT	QS				LS													
PORTABLE TOILETS	R			10	MO				600									600
TOTAL SANITARY									600			11,343						11,943
WATER SUPPLY																		
CONNECT TO MAIN	S				LF													
WELLS	S	(by others)			LF													
WELL PUMPS	S	(by others)			LS													
SURFACE LINE	PL	4 IN		1,000	LF	3,883		3,883										3,883
INSULATION	A	4 IN			LF													
TUNNEL LINE	PL	4 IN			LF													
VALVES	P			1	LS	388	61	328										328
	P																	
ICE MACHINE	P			1	EA	1,289	201	1,088										1,088
TOTAL WATER SUPPLY						5,561	262	5,299										5,299
COMMUNICATIONS																		
COMMERCIAL PHONE LINE	S			5,000	LF							5,124						5,124
JOB PHONES	P			10	EA	3,321	518	2,803										2,803
PHONE LINE	P			30,626	LF	4,520		4,520										4,520
RADIOS	P				EA													
TOTAL COMMUNICATIONS						7,840	518	7,322				5,124						12,447
VENTILATION																		
FANS	PL	50 HP		10	EA	47,917	14,950	32,967										32,967
	PL	100 HP			EA													
	PL	200 HP			EA													
ACCESSORIES	P	50 HP		9	EA	3,321	518	2,803										2,803
STARTERS	PL	50 HP		10	EA	10,377	4,856	5,520										5,520
FANLINE & COUPLINGS	PL	36 IN		29,460	LF	298,902		298,902										298,902
	PL	48 IN			LF													
BULKHEADS	AD			100	SF						1,848	615	308					2,771
DOORS	PAD	6'w x 8'h		1	EA	5,534		5,534			3,080	1,025	616					10,255
TOTAL VENTILATION						366,051	20,325	345,726			4,928	1,640	924					353,218
FREIGHT ON PURCHASES				2.0	LOADS					400							1,000	1,400
				TOTALS		379,452	21,104	358,348	600	400	4,928	18,107	924				1,000	384,307

ARIZONA SSC P. E. Sperry 30-Jun-87 \AZM1-COS\P&E

184	UTILITIES TWO	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
185						UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
186	DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
187	ELECTRICAL																		
188	POWER COMPANY LINE	QS				LF													
189	SUBSTATION	QS				LS													
190	SURFACE SUBSTATION																		
191	TRANSFORMERS	PL	3000 KW		1	EA	39,293	18,389	20,904			4,312	1,332	1,725	400				28,673
192	DISTRIBUTN & LIGHTING	AL	2 W		1	LS						9,240	4,612	2,772	922				17,546
193	GENERATORS	PL	KW			EA													
194	UNDERGROUND, 15KV																		
195	MAIN POWER CABLE	PL	4 /0		29,000	LF	189,917	88,881	101,036										101,036
196	TRAILING CABLE	P	2 /0		1,000	LF	12,175	3,799	8,377										8,377
197	TRANSFORMERS, LIGHTING	P	25 KVA		10	EA	6,918	3,238	3,680										3,680
198	TRANSFORMERS, FANS	PL	100 KVA		10	EA	62,030	29,030	33,000										33,000
199	DISCONNECTS	P			10	EA	28,142	13,170	14,971										14,971
200	LIGHT LINE	P			29,460	LF	102,170	7,969	94,201										94,201
201	TOTAL ELECTRICAL						440,645	164,476	276,169			13,552	5,944	4,497	1,322				301,484
202	COMPRESSED AIR																		
203	STATIONARY COMPRESSORS	PL	1000 CFM		1	EA	39,662	15,468	24,194			1,540	1,025	616	410				27,785
204	PORTABLE COMPRESSORS	PL	1000 CFM			EA													
205	COMPRESSOR HOUSE & PIPING	S	1 EA		150	SF							2,306						2,306
206	SURFACE LINE	PL	4 IN		1,000	LF	3,883		3,883										3,883
207	TUNNEL LINE	PL	4 IN		29,460	LF	114,398	26,769	87,629										87,629
208	VALVES	P			1	LS	11,828	2,768	9,060										9,060
209	TANNER TANK	P	6 IN			EA													
210	TOTAL COMPRESSED AIR						169,771	45,005	124,766			1,540	3,331	616	410				130,663
211	DEWATERING																		
212	PUMPS, SUBMERSIBLE, ELECT	PL	3 HP			EA													
213		PL	13 HP		2	EA	3,431	535	2,896										2,896
214	PUMPS, SUBMERSIBLE, AIR	P	35A1			EA													
215	TUNNEL DISCHARGE LINE	PL	6 IN			LF													
216	SHAFT DISCHARGE LINE	PL	6 IN		70	LF	798		798										798
217	SURFACE DISCHARGE LINE	PL	6 IN		500	LF	2,850		2,850										2,850
218	VALVES	P			1	LS	365		365										365
219	SHAFT SUMP	A				EA													
220	SETTLING BASIN/OIL SKIMMER	PA				EA													
221	WIERS & RECORDERS					EA													
222	TOTAL DEWATERING						7,444	535	6,909										6,909
223	FREIGHT ON PURCHASES				13.0	LOADS					15,600							6,500	22,100
224																			
225			UTILITY		TOTALS		997,313	231,121	766,192	600	16,000	20,020	27,382	6,037	1,732			7,500	845,463
226																			
227																			

HOISTING	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
HOISTS																		
SHAFT	Q	400 HP			EA													
HOIST HOUSE	Q				EA													
WINCHES	Q				EA													
TUGGERS, 2000#	P				EA													
					EA													
ALIMAC MAN HOIST	P				EA													
ALIMAC RAIL	P				LF													
					EA													
TOTAL HOISTS																		
SHAFT EQUIPMENT																		
HEAD FRAME	Q				LBS													
STEEL & GUIDES	Q				FT													
CABLE & FITTINGS	Q				LS													
SHEAVES	Q				LS													
SKIP & SCROLLS	Q				LS													
AUTOMATIC CONTROLS	Q				LS													
COUNTERWEIGHT	Q				LS													
FOUNDATION	Q				LS													
MUCK HOPPER	Q				CY													
BULKHEAD	Q				LS													
BUCKETS	Q	CY			EA													
TOTAL SHAFT EQUIPMENT																		
CRANES																		
YARD CRANE, USED	P	15 T		1	EA	69,178	32,375	36,803										36,803
	P	25 T			EA													
TRUCK CRANE	RLAD	90 T		2	MO				14,574	1,000	4,928	2,870	1,971	1,148			1,000	27,490
CRAWLER CRANE	RLAD	120 T			MO													
TOTAL CRANES						69,178	32,375	36,803	14,574	1,000	4,928	2,870	1,971	1,148			1,000	64,293
FREIGHT ON PURCHASES				1.0	LOADS					1,200							500	1,700
				TOTALS		69,178	32,375	36,803	14,574	2,200	4,928	2,870	1,971	1,148			1,500	65,993

RUBBER	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
OFF HIGHWAY																		
REAR DUMP	Q				EA													
ROCKER DUMP	Q				EA													
WATER	Q				EA													
TOTAL OFF HIGHWAY																		
HIGHWAY																		
FLAT BED	P	2.5 T		1	EA	27,671	4,317	23,355										23,355
FLAT BED	P	T			EA													
FUEL					EA													
GREASE					EA													
MECHANIC	P				EA													
POWDER	P				EA													
LOW BED					EA													
WATER	Q				EA													
MANHAUL BUS, 25 MAN	P				EA													
SCRUBBER, 100-150 HP	P				EA													
TOTAL HIGHWAY						27,671	4,317	23,355										23,355
CONVEYOR																		
DRIVE	Q	50 HP		1	EA	18,448	5,756	12,692			7,700	3,075	3,080	512				27,059
	Q				EA													
	Q				EA													
STRUCTURE	Q			400	LF	95,927	22,447	73,480										73,480
STRUCT W/DOLLY TRAC	Q				LF													
BELT	Q	30 IN		800	LF	13,282		13,282										13,282
	Q				LF													
TAKEUP	Q				EA													
CLUSTERS	Q				EA													
TRUSS CONVEYOR	Q				LF													
BRIDGE CONVEYOR	Q				LF													
FEEDER, VIBRATING	Q	30 FT		1	EA	23,336	5,461	17,875			3,080	2,562	1,232	154				24,903
HOPPER	Q			1	LF	64,566	15,109	49,458			4,620	3,280	1,848	205				59,410
TOTAL CONVEYOR						215,559	48,772	166,787			15,400	8,916	6,160	871				198,135
FREIGHT ON PURCHASES				5.0	LOADS					1,000							2,500	3,500
					TOTALS	243,230	53,088	190,142		1,000	15,400	8,916	6,160	871			2,500	224,989

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319	RAIL	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
320						UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
321	DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
322	RAIL & SWITCHES																		
323	RAIL	P	80 #		825	T	228,317	89,044	139,273										139,273
324	TIES, STEEL	P				EA													
325	SPLICE BARS	P			2,063	PR	24,734	9,646	15,088										15,088
326	TRACK BOLTS	P			8,251	EA	10,503		10,503										10,503
327	RAIL CLIPS	P			35,362	EA	63,603	24,805	38,798										38,798
328	SWITCHES	P			6	EA	9,962	3,885	6,077										6,077
329	SWITCH TIES	P	24 IN		2.4	MBF	720		720										720
330	CALIF SWITCH, TNOUT & RAMP	Q	24 IN		2	PR	66,411	25,900	40,511			18,480	2,050	7,392	820				69,252
331	CALIF SWITCH, PANEL	Q	24 IN		20	EA	129,133	50,362	78,771										78,771
332	CAR MOVER	P	24 IN		1	EA	5,777	2,253	3,524			1,232	461	308	51				5,576
333	SHAFT BOTTOM SETUP	AL	24 IN			EA													
334	BACKFILL TAIL TUNNEL	Q				CY													
335	WALKWAY	P				LF													
336	FREIGHT ON PURCHASES				30.0	LOADS					36,000							15,000	51,000
337	TOTAL RAIL & SWITCHES						539,158	205,895	333,263		36,000	19,712	2,511	7,700	871			15,000	415,057
338	LOCOMOTIVES																		
339	DIESEL	PL	8 T		5	EA	232,439	90,651	141,788										141,788
340		PL	10 T			EA													
341	BATTERY	Q	T			EA													
342	BATTERIES	Q				EA													
343	CHARGERS	Q				EA													
344	FREIGHT ON PURCHASES				3.0	LOADS					9,600							1,500	11,100
345	TOTAL LOCOMOTIVES						232,439	90,651	141,788		9,600							1,500	152,888
346	CARS																		
347	MUCK, SIDE DUMP	PL	CY			EA													
348	ROTARY	PL	15 CY		13	EA	226,628	88,385	138,243										138,243
349	LIFT OFF	PL	CY			EA													
350	DUMP, SIDE	P				EA													
351	ROTARY	P	15 CY		1	EA	178,019	69,427	108,591			27,720	10,249	11,088	2,050				159,698
352	POWDER	P				EA													
353	FLAT	PL	24 IN		9	EA	115,389	45,002	70,387										70,387
354	FANLINE	P			1	EA	27,671	10,792	16,879										16,879
355	MANTRIP	PL	15 MAN		1	EA	17,248	6,727	10,522										10,522
356	BRAKEMAN	P				EA													
357	FREIGHT ON PURCHASES				10.0	LOADS					12,000							5,000	17,000
358	TOTAL CARS						564,955	220,332	344,623		12,000	27,720	10,249	11,088	2,050			5,000	412,729
359																			
360					TOTALS		1,336,552	516,879	819,674		57,600	47,432	12,760	18,788	2,921			21,500	980,674
361																			
362																			

EXCAVATION DESCRIPTION	D IND	E SIZE	F	G QUANTITY	H UNIT	I PURCHASE	J SALVAGE	K DEPRECIATE	L RENT	M FREIGHT IN	N ASSEMBLE LABOR	O ASSEMBLE OTHER	P DISASSEMBLE LABOR	Q DISASSEMBLE OTHER	R SALES TAX	S OTHER	T FREIGHT OUT	U JOB CHARGE
EXCAVATORS																		
SHOVEL	Q				MO													
BACKHOE	Q		CY		EA													
CLAMSHELL	Q				MO													
DRAGLINE	Q				MO													
GRADALL	Q				MO													
MATS	Q				LS													
TOTAL EXCAVATORS																		
EARTHMOVERS																		
TRACTOR, D-6, USED	P	140 HP			EA													
D-7, USED	P	200 HP			EA													
D-8, USED	P	335 HP			EA													
LOADER, 950, USED	P	3.5 CY			EA													
966, USED	P	4.5 CY			EA													
980, USED	P	5.8 CY		1	EA	131,900	51,441	80,459										80,459
988, USED	P	8.0 CY			EA													
GRADER, CAT12, USED	P				EA													
SCRAPERS	Q				EA													
TOTAL EARTHMOVERS						131,900	51,441	80,459										80,459
COMPACTORS																		
SELF-PROPELLED, PNEUMATIC	R	15 TON			MO													
TOWED, 10,000#	R	35 HP			MO													
WALK BEHIND, 1200#	R	10 HP			MO													
PLATE VIBRATORS	R	300 #			MO													
RAMMERS	R	120 #			MO													
TAMPERS	R	35 #			MO													
TOTAL COMPACTORS																		
FREIGHT ON PURCHASES				1.0	LOADS					100							500	600
				TOTALS		131,900	51,441	80,459		100							500	81,059

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DRILLS	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
DRILLS																		
DRIFTERS, PNEUMATIC	P	PR-55			EA													
HYDRAULIC	P	75 HP			EA													
JACKLEGS	P				EA													
STOPERS	P				EA													
SINKERS	P			1	EA	1,476	345	1,130										1,130
AIR TRACK, ATD-3100A	P	PR-55			EA													
DIAMOND	P				EA													
					EA													
FEEDS & MOUNTS																		
FEEDS & EXTNS, TELESCOPIC	P	14 FT			EA													
ROLLOVER PARALLEL BOOMS	P	HD105			EA													
ROLLOVER PARALLEL EXTN BOOM	P	HD148			EA													
BOOM & BASKET	P				EA													
					EA													
AIR-HYDRAULIC PUMPS	P	1per2 boom			EA													
ELEC-HYD POWER PACK	P	75 HP			EA													
CABLE REEL, 300 FT	P				EA													
WATER BOOSTER PUMP	P	125 psi			EA													
JUMBOS																		
TUNNEL	Q				EA													
	Q																	
SHAFT	Q				EA													
MISCELLANEOUS																		
SPADERS	P				EA													
BREAKERS, AIR	P			1	EA	830	130	701										701
HYDRAULIC	Q				EA													
IMPACT WRENCHES	P			1	EA	1,937	302	1,635										1,635
TENSIONERS	Q				EA													
PRILL POTS	Q				EA													
BIT GRINDER	P				EA													
SAWS	P			1	EA	1,476		1,476										1,476
BLASTING MATS	Q				LS													
AIR LIGHTS	P				EA													
FREIGHT ON PURCHASES					LOADS													
				TOTALS		5,719	777	4,942										4,942

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Row	MUCKERS	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
455						UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
456	DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
457	LOAD-HAUL-DUMP UNITS																		
458		PL	CY			EA													
459		PL	CY			EA													
460	STARTING CHAMBER	PL	1.0 CY		1	MO				3,321	1,200							1,200	5,721
461	CLEANUP	PL	1.0 CY		2	MO				6,641	1,200							1,200	9,041
462	RUBBER																		
463	BOBCAT, 741	P			1	EA	15,811	6,166	9,645										9,645
464	BACKHOE ATTACH	P				EA													
465						EA													
466						EA													
467						EA													
468	CRAWLER																		
469	CAT 931, 65HP	P	1.0 CY			EA													
470	CAT 963, 150HP	P	2.5 CY			EA													
471	CAT 973, 210HP	P	3.8 CY			EA													
472	EIMCO 630	P	10 CF			EA													
473						EA													
474	RAIL																		
475	EIMCO 12B	P	5 CF			EA													
476	EIMCO 22	P	9 CF		1	EA	24,258	7,569	16,690										16,690
477	EIMCO 26	P	12 CF			EA													
478	MITSUI 55	P	11 CF			EA													
479	MITSUI 85	P	14 CF			EA													
480	SHAFT																		
481						EA													
482						EA													
483						EA													
484						EA													
485	MISCELLANEOUS																		
486	SLUSHERS, 20 HP					EA													
487						EA													
488						EA													
489						EA													
490																			
491																			
492	FREIGHT, LHD & RAIL				0.5	LOADS					1,100							250	1,350
493	FREIGHT, OTHER					LOADS													
494																			
495					TOTALS		40,070	13,735	26,335	9,962	3,500							2,650	42,446
496																			
497																			

TBM	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
SHIELD																		
	Q		FT		EA													
	Q																	
TOTAL SHIELD																		
TUNNEL BORING MACHINE																		
TUNNEL BORING MACHINE	Q	11 FT		1	EA	2,305,939	899,316	1,406,623			40,040	3,075	16,016	1,230				1,466,983
SPARE PARTS STOCK	P			1	LS	345,891	26,979	318,911										318,911
REMOVAL DOLLY	P			1	EA	20,753	4,856	15,897										15,897
TOTAL TUNNEL BORING MACHINE						2,672,584	931,152	1,741,431			40,040	3,075	16,016	1,230				1,801,792
TUNNEL DIGGING MACHINE																		
TUNNEL DIGGING MACHINE	Q		FT		EA													
SPARE PARTS STOCK	Q				LS													
TOTAL TUNNEL DIGGING MACHINE																		
ROADHEADER																		
ROADHEADER	Q				EA													
SPARE PARTS STOCK	Q				LS													
TOTAL ROADHEADER																		
TRAILING EQUIPMENT																		
TRAILING FLOOR	Q	10 FT		1	EA	461,188	107,918	353,270			18,480	1,537	7,392	615				381,294
TOTAL TRAILING EQUIPMENT						461,188	107,918	353,270			18,480	1,537	7,392	615				381,294
SUPPORT EQUIPMENT																		
RIB ERECTOR & EXPANDER	Q				LS													
ROCK BOLT PLATFORMS	Q				LS													
FEELER HOLE DRILL	Q				EA													
SCRUBBER	P			1	LS	16,049	3,756	12,294										12,294
WELDER	P			1	LS	1,476	230	1,246										1,246
METHANE DETECTOR	P				LS													
ZED GUIDANCE SYSTEM	P			1	LS	59,493	23,202	36,291										36,291
CUTTER REBUILD EQUIPMENT	P			0.5	LS	31,637	9,871	21,767										21,767
TOTAL SUPPORT EQUIPMENT						108,656	37,059	71,597										71,597
FREIGHT ON PURCHASES				13.0	LOADS					31,200							6,500	37,700
				TOTALS		3,242,427	1,076,129	2,166,298		31,200	58,520	4,612	23,408	1,845			6,500	2,292,383

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		D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
544	CONCRETE	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
545						UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
546	DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
547	INVERT BRIDGE & CONVEYOR	Q				EA													
548	BRIDGE SUPPORTS	Q				EA													
549	TUGGER	Q				EA													
550	SAND BLAST POT & GUN	P				EA													
551	CONCRETE PUMP	P		USED	1	EA	60,877	37,987	22,890										22,890
552	HOPPER	A				EA													
553	WET BELT	P			1	EA	27,671	10,792	16,879										16,879
554	SLICKLINE SUPPORT CAR	A				EA													
555						EA													
556	TRANSIT MIXERS	Q				EA													
557	SCRUBBERS, 300HP	P				EA													
558	AGITATOR CARS, 6 CY, USED	P			7	EA	355,115	221,592	133,523										133,523
559	12 CY, USED	P				EA													
560	LOADING DOCK	A			1	LS						1,540	512	308	102				2,463
561	PIPE CARRIER	P				EA													
562	REBAR JUMBO	AL		'DIA		EA													
563	FINISHING JUMBO	AL	18	'DIA		EA													
564						EA													
565	VIBRATORS, INTERNAL	P			6	EA	5,385	420	4,965										4,965
566	EXTERNAL	P				EA													
567	GROUT JUMBO	AL	18	'DIA		EA													
568	MIXER & PUMP	PL	2 #			EA													
569		Q				EA													
570		Q				EA													
571	SHOTCRETE GUN, WET	P				EA													
572	DRY	P			1	EA	16,372	6,385	9,987										9,987
573	ADDITIVE FEEDER	P			1	EA	1,568	612	957										957
574	ACCESSORIES	P			1	EA	978		978										978
575	SPARE PARTS	P			1	EA	876		876										876
576	REMOTE CONTROL SPRAY BOOM	P			1	EA	63,275	24,677	38,598										38,598
577	HOSE, 150 FT	P			1	EA	2,135		2,135										2,135
578	MATERIALS PIPE & FTTINGS	P				FT													
579	WIRE FIBER FEEDER	P				EA													
580	BATCHER, SKID	P			1	EA	13,282	5,180	8,102										8,102
581	BATCH PLANT	P				EA													
582						EA													
583	FREIGHT ON PURCHASES				9.0	LOADS					21,600							4,500	26,100
584	---																		
585					TOTALS		547,534	307,644	239,890		21,600	1,540	512	308	102			4,500	268,453
586																			
587																			

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GENERAL	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
					UNIT		SALVAGE			FREIGHT	ASSEMBLE		DISASSEMBLE		SALES		FREIGHT	
DESCRIPTION	IND	SIZE		QUANTITY		PURCHASE		DEPRECIATE	RENT	IN	LABOR	OTHER	LABOR	OTHER	TAX	OTHER	OUT	JOB CHARGE
VEHICLES																		
SEDAN	P			1	EA	12,913	3,022	9,892										9,892
PICKUPS, 3/4 T, GAS	P			10	EA	129,133	30,217	98,916										98,916
DIESEL	P				EA													
AMBULANCE, USED	P			1	EA	6,457	1,511	4,946										4,946
MISCELLANEOUS EQUIPMENT																		
MECHANIC SHOP TOOLS	PL	3 #		1	LT	92,238	21,584	70,654										70,654
WELDER, DIESEL	P			1	EA	5,903	1,381	4,522										4,522
ELECTRIC	P			3	EA	4,427	1,036	3,391										3,391
STEAM CLEANER	P			1	EA	2,394	560	1,833										1,833
CARPENTER SHOP	PL	1 #		1	LT	922	216	707										707
FIRE FIGHTING	PL	2 #		1	LT	1,845	288	1,557										1,557
SAFETY	PL	3 #		1	LT	9,224	1,439	7,785										7,785
LIGHTENING DETECTOR	P				EA													
VIBRATION MONITOR	P				LT													
ENGINEERING EQUIPMENT																		
TRANSITS	P			1	EA	2,767	1,079	1,688										1,688
LEVELS	P			1	EA	1,384	540	844										844
LASERS	P			3	EA	21,030	4,921	16,109										16,109
LASER STANDS	A			4	EA						1,232	410						1,642
DRAFTING TABLE	P			1	EA	461	108	353										353
OFFICE																		
COMPUTER	P			1	EA	3,690	863	2,826										2,826
CALCULATOR	P			2	EA	129		129										129
COPIER	P			1	EA	2,767	648	2,120										2,120
BLUEPRINT MACHINE	P			1	EA	922	216	707										707
DESK, TABLE, CHAIR	P			20	SET	7,379	1,727	5,652										5,652
FILING CABINET	P			20	EA	2,767	216	2,551										2,551
MISC FURNISHINGS	PL	3 #		1	LT	7,379	576	6,803										6,803
OWNER OFFICE EQUIP	PL	2 #		1	LT	922	144	778										778
FREIGHT ON PURCHASES				1.0	LOADS					100							500	600
				TOTALS		317,053	72,290	244,763		100	1,232	410					500	247,005

49	INPUT DATA FROM OTHER FILES	Labor Cost, $ per man-shift:	308
50		Small tools, %	4.67
51		Sales Tax Rate, %	0
52		Power cost, cents per KWH	4
53		Payroll, millions of $:	8.5
54		Contract Amt, millions of $:	19.6
55		P&E Ave Value, millions of $:	4.7
56			
57			
58	SCHEDULE DURATIONS IN MONTHS	Shaft Excavation	
59		Tunnel Excavation	9.5
60		Tunnel Concreting	3.7
61		Total Project	25.6
62			

		D	E	F	G	H	I	J	K
63		D	E	F	G	H	I	J	K
64	DESCRIPTION								
65		NO.	MONTHS	MAN	RATE	COST	DTC	VEH	MOVE IN
66	ENGINEERING								
67	PROJECT ENGINEER	1.0	24.6	24.6	8408	206,667	1	1	1
68	OFFICE ENGINEER	1.0	23.6	23.6	5174	122,005	1		
69	COST ENGINEER	1.0	22.6	22.6	5174	116,831	1		
70	TUNNEL ENGINEER	1.0	10.5	10.5	6468	68,174	1	1	1
71	DRAFTSMAN	1.0	13.2	13.2	3234	42,835	1		
72									
73	FIELD ENGINEER	1.0	13.7	13.7	7115	97,795	1	1	1
74	PARTY CHIEF	1.0	13.2	13.2	6468	85,670	1	1	
75	INSTRUMENTMAN	1.0	13.2	13.2	5821	77,103			
76	RODMAN		13.2		5174				
77									
78	SAFETY ENGINEER	1.0	13.7	13.7	6468	88,904	1	1	
79	FIRST AID PERSONS	3.0	13.2	39.7	3234	128,506			
80									
81	ADMINISTRATIVE								
82	OFFICE MANAGER	1.0	23.6	23.6	7115	167,757	1	1	1
83	PURCHASING AGENT	1.0	13.2	13.2	5174	68,536	1		
84	ACCOUNTANT	1.0	22.6	22.6	3881	87,623	1		
85	PAYMASTER		13.2		3881				
86	TIMEKEEPER	1.0	13.2	13.2	3234	42,835	1		
87	CLERK	1.0	13.2	13.2	3234	42,835	1		
88	SECRETARY	1.0	22.6	22.6	1940	43,812	1		
89	WAREHOUSEMAN	1.0	13.7	13.7	6468	88,904	1		
90	GUARDS, FULL TIME	1.0	16.2	16.2	1940	31,522			
91	GUARDS, WEEKEND	1.0	16.2	16.2	1940	31,522			
92									
93	INDIRECT COSTS								

DESCRIPTION	O	P	Q	R	S	T	U	V
	NO.	MONTHS	MAN MONTHS	RATE	COST	DTC	VEH	MOVE IN
SUPERVISION								
PROJECT MANAGER	1.0	25.6	25.6	9702	248,164	1	1	1
GENERAL SUPT	1.0	16.2	16.2	9055	147,104	1	1	1
TUNNEL SUPT	1.0	13.7	13.7	8408	115,576	1	1	1
EXCAVATION WALKERS	3.0	9.5	28.6	7762	222,140			3
CONCRETE WALKERS	3.0	3.7	11.1	7762	86,274			
EQUIPMENT SUPT	1.0	16.2	16.2	8408	136,597	1	1	1
SHAFT SUPT				7762				
EXCAVATION SUPT				7762				
ELECTRICAL SUPERINTENDENT		16.2		9055		1	1	
CARPENTER SUPT				7762				
CONCRETE SUPT				7762				

==

INDIRECT COST SUMMARY

	NO	MAN-MONTHS		COST	DTC	VEH	MOVE IN
OVERHEAD LABOR							
SUPERVISION	10.0	111.6	955,854		5	5	7
ENGINEERING	12.0	188.2	1,034,490		8	5	3
ADMINISTRATIVE	9.0	154.7	605,348		7	1	1
TOTAL OVERHEAD LABOR	31.0	454.5	-	$2,595,692	20	11	11
OVERHEAD EXPENSE							
MOVE IN	*	11 EA AT 8,000	$88,000				
VEHICLE OPERATION	*	$250 /MONTH	41,925				
MAINTAIN SUPERVISION	*	$1,000 /MONTH	11,000	140,925			
GENERAL OPERATIONS	LABOR		780,323				
	EXPENSE		47,977	828,300			
MISCELLANEOUS JOB EXPENSE				230,410			
INSURANCE, TAXES AND BOND				823,384			
TOTAL INDIRECT COST				$4,618,710			

4	AB	AC	AD	AE	AF	AG	AH	AI	AJ
5	CREW					RATE			
6		NUMBER OF MEN				PER		MAN-	LABOR
7	CLASSIFICATION	DAY	SW	GY	TOTAL	SHIFT	MONTHS	MONTHS	COST
8									
9	GENERAL OPERATIONS DIRECT LABOR								
10	BIT GRINDER						9.5		
11	GENERAL CARPENTER FOREMAN						3.0		
12	COMPRESSOR OPERATOR						13.2		
13									
14	SHAFT OPERATION								
15	TOPMAN						13.2		
16	HOIST OPERATOR						13.2		
17	OILER						13.2		
18	BOTTOMMAN						13.2		
19									
20	DRYHOUSEMAN	0.5			0.5		13.2	6.6	42,835
21									
22	OUTSIDE CREW								
23	LABOR FOREMAN	1.0			1.0		14.2	14.2	92,138
24	LABORERS	2.0			2.0		14.2	28.5	184,277
25	UTILITY OPERATOR						14.2		
26	LOADER OPERATOR	1.0			1.0		9.5	9.5	61,706
27	TEAMSTER	1.0			1.0		13.7	13.7	88,904
28									
29	MECHANICS								
30	UNION MASTER MECHANIC						14.2		
31	SMALL TOOL MECHANIC	1.0			1.0		13.2	13.2	85,670
32	GREASER						9.5		
33									
34	PUMPMAN						13.2		
35									
36	ELECTRICIANS								
37	FOREMAN	1.0			1.0		16.2	16.2	105,074
38	OUTSIDE						16.2		
39	TUNNEL EXCAVATION	1.0			1.0		9.5	9.5	61,706
40	OVERTIME	2.0	8 hours/week				13.2	-	52,993
41	TUNNEL CONCRETE						3.7		
42									
43	TOTALS PER DAY	8.5			8.5				
44	TOTAL GENERAL OPERATIONS DIRECT LABOR							111.7	775,304
45									
46	TOTAL GENERAL OPERATIONS LABOR								$780,323
47									
48	INDIRECT COSTS								

4	AK	AL	AM	AN	AO A	AQ	AR	AS	AT	AU	AV	AW
5	!!	EQUIPMENT OPERATION				HR	SH	HR				
6	!!			UNITS		OPR	OPR	OPR	REPAIR LABOR		PARTS & SUPPLIES	
7	!!	DESCRIPTION	TOT	SPA	USE	PER	PER	PER	MAN-HOURS		DOLLARS	
8	!!					SH	DAY	DAY	UNIT	TOTAL	UNIT	TOTAL
9	!!											
10	!!	BIT GRINDER							0.010		1.57	
11	!!											
12	!!	COMPRESSOR, 1200 CFM				3.0	3.0		0.071		8.02	
13	!!											
14	!!											
15	!!											
16	!!	CRANE, CRAWLER, 70 T				1.0	3.0		0.382		10.36	
17	!!											
18	!!											
19	!!											
20	!!											
21	!!											
22	!!											
23	!!											
24	!!											
25	!!	CRANE, HYD., 15 T				0.2	1.0		0.231		15.82	
26	!!	FEL, 2.5 CY, Cat 950				1.0	1.0		0.250		14.07	
27	!!	FLATRACK	1.0		1.0	2.0	1.0	2.0	0.210	121	16.11	9,300
28	!!											
29	!!											
30	!!	ELECTRIC WELDERS, 300A	1.0		2.0	1.0	1.0	2.0	0.005	3	0.76	455
31	!!	DIESEL WELDERS, 300A	1.0		1.0	0.5	1.0	0.5	0.041	6	3.05	456
32	!!											
33	!!											
34	!!	PUMP, SUB, 3 HP				1.0	3.0		0.005		0.39	
35	!!											
36	!!	TOTAL MAN-HOURS								130		-
37	!!	TOTAL GENERAL OPERATIONS REPAIR LABOR				chk: 1 mech =			$85,670	$5,019		-
38	!!	TOTAL REPAIR PARTS & SUPPLIES										10,211
39	!!	TOTAL REPAIR PARTS & SUPPLIES INCLUDING SALES TAX								0.0 %		10,211
40	!!											
41	!!	JANITORAL SUPPLIES	$100 PER MONTH									1,325
42	!!	SMALL TOOLS & EXPENDABLES	4.67 % OF TOTAL GENERAL OPERATIONS LABOR									36,441
43	!!	TOTAL EXPENDABLE MATERIALS										37,766
44	!!	TOTAL GENERAL OPERATIONS EXPENDABLE MATERIALS INCLUDING SALES TAX								0.0 %		37,766
45	!!											
46		TOTAL GENERAL OPERATION EXPENSE										$47,977

AZ SSC MARICOPA P. E. Sperry 01-Jul-87 \AZM1-COS\INDIRECT

EC	EE	EF	EH	EI
DESCRIPTION	QUANTITY	UNITS	COST PER UNIT	COST
SUPPLIES				
OFFICE	16	MONTHS	782	12,704
ENGINEERING	14	MONTHS	586.5	8,355
SAFETY & FIRST AID	13	MONTHS	977.5	12,947
FACILITY MAINTENANCE	13	MONTHS	195.5	2,589
TOTAL SUPPLIES				36,595
SERVICES				
AUDIT		LS *		19,550
CONSULTANTS		LS *		29,325
CRITICAL PATH SCHEDULE		LS *		9,775
DISPUTES REVIEW BOARD	4	MTNGS	3,000	12,000
HEAT *	4	MONTHS *	400	1,550
HOME OFFICE CHARGE	13	MONTHS *	3,000	39,000
LEGAL		LS *		19,550
TUNNEL LIGHTING *	589,399	KWH	0.04	23,576
PORTAL LIGHTING & MISC PWR *	43,709	KWH	0.04	1,748
PHOTOGRAPHY	13	MONTHS *	50	662
PHYSICAL EXAMINATIONS *	3	EACH	100	300
POSTAGE	16	MONTHS	293.25	4,764
TELEPHONE	16	MONTHS *	977.5	15,880
WATER, CHLORINE & ICE	16	MONTHS *	100	1,625
TOTAL SERVICES				179,305
FEES				
DONATIONS	2	YEAR	1500	3,197
DUES		LS *		
LICENSES, AUTOMOTIVE *	13	EACH/YR *	300	8,313
LICENSES, OTHER		LS *		2,000
PERMITS		LS *		1,000
TOTAL FEES				14,510
TOTAL MISCELLANEOUS JOB EXPENSE				$230,410

EL	EN	EO	EQ	ER	ET	EU
DESCRIPTION		BASIS	QUANTITY	UNITS	COST PER UNIT	COST
INSURANCE						
AUTOMOTIVE	2.1	YEARS *	13	Vehicles *	800	21,840
BUILDER'S RISK		CONTR AMT	19,550,000	/$100		
CONTRACTURAL LIABILITY		PAYROLL	8,459,000	/$100	5.00	422,950
DEDUCTIBLE		-	-	LS	*	
EQUIPMENT TRANSPORTATION		-	-	LS	*	10,000
FIDELITY & FORGERY		-	-	LS	-	5,000
MEDICAL - SALARIED EMPLOYEES		-	454.5	MAN-MO	150	68,174
PLANT & EQUIPMENT	1.0	AVE VALUE	4,700,000	/$100/YR	1.50	150,274
RAILROAD		-	-	LS	*	
TOTAL INSURANCE						678,239
TAXES						
GROSS RECEIPTS		CONTR AMT	19,550,000	Percent *		
HIGHWAY USE		*	-			
INVENTORY		*	-			
PLANT & EQUIPMENT	* 0.5	AVE VALUE	4,700,000	/$100/YR *	1.00	49,350
TOTAL TAXES						49,350
BONDS						
MAINTENANCE						
PERFORMANCE		CONTR AMT	19,550,000		0.0049	95,795
SUBCONTRACTOR						
TOTAL BONDS						95,795
TOTAL INSURANCE, TAXES AND BOND						$823,384

BB BC BD BE BF BG BH BI BK BL BM BN BO BP BQ BR BS BT BU BV BW BX

OPERATION	PRODUCTION	WORK DAYS SETUP &/OR DELAY TIME	QUANTITY	MONTHS	CUMULATIVE MONTHS
NOTICE TO PROCEED					
PROCURE EQUIPMENT, MOVE IN, EXCAV PORTAL & STARTING CHAMBER		210.0		10.00	10.00
ERECT TUNNEL BORING MACHINE & TRAILING FLOOR		29.0		1.38	11.38
EXCAVATE & SUPPORT TUNNEL	201.0 FPD		29,568 FT	7.00	18.39
DELAY TO INSTALL CALIFORNIA SWITCH		2.0	2 EA	0.19	18.58
REMOVE TBM AND/OR PREPARE TO CONCRETE	3,000 FPD		9.9 WD	0.47	19.05
CONSTRUCT ELECTRONIC SHIELDING NITCHES (630' OC)	0.5 WD/EA		47 EA	1.12	20.16
CONSTRUCT POWER ALCOVES (4408' OC)	2 WD/EA	2.5	7 EA	0.76	20.92
PLACE FINAL LINING IN DRILL & SHOOT & STEEL SET SUPPORTED	75 FPD		300 FT	0.19	21.11
PLACE INVERT CONCRETE	700 FPD	2.0	29,568 FT	2.11	23.22
REMOVE UTILITIES & FINAL TUNNEL CLEANUP	1000 FPD		29,568 FT	1.41	24.63
YARD CLEANUP & MOVEOUT		20.0		0.95	25.58

Total length of tunnel 29568 feet

Overall tunnel production 96.3 ft/day

DURATIONS:		
Mobilization	10.00	months
Shaft Excavation		months
Tunnel Excavation	9.54	months
Tunnel Concrete	3.71	months
Total Job	25.58	months

5.0 CUT AND FILL COST ESTIMATE

This section gives the details of the cut-and-fill estimating process. The first page gives a summary estimate by facility. Details of the facility estimates are given on the following pages. Finally, the Lab Building is used as an example of the building cost estimating process.

Cut-and-fill estimates are given in the following order:

UNIT PRICE WORKSHEET DATE:

PROJECT NAME: SSC - MARICOPA

ITEM NO: RECAP

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT LABOR	TOTAL LABOR	UNIT EQUIP.	TOTAL EQUIP.	UNIT MAT'L.	TOTAL MAT'L.	UNIT SUBS	TOTAL SUBS	UNIT COST	TOTAL COST
EXCAVATE ACCEL.RING	*********	CY	0.03	90674	0.38	1148542		0		0	0.41	1239216
EXCAVATE HE BOOSTER	*********	CY	0.03	38073	0.38	482259		0		0	0.41	520332
EXCAVATE ME BOOSTER	*********	CY	0.03	30495	0.39	396429		0		0	0.42	426923
EXCAVATE LE BOOSTER	235,659	CY	0.05	11783	0.43	101333		0		0	0.48	113116
EXC. FOR STRUCTURES	674,667	CY	0.31	209147	0.99	667920		0		0	1.30	877067
120" CIP PIPE	88,730	LF	74.36	6597963	47.40	4205802	88.08	7815338	43.63	3871290	253.47	22490393
8' CONCRETE INVERT	52,581	CY	5.00	262904	10.00	525807	40.00	2103230	15.00	788711	70.00	3680652
8'x8' LEB STRUCTURE	1,090	CY	75.00	81750	25.00	27250	100.00	109000	50.00	54500	250.00	272500
12'X12'LINAC STR.	951	CY	75.00	71325	25.00	23775	100.00	95100	50.00	47550	250.00	237750
BACKFILL PIPE	537,166	CY	0.30	161150	0.80	429733		0		0	1.10	590883
REGULAR BACKFILL	*********	CY	0.10	672956	0.40	2691824		0		0	0.50	3364780
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
TOTAL	1	LS	*********	8228219	********	10700674	********	10122668	********	4762051	********	33813612
BID TOTAL	1	LS	*********	8228219	********	10700674	********	10122668	********	4762051	********	*********

CREWSHEET DATE: 01-Jan-80

PROJECT NAME: SSC
ITEM: ACCELERATION RING
QUANTITY:******** CY

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT LABOR	TOTAL LABOR	UNIT EQUIP.	TOTAL EQUIP.	UNIT MAT'L.	TOTAL MAT'L.	UNIT SUBS	TOTAL SUBS	UNIT COST	TOTAL COST
TAKE-OFF QUANTITY =	********	CY										
D-9	2		49.92	0	236.00	0		0		0	0.00	0
WATERPULL			23.86	0	65.00	0		0		0	0.00	0
14 BLADE			25.62	0	58.00	0		0		0	0.00	0
FMN & PU			27.22	0	9.25	0		0		0	0.00	0
TOTAL CREW	593	HR	126.62	75038	368.25	218233		0		0	494.87	293270
ADD HOLLAND LOADER	********	CY	0.0046	12422	0.10	268311		0		0	0.10	280732
ADD HOLLAND CONVEYOR	********	CY			0.20	536621		0		0	0.20	536621
ALLOW 5000 CY/HR +								0		0	0.00	0
2 HR/RAMP +1 HR/T.A.								0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
MMS TOTAL	********	CY	0.0326	87459	0.3813	1023164	0.00	0	0.00	0	0.41	1110624
BID TOTAL	********	CY	0.03	80493	0.38	1019580	0.00	0	0.00	0	0.41	1100073

UNIT PRICE WORKSHEET DATE: 01-Jan 1987

PROJECT NAME: SSC

ITEM NO: 120" CAST-IN-PLACE PIPE

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT LABOR	TOTAL LABOR	UNIT EQUIP.	TOTAL EQUIP.	UNIT MAT'L.	TOTAL MAT'L.	UNIT SUBS	TOTAL SUBS	UNIT COST	TOTAL COST
FINE GRADE	113813	SY	1.00	113813	2.50	284533		0		0	3.50	398347
4" WASTE SLAB	3756	CY	60.00	225350	10.00	37558	40.00	150234		0	110.00	413142
BUY READYMIX	62572	CY		0		0	45.00	2815753		0	45.00	2815753
BUY WATERSTOP	64371	LF	1.00	64371		0	5.00	321857		0	6.00	386228
BUY FORMS	1	LS		0		0	250000	250000		0	********	250000
FAB & ERECT FORMS	120	HR	150.00	18000	80.00	9600		0		0	230.00	27600
FORM & STRIP PIPE	3377183	SF	0.80	2701746	0.40	1350873	0.20	675437		0	1.40	4728056
POUR CONCRETE	59593	CY	6.50	387355	7.50	446948		0		0	14.00	834302
CURE & MISC	59593	CY	5.00	297965	5.00	297965	5.00	297965		0	15.00	893895
REBAR	1	LS		0		0		0	2234738	2234738	********	2234738
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
				0		0		0		0	0.00	0
TOTAL	51216	LF	74.36	3808601	47.40	2427477	88.08	4511245	43.63	2234738	253.48	12982061
BID TOTAL	77114	LF	74.36	5734197	47.40	3655204	88.08	6792201	43.63	3364484	253.47	19546086

CREWSHEET DATE: 16-Jun-87

PROJECT NAME: SSC
ITEM: BUILDING EXCAVATION
QUANTITY: 674667 CY

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT LABOR	TOTAL LABOR	UNIT EQUIP.	TOTAL EQUIP.	UNIT MAT'L.	TOTAL MAT'L.	UNIT SUBS	TOTAL SUBS	UNIT COST	TOTAL COST
TAKE-OFF QUANTITY =	674667	CY										
D-9			24.96	0	118.00	0		0		0	0.00	0
988 LDR			26.81	0	90.00	0		0		0	0.00	0
65T ROCK TRK	3		71.58	0	345.00	0		0		0	0.00	0
14 BLADE	0.5		12.81	0	29.00	0		0		0	0.00	0
GR CHKR			21.16	0	0.00	0		0		0	0.00	0
FMN & PU			27.22	0	9.25	0		0		0	0.00	0
TOTAL CREW	1124	HR	184.54	207423	591.25	664565		0		0	775.79	871988
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
			0.00	0	0.00	0		0		0	0.00	0
MMS TOTAL	674667	CY	0.31	207423	0.99	664565	0.00	0	0.00	0	1.29	871988
BID TOTAL	674667	CY	0.31	209147	0.99	667920	0.00	0	0.00	0	1.30	877067

DATE 23-Jun-87 SUNDT CORP

PROJECT: ARIZONA B.S.C. CONCEPTUAL DESIGN ESTIMATE
SUNDT CORP 6-18-87

DESCRIPTION	QUANT.		UNIT	TOTAL	DURATION	MAN-HOURS
BUILDING: LAB BUILDING						
BUILDING AREA:	365,000	SF				
SITEWORK:	--------			1,500,000		
SUBSTRUCTURE:						
CONCRETE I	5.00	CY	250.00	1,250		
CONCRETE II	161.00	CY	260.00	41,860		
CONCRETE III	942.00	CY	270.00	254,340		
CONCRETE IV	0.00	CY	--------	0		
REINFORCING STEEL	220.00	TNS	900.00	198,000		
SUPERSTRUCTURE:	365000.00	SF	12.00	4,380,000		
EXTERIOR WALL:	106500.00	SF	20.00	2,130,000		
ROOFING:	100000.00	SF	4.50	450,000		
INTERIOR CONSTR:	265000.00	SF	5.00	1,325,000		
SPECIALTIES:	--------	LS		500,000		
EQUIP. & FURNISHINGS:	--------	LS	--------	500,000		
SPECIAL CONSTR: SOLAR	--------	LS	--------	300,000		
CONVEYING SYSTEMS:	2.00	EA	60000.00	120,000		
FIRE PROTECTION:	365000.00	SF	1.50	547,500		
PLUMBING:	365000.00	SF	4.00	1,460,000		
H.V.A.C.	365000.00	SF	6.00	2,190,000		
ELECTRICAL:	365000.00	SF	8.00	2,920,000		
----------------------------	--------	-	--------	0		
BUILDING AREA	--------	SF	--------	0		
----------------------------	--------	-	--------	0		
----------------------------	--------	-	--------	0		
TOTAL				18,817,950	18 MO.	752718.00
			$/SF =	51.56		

DESCRIPTION	QUANT.		UNIT	TOTAL	DURATION	MAN-HOURS	
BUILDING: HEAVY WORKS BLDG 1,2							
BUILDING AREA:	26,226	SF					
SITEWORK:	1.00	LS	20000.00	20,000			
SUBSTRUCTURE:							
CONCRETE I	3.00	CY	250.00	750			
CONCRETE II	67.00	CY	260.00	17,420			
CONCRETE III	162.00	CY	270.00	43,740			
CONCRETE IV	0.00	CY	--------	0			
REINFORCING STEEL	46.00	TNS	900.00	41,400			
SUPERSTRUCTURE:	30456.00	SF	10.00	304,560			AREA INCLUDES MEZZANINE
EXTERIOR WALL:	41250.00	SF	12.00	495,000			
ROOFING:	26226.00	SF	3.00	78,678			

6.0 SHAFT ESTIMATES

In this section four of the basic shaft estimating models are presented. Shafts were estimated based upon the finished diameter and on the muck hoisting method used. Models are presented for 20 and 30 foot diameter shafts excavated with a crane, and for 20 and 30 foot diameter shafts excavated with a hoist and headframe. Finally, the labor cost calculation for both 20 and 30 foot shafts is detailed.

Shaft estimates are presented in the following order:

AZ SSC MARICOPA SHAFTS
MODEL C - 20 FT DIAMETER : CRANE

	OFF SITE MOB	ON SITE MOB	COLLAR TO 28 FT	SINK SHAFT	DRIVE DRIFT ROCK	FURNISH SHAFT	CLEAR SHAFT	DEMOB	TOTAL
				10.47					
STAFF		23924	17943	62622	7476	4486	2991	11962	131405
HOURLY LABOR	1250	12517	59530	493064	50197	26519	20079	23581	686736
CONSUMABLES		7433	5246	0	5814	0	2325	3463	24281
SITE RUNNING		2230	1573	0	1744	0	697	1039	7283
INTERNAL PLANT		3605	15015	0	6133	0	1000	3275	29028
EXTERNAL PLANT	2400	4000	10285	0					16685
CONCRETE		5200	10400		3435				19035
LINER									0
EXPLOSIVE DETS			3445	0	7600				11045
DRILL STEEL BITS			1306	0	6400				7706
W.W. MESH				0	488				488
ROCKBOLTS				0	1313				1313
DIESEL		500	1474	0	1440	0	754	1000	5168
INSTALLED EQUIPMENT		46695							46695
FREIGHT		6000						7000	13000
RELOCATE PERSONNEL	8000								8000
REINFORCEMENT			4546						4546
FORMWORK			6686						6686
SHOTCRETE				8240	2640				10880
SERVICE PIPES		1000	1998	0	3600				6598
LADDERWAY+SHAFT STEEL						0			0
SUBTOTAL	11650	113104	139447	563927	98280	31005	27845	51320	1036578
MARKUP @ 17%	1981	19228	23706	95868	16708	5271	4734	8724	176218
TOTAL	13631	132332	163153	659794	114988	36276	32579	60044	1212796

AZ SSC MARICOPA SHAFTS
MODEL A - 20 FT DIAMETER : HOIST AND HEAD FRAME

	OFF SITE MOB	ON SITE MOB	COLLAR TO 28 FT	SINK SHAFT	DRIVE DRIFT ROCK	FURNISH SHAFT	CLEAR SHAFT	DEMOB	TOTAL
				16					
STAFF		34690	17943	97193	7476	8972	2991	11962	181227
HOURLY LABOR	1250	108895	29765	765262	50197	53038	17679	20381	1046468
CONSUMABLES		13808	5246	0	5814	0	2325	3463	30656
SITE RUNNING		4143	1573	0	1744	0	697	1039	9196
INTERNAL PLANT		14014	15015	0	6133	0	1000	3275	39437
EXTERNAL PLANT	2400	4000	10285						16685
CONCRETE		8910	10400		3435				22745
LINER									0
EXPLOSIVE DETS			3445	0	7600				11045
DRILL STEEL BITS			1306	0	6400				7706
W.W. MESH				0	488				488
ROCKBOLTS				0	1313				1313
DIESEL		1000	1474	0	1440	0	754	1000	5668
INSTALLED EQUIPMENT		46695							46695
FREIGHT		8000						7000	15000
RELOCATE PERSONNEL	8000								8000
REINFORCEMENT			4546						4546
FORMWORK			6686						6686
SHOTCRETE				15680	2640				18320
SERVICE PIPES		1000	1998	0	3600				6598
LADDERWAY+SHAFT STEEL						0			0
SUBTOTAL	11650	245156	109682	878135	98280	62010	25446	48121	1478480
MARKUP @ 17%	1981	41676	18646	149283	16708	10542	4326	8181	251342
TOTAL	13631	286832	128328	1027418	114988	72551	29772	56301	1729821

AZ SSC MARICOPA SHAFTS
MODEL D - 30 FT DIAMETER : CRANE

	OFF SITE MOB	ON SITE MOB	COLLAR TO 28 FT	SINK SHAFT	DRIVE DRIFT ROCK	FURNISH SHAFT	CLEAR SHAFT	DEMOB	TOTAL
				3.30					
STAFF		23924	20934	19738	25420	1495	2991	11962	106464
HOURLY LABOR	1250	12517	71399	155407	150274	8840	17679	20381	437748
CONSUMABLES		7433	6529	0	19768	0	2325	3463	39518
SITE RUNNING		2230	1959	0	5930	0	697	1039	11855
INTERNAL PLANT		3605	17517	0	20853	0	1000	3275	46250
EXTERNAL PLANT	2400	4000	12000	0				2000	20400
CONCRETE		5200	17600		9018				31818
LINER					11000				11000
EXPLOSIVE DETS			5399	0	9757				15156
DRILL STEEL BITS			2047	0	1078				3125
W.W. MESH				0	3623				3623
ROCKBOLTS				0	4986				4986
DIESEL		500	1720	0	4896	0	754	1000	8870
INSTALLED EQUIPMENT		46695							46695
FREIGHT		6000						7000	13000
RELOCATE PERSONNEL	8000								8000
REINFORCEMENT			7950						7950
FORMWORK			10040						10040
SHOTCRETE				0	6880				6880
SERVICE PIPES		1000	1998	0	5264				8262
LADDERWAY+SHAFT STEEL						0			0
SUBTOTAL	11650	113104	177092	175145	278747	10335	25446	50121	841639
MARKUP @ 17%	1981	19228	30106	29775	47387	1757	4326	8521	143079
TOTAL	13631	132332	207198	204919	326134	12092	29772	58641	984718

AZ SSC MARICOPA SHAFTS
MODEL C - 30 FT DIAMETER : HOIST AND HEADFRAME

SHAFT COSTS: J.G.S. HYND & J. MILLIGAN: JUNE 1987

	OFF SITE MOB	ON SITE MOB	COLLAR TO 28 FT	SINK SHAFT	DRIVE DRIFT ROCK	FURNISH SHAFT	CLEAR SHAFT	DEMOB	TOTAL
				3.30					
STAFF		35887	20934	19738	25420	1495	2991	11962	118426
HOURLY LABOR	1250	124291	71399	155407	150274	8840	17679	20381	549522
CONSUMABLES		15828	6529	0	19768	0	2325	3463	47913
SITE RUNNING		4748	1959	0	5930	0	697	1039	14373
INTERNAL PLANT		15015	17517	0	20853	0	1000	3275	57660
EXTERNAL PLANT	2400	4000	12000	0				2000	20400
CONCRETE		8910	17600		9018				35528
LINER					11000				11000
EXPLOSIVE DETS			5399	0	9757				15156
DRILL STEEL BITS			2047	0	1078				3125
W.W. MESH				0	3623				3623
ROCKBOLTS				0	4986				4986
DIESEL		1000	1720	0	4896	0	754	1000	9370
INSTALLED EQUIPMENT		46695							46695
FREIGHT		8000						7000	15000
RELOCATE PERSONNEL	8000								8000
REINFORCEMENT			7950						7950
FORMWORK			10040						10040
SHOTCRETE				0	6880				6880
SERVICE PIPES		1000	1998	0	5264				8262
LADDERWAY+SHAFT STEEL						0			0
SUBTOTAL	11650	265374	177092	175145	278747	10335	25446	50121	993909
MARKUP @ 17%	1981	45114	30106	29775	47387	1757	4326	8521	168965
TOTAL	13631	310487	207198	204919	326134	12092	29772	58641	1162873

CREW LABOR FOR 20 FT DIAMETER SHAFTS

STAFF LABOR	#	YEARLY	DAILY	MOB CREW	COLLAR CREW	SET UP CREW	EXCAV CREW	DRIFT CREW	CLEAR CREW	DEMOB CREW
PROJECT MANAGER	1	73093	281							
SUPERINTENDENT	1	68068	262							
ENGINEER	1	52627	202							
MANAGEMENT TOTAL			745	745	745	745	745	745	745	745
STOREKEEPER			0	0	0	0	0	0	0	0
SITE ACCOUNTANT	1	45456	175	175	175	175	175	175	175	175
SECRETARY	0	24533	0	0	0	0	0	0	0	0
STAFF TOTAL(DAILY)			920	920	920	920	920	920	920	920
STAFF TOTAL(WEEKLY)				5981	5981	5981	5981	5981	5981	5981
HOURLY LABOR		WEEKLY								
SUPERVISORS	1	63985	246	0	246	246	738	738	738	246
LEAD MINER	1	1135	189	0	189	189	568	568	568	189
MINER	1	1031	172	0	688	688	2579	2063	2063	0
OPERATOR	1	1103	184	184	368	368	1103	551	551	368
TOPLANDER	1	984	164	0	164	164	492	492	492	164
LABORER	1	959	160	320	479	479	479	479	479	479
MECHANIC	1	1103	184	184	368	551	551	551	551	184
ELECTRICIAN	1	1103	184	184	368	551	551	551	551	184
FEL	1	1103	184	92	184	184	184	184	184	0
TOTAL HOURLY				963	3053	3420	7245	6178	6178	1814
TOTAL LABOR(WEEKLY)				6258	19843	22232	47093	40157	40157	11790

CREW LABOR FOR 30 FT DIAMETER SHAFTS

STAFF LABOR	#	YEARLY	DAILY	MOB CREW	COLLAR CREW	SET UP CREW	EXCAV CREW	DRIFT CREW	CLEAR CREW	DEMOB CREW
PROJECT MANAGER	1	73093	281							
SUPERINTENDENT	1	68068	262							
ENGINEER	1	52627	202							
MANAGEMENT TOTAL			745	745	745	745	745	745	745	745
SITE ACCOUNTANT	1	45456	175	175	175	175	175	175	175	175
SUPERVISORS	1	63985	246	0	246	246	738	738	738	246
STAFF TOTAL(DAILY)			421	920	1166	1166	1658	1658	1658	1166
STAFF TOTAL(WEEKLY)				4601	5831	5831	8292	8292	8292	5831
HOURLY LABOR		WEEKLY								
LEAD MINER	1	1135	189	0	189	189	568	568	568	189
MINER	1	1031	172	0	860	860	3610	2063	2063	0
OPERATOR	1	1103	184	184	368	368	1103	551	551	368
TOPLANDER	1	984	164	0	164	164	492	492	492	164
LABORER	1	959	160	320	639	639	479	479	479	479
MECHANIC	1	1103	184	184	368	551	551	551	551	184
ELECTRICIAN	1	1103	184	184	368	551	551	551	551	184
FEL	1	1103	184	92	184	184	184	184	184	0
TOTAL HOURLY				963	3138	3506	7538	5440	5440	1568
TOTAL LABOR(WEEKLY)				6258	20400	22789	48998	35359	35359	10191