APPENDIX S

Design Memorandum, Miner Flat Dam, February 1987

MORRISON-MAIERLE, INC., VOLUMES I THRU V OF VI

FEBRUARY 2007

DESIGN MEMORANDUM

MINER FLAT DAM

DECEMBER, 1986

WHITE MOUNTAIN APACHE TRIBE
WHITERIVER, ARIZONA

VOLUME 5 OF 6

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MINER FLAT DAM
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SECTION J

J.1 DAM DESIGN - GENERAL

A conservative approach has been taken in design. The concept is to provide a very stable, permanent, simple, and low maintenance dam without complex construction.

Although a rock fill dam could be used, it has unique problems resulting from the vally shape, there was concern early in exploration about the extent of sound foundation rock, and a major separate spillway structure could be required.

An embankment or fill dam was considered unacceptable because of the lack of suitable materials, the valley shape, and its potential for erosion.

A concrete gravity dam is most desireable because of permanence, low maintenance, available good sources for aggregate, the ability to put the spillway over the structure, and the valley shape. However, as discussed in the cost and schedule sections J.6 and J.7, it would be expensive if built by conventional methods. Fortunately then is an alternate method that can be used to place mass concrete in a gravity dam. When applied to Miner Flat, this reduces the estimated conventionally built concrete gravity dam cost form about $15 million to $9 million. The resulting structure is still a very stable mass concrete gravity dam. The construction method is called "Roller Compacted Concrete" or "RCC". This procedure uses heavy earthmoving equipment to transport and place the material in a very efficient, rapid, and economical manner. RCC has recently been used very successfully to save time and money on a number of projects throughout the world. Within the United States it has become a common dam construction method. This includes projects by both the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation.

The RCC Dam will require normal construction preparations, but only about two months for it to then be raised in a "Round the clock" continuous operation without verticle joints typically needed with conventional placement methods. This is technically and practically very achievable within the controls stipulated in the construction specifications of Section J.8.

Even with the savings achieved by using RCC, it has been possible to keep stresses to very low levels (lower than in the conventional approach), add extra mass, and build redundency into the design which assures better performance with higher factors of safety. Some of this could be deleted, but for the modest premium in cost, it is considered appropriate for this project. For example, internal drains have been included throughout the entire structure, a special bedding mix is included near the upstream face between layers of the RCC to provide extra strength and water tightness, and a very heavy duty permanent independent water barrier is provided at the upstream face. Even without the barrier, the dam design is safe and complete. With it, seepage will be minimal or none existent, and factors of safety for stability increases substantially.

The water barrier is described in detail in the specifications of Section J.8. It is a thick, continuous, flexible sheet of PVC or Hi Density Polyethylene. In essence, it is a water stop from the top to the bottom of the dam and from abutment to abutment.

The upstream face of the dam will consist of attractive, high quality precast concrete panels that protect the RCC and water barrier, and act as forms during construction. This technique has worked very well in previous projects.

The downstream face and top of the dam will be constructed using durable conventional concrete formulated to have minimal shrinkage. This will be placed monolithically with the RCC so there is no distinctive joint between them. This technique has also been used successfully at other projects. It is discussed further in Section J.5. The result will be conventional concrete fully encasing an economical mass of stable Roller Compacted Concrete.

The detailed preliminary designs for a conventional concrete and RCC dome have been made for this Design Memorandum to provide sufficient details for realistic cost estimates, construction schedules, and to provide the basis for final designs. The preliminary designs are the basis for the drawings included in Section J.15.

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DESIGN MEMORANDUM

SECTION J

J.2 DAM DESIGN AND STABILITY ANALYSIS

The following information and summaries are provided as design criteria for final design and to show methodology in arriving at the recommended dam sections. Detailed computations and computer runs have not been encluded in this Memorandum due to the volume of those computations. All computations have been retained by the designers for back-up to this Memorandum and may be reviewed if required.

DESIGN AND LOADING CONDITIONS EVALUATED

IN GENERAL:

United States Bureau of Reclamation Design Criteria were used.

USBR "Design of Gravity Dams" 1976
USBR "Design of Small Dams" 1977

R = Roller Compacted Placement Method used in construction
C = Conventional Placement Method used in construction
V = Verticle
H = Horizontal
Y = Yes
N = No

Empty Load Conditions:

Minimum required factor of safety = 3
No reservoir
Deadload of concrete mass
Dam base at elevation 5907
Dam cost at elevation 6062 (spillway)
No silt
No tailwater
Wind pressure (horizontal) against the downstream face = 1.6 psf
No uplift pressure
No earthquake

Usual Load Conditions:

Minimum required factor of safety = 3
Normal Reservoir Evaluation of 6062 (Spillway Crest)
Dead Load of Concrete Mass
Dam Base at Elevation 5907
Dam Crest at Elevation 6062 (Spillway)
Silt - Accumulation to Elevation 5950
Silt - Produces an effective horizontal equivalent of a fluid in mass at 85 pcf
Tailwater at elevation 5912
Applicable uplift pressures applied along lift joint surfaces
No earthquake

Unusual Load Conditions:

Minimum required factor of safety = 2
Reservoir level at PMF of 6082
Dead Load of Concrete Mass
Dam Base at Elevation 5907
Dam Crest at Elevation 60602 (Spillway)
Silt Accumulation at elevation 5950
Silt produces an effective horizontal equivalent of a fluid mass at 85 pcf
Tailwater at elevation 5979
Applicable uplift pressures applied along L ft joint surfaces
No earthquake

Extreme Load Condition:

Minimum required factor of safety = 1
Normal reservior elevation at 6062 (spillway crest)
Dead Load of concrete mass
Dam base at elevation 6907
Dam crest at elevation 6062 (spillway)
Silt accumulated to elevation 6960
Silt produces an effective horzontal equivalant of a fluid mass at 85 pcf
Tailwater at elevation 6912
Applicable uplift pressures with and without drains openable
Earthquake horizontal acceleration = 0.10 x gravity
Earthquake vertical acceleration - 0.05 x gravity

Elevations Studied:

Stresses and/or factors of safety were determined at approximately 10 foot increments (9.8425 feet exact) in elevation starting at the assumed foundation of 5907 and progressing up to the spillway crest elevation of 6062.

Approach:

Two approaches were used to assist in development and selections of the final design sections for both the conventional and roller compacted gravity dams. One method used specific values for shear strength (along the joint interface), compressive strength, density, and tensile strength. The resulting factors of safety were then calculated and compared to the minimum required factors of safety for the different load conditions. The other method set the factors of safety at their minimum acceptable levels and then calculated the material properties or strengths necessary to achieve them. The different situations evaluated are summarized in the following tabulations. Properties used for the different concretes to determine the resulting factors of safety are as shown below, or are indicated on the table when a different strength was studied. A very conservative approach was used in estimated strengths. Where bedding mix, internal drains, and a membrane were included in various designs studied, the efficiency at which they were considered is shown in the summary. For example, the upstream membrane is not required for stability (efficiency = 0%). If considered, it provides extraordinary factors of safety where fully effective (efficiency = 100%). The drains and bedding mix were considered to reduce uplift to varying degrees ranging from 0% to 67% of the difference between the reservoir and tailwater head pressure. Again they are not fully necessary and result in very substantial factors of safety where considered.

MATERIAL PROPERTIES FOR ROLLER COMPACTED CONCRETE

PROPERTY	RCC		BEDDING MIX	
	Probable	Used in Computations	Probable	Used in Computations
Density	153+ pcf	153 pcf	153 pcf	153 pcf
Tensile Strength (usual - 6 mo±)	35 psi	0 psi	160 psi	0 psi
Tensile Strength (unusual - 1 yr+)	40 psi	0 psi	185 psi	0 psi
Tensile Strength (extreme - 1 yr+)	55 psi	0 psi	240 psi	0 psi
Shear (usual - 6 mo+)	100 psi @ 45°	80 psi @ 40°	200 psi @ 45°	80 psi @ 40°
Shear (unusual - 1 yr+)	115 psi @ 50°	90 psi @ 45°	230 psi @ 50°	90 psi @ 45°
Shear (extreme - 1 yr+)	155 psi @ 55°	120 psi @ 45°	300 psi @ 55°	120 psi @ 45°
Compression (usual - 6 mo±)	1600 psi	1400 psi	2000 psi	1400 psi
Compression (unusual - 1 yr+)	1800 psi	1600 psi	2400 psi	1600 psi
Compression (extreme - 1 yr+)	2200 psi	1600 psi	2800 psi	1600 psi

MATERIAL PROPERTIES FOR CONVENTIONAL MASS CONCRETE

PROPERTY	Conventional Mass Concrete	
	Probable	Used in Computations
Density	153 pcf	153 pcf
Tensile Strength (usual - 1 yr)	150 psi	0 psi
Tensile Strength (unusual - 1 yr+)	175 psi	0 psi
Tensile Strength (extreme - 1 yr+)	233 psi	0 psi
Shear (usual - 1 yr)	250 psi @ 45°	250 psi @ 45°
Shear (unusual - 1 yr+)	300 psi @ 50°	300 psi @ 45°
Shear (extreme - 1 yr+)	400 psi @ 55°	400 psi @ 45°
Compression (usual - 1 yr)	2500 psi	1600 psi
Compression (unusual - 1 yr+)	3000 psi	1800 psi
Compression (extreme - 1 yr+)	3800 psi	1800 psi

*unless otherwise noted.

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DESIGNS AND LOADING CONDITIONS INVESTIGATED

Case	Placement Method	Loading Conditions	Downstream Slope H:1.0	Upstream Face	Gallery	Membrane Y/N	Membrane Efficiency	Found Drain Y/N	Found Drain Efficiency	Internal Drains Y/N	Internal Drains Efficiency	Bedding Y/N	Bedding Efficiency	Grout Curtain Y/N	Grout Curtain Efficiency
1	R	Usual	.80	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
2	R	Usual	.80	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
3	R	Extreme	.80	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
4	R	Empty	.80	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
5	R	Usual	.75	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
6	R	Unusual	.75	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
7	R	Extreme	.75	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
8	R	Empty	.75	V	Y	N	0%	Y	67%	Y	67%	Y	67%	Y	0%
9	R	Usual	.80	V	Y	N	0%	Y	67%	N	0%	Y	67%	Y	0%
10	R	Unusual	.80	V	Y	N	0%	Y	67%	N	0%	Y	67%	Y	0%
11	R	Extreme	.80	V	Y	N	0%	Y	67%	N	0%	Y	67%	Y	0%
12	R	Usual	.80	V	Y	N	0%	Y	67%	Y	67%	N	0%	Y	0%
13	R	Usual	.80	V	Y	N	0%	Y	67%	Y	67%	N	0%	Y	0%
14	R	Extreme	.80	V	Y	N	0%	Y	67%	Y	67%	N	0%	Y	0%
15	R	Usual	.80	V	N	N	0%	N	0%	N	0%	N	0%	N	0%
16	R	Unusual	.80	V	N	N	0%	N	0%	N	0%	N	0%	N	0%
17	R	Extreme	.80	V	N	N	0%	N	0%	N	0%	N	0%	N	0%
18	R	Usual	.80	Y	N	Y	90%	N	0%	N	0%	N	0%	N	0%
19	R	Unusual	.80	Y	N	Y	90%	N	03%	N	0%	N	0%	N	0%
20	R	Extreme	.80	Y	N	Y	90%	N	0%	N	0%	N	0%	N	0%
21	R	Usual	.75	V	N	Y	90%	N	0%	N	0%	N	0%	N	0%
22	R	Unusual	.75	V	N	Y	90%	N	0%	N	0%	N	0%	N	0%
23	R	Extreme	.75	V	N	Y	90%	N	0%	N	0%	N	0%	N	0%
24	R	Usual	.75	V	Y	N	0%	N	0%	N	0%	Y	67%	N	0%
25	R	Unusual	.75	V	Y	N	0%	N	0%	N	0%	Y	67%	N	0%
26	R	Extreme	.75	V	Y	N	0%	N	0%	N	0%	Y	67%	N	0%
27	R	Usual	.75	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
28	R	Unusual	.75	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
29	R	Extreme	.75	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
30	R	Usual	.72	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
31	R	Unusual	.72	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
32	R	Extreme	.72	V	Y	N	0%	Y	67%	Y	67%	N	0%	N	0%
33	R	Empty	.72	V	Y	N	0%	Y	67%	Y	67%	Y	67%	N	0%
34	R	Usual	.72	V	Y	N	0%	Y	67%	Y	67%	Y	67%	N	0%
35	R	Unusual	.72	V	Y	N	0%	Y	67%	Y	67%	Y	67%	N	0%
36	R	Extreme	.72	V	Y	N	0%	Y	67%	Y	67%	Y	67%	N	0%

DESIGNS AND LOADING CONDITIONS INVESTIGATED
(continued)

Case	Placement Method	Loading Conditions	Downstream Slope H:1.0	Upstream Face	Gallery	Membrane		Found Drain		Internal Drains		Bedding		Grout Curtain	
						Y/N	Efficiency	Y/N	Efficiency	Y/N	Efficiency	Y/N	Efficiency	Y/N	Efficiency
37	R	Usual	.72	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
38	R	Unusual	.72	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
39	R	Extreme	.72	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
40	R	Usual	.80	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
41	R	Unusual	.80	V	Y	Y	0%	N	67%	N	67%	N	67%	N	0%
42	R	Extreme	.80	V	Y	Y	0%	N	67%	N	67%	N	67%	N	0%
43	R	Empty	.80	V	Y	Y	0%	N	67%	N	67%	N	67%	N	0%

* 37 through 43 used friction angle = 45^{o}, shear Cohesion = 80 psi, tensile strength (Bedding) = 15 psi; Compressive Strength = 1750 psi.

DESIGNS AND LOADING CONDITIONS INVESTIGATED
(continued)

Case	Placement Method	Loading Conditions	Downstream Slope	Upstream Face	Gallery	Internal Drains Y/N	Internal Drains Efficiency	Age	F'c (psi)	Shear F't (psi)	Shear C (psi)
44	C	Usual	.72	V	N	N	0%	6 mo.	1600	0	250
45	C	Unusual	.72	V	N	N	0%	1 yr+	1800	0	300
46	C	Extreme	.72	V	N	N	0%	1 yr+	1800	0	400
47	C	Usual	.75	V	N	N	0%	6 mo.	1600	0	250
48	C	Unusual	.75	V	N	N	0%	1 yr+	1800	0	300
49	C	Usual	.75	V	N	N	0%	6 mo.	1600	0	250
50	C	Unusual	.75	V	N	N	0%	1 yr+	1800	50	300
51	C	Usual	.72	V	Y	Y	67%	6 mo	1600	0	250
52	C	Unusual	.72	V	Y	Y	67%	1 yr+	1800	o	300
53	C	Extreme	.72	V	Y	Y	67%	1 yr+	1800	0	400
54	C	Empty	.72	V	Y	Y	67%	6 mo.	1600	0	250

DESIGNS AND LOADING CONDITIONS INVESTIGATED
(continued)

Case	Placement Method	Loading Conditions	Downstream Slope	Upstream Face	Gallery	Internal Drains Y/N	Internal Drains Efficiency	Age	F'c (psi)	F't (psi)	Shear C (psi)
55	C	Usual	.72	V	Y	Y	67%	6 mo.	1600	0	200
56	C	Empty	.72	V	Y	Y	67%	6 mo.	1600	0	200
57	C	Unusual	.72	V	Y	Y	67%	1 yr+	1800	0	225
58	C	Extreme	.72	V	Y	Y	67%	1 yr+	1800	0	300
59	C	Usual	.72	V	Y	N	0%	6 mo.	1600	100	200
60	C	Unusual	.72	V	Y	N	0%	1 yr+	1800	117	225
61	C	Extreme	.72	V	Y	N	0%	1 yr+	1800	156	300
62	C	Usual	.72	V	Y	N	0%	6 mo	1600	50	200
63	C	Unusual	.72	V	Y	N	0%	1 yr+	1800	53	225
64	C	Extreme	.72	V	Y	N	0%	1 yr+	1800	78	300
65	C	Unusual	.72	V	Y	N	0%	1 yr+	1800	58	225
66	C	Unusual	.72	V	Y	N	0%	1 yr+	1800	0	225

DESIGNS AND LOADING CONDITIONS INVESTIGATED
(continued)

Case	Placement Method	Loading Conditions	Downstream Slope H:1.0	Upstream Face	Gallery	Membrane Y/N	Membrane Efficiency	Found Drain Y/N	Found Drain Efficiency	Internal Drains Y/N	Internal Drains Efficiency	Bedding Y/N	Bedding Efficiency	Grout Curtain Y/N	Grout Curtain Efficiency
67	R	Usual	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
68	R	Unusual	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
69	R	Extreme	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
70	R	Empty Res	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
71	R	Unusual	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
72	R	Unusual	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
73	R	Extreme	.77	V	Y	Y	0%	Y	67%	Y	67%	Y	67%	Y	0%
74	R	Usual	.77	V	Y	Y	90%	Y	67%	Y	0%	Y	0%	Y	0%
75	R	Unusual	.77	V	Y	Y	90%	Y	67%	Y	0%	Y	0%	Y	0%
76	R	Extreme	.77	V	Y	Y	90%	Y	67%	Y	0%	Y	0%	Y	0%
101	R	Empty	.77	V		Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
102	R	Usual	.77	V		Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
103	R	Unusual	.77	V		Y	0%	Y	67%	Y	67%	Y	0%	Y	0%
104	R	Extreme	.77	V		Y	0%	Y	0%	Y	0%	Y	0%	Y	0%

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J.3 DAM THERMAL STRESS STUDIES

GENERAL

A major factor in any Mass Concrete Dam is the internal stress and related cracking potential due to temperature changes. There are essentially two problems:

(1) Long term internal tensile stresses within the mass or body of the dam. These relate to contraction of the mass as it undergoes slow long term cooling from the elevated early temperatures because of heat generation during the hydration process. When the contraction is resisted or restrained by things such as the foundation or portions of the structure that do not cool and contract, a resulting tensile stress develops.

(2) Tensile stresses that develop near the surface if it is subjected to rapid cooling such as during a cold night while the interior just below the surface remains warm. This stress is removed when the surface warms again, for example, when the sun shines on it the next morning. This is often referred to as thermal shock.

In both cases, cracking will develop if the tensile stress from thermal contraction exceeds the tensile strength or strain capacity at that time. In the case of thermal shock, the concrete may be at a very early age and consequently have a low strength. In the case of the long term deep internal stresses, the strength can be much higher and it can be relieved somewhat by creep.

The "Stress Coefficient" is a convenient tool to help evaluate thermal stresses. It is a material property value unique to each mix and applicable to the time period during which the temperature change takes place. Specifically, the stress coefficient tells how much tensile stress (psi) will develop in a given restrained mix for every degree of temperature drop that it undergoes during the time period under question. It considers creep, the modulus of elasticity, and the coefficient of thermal expansion. For the aggregate materials and probable mix proportions at miner Flat, stress coefficients similar to the following can be expected for concrete subjected to the start of thermal loading at seven (7) days.

STRESS COEFFICIENTS	
Roller Compacted Concrete	5 - 7 psi/F degree
Conventional Mass Concrete	10 - 12
Spillway Facing	15 - 18
Conventional Concrete (C.I.P.)	
Upstream Face	15 - 18

These values are consistent with similar mixes of similar material composition at other projects. The values will be verified for the exact mix designs used at Miner Flat when they are finalized.

Thermal stresses are thus a function of the material properties and the quantity or extent of the temperature drop. The temperature change that will occur depends on many factors for each set of circumstances. These include:

1. Adiabatic heat rise generated from cement hydration;
2. Ambient Conditions (wind, temperatures and their fluctuation from season to season as well as within each day);
3. The rate of concrete placement;
4. The temperature of the mix when it is placed;
5. The effect of surrounding materials such as foundation rock, forms, and insulation;
6. Delays in construction due to rain or other circumstances;
7. The lift height or depth of each concrete placement;
8. The time between placements.

For the Miner Flat Project, an adiabatic rise of 37.3 F degrees was applied to the conventional mass concrete and a rise of 26.0 F degrees was used in the Roller Compacted Concrete.

A proven finite element analysis method for determining temperatures and their rate of change was made for both the conventional mass concrete and the RCC dams. The computor program takes into account the influencing factors listed above. Based on results of these studies, controls for constructions were established that minimize thermal stresses to tolerable levels for the designs recommended. These in turn provided the basis for the cost estimate and a realistic schedule as discussed in Sections J.6 and J.7. The Controls are "in-line" with controls used in the past on projects of a similar nature with similar materials and under similar environments.

For the RCC dam, the construction controls are detailed in the enclosed preliminary specifications (Section J.8). A sample of resulting temperatures at selected points of interest in the dam is shown in the following Figure # J.3A.

For the Conventional Concrete, the following controls were used in the thermal study.

- Placement allowed from March 15 to November 15
- Surface Insulation used as needed to prevent excessive thermal shock in the fall
- Maximum placing temperature 50° - 55° F
- Five foot lift heights
- Five days between placements.

A sample of resulting temperatures at selected points of interest in the dam is shown in Figure # J.3B.

It is worth noting that the precast concrete panels used in the upstream face of the recommended RCC dam design provides permanent insulation to the RCC mass and reduces the "thermal shock" to which the dam mass is subjected. This benefit is not realized in the conventional mass concrete dam. It is also worth noting that minor and shallow "thermal shock" cracking on the top of the dam and at the downstream face (but not transverse to the spillway flow) is a tolerable condition.

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ROLLER COMPACTED CONCRETE

120 LBS. TYPE II CEMENT PER CUBIC YARD
PLACING SCHEDULE AS DISCUSSED IN SECTION J.3

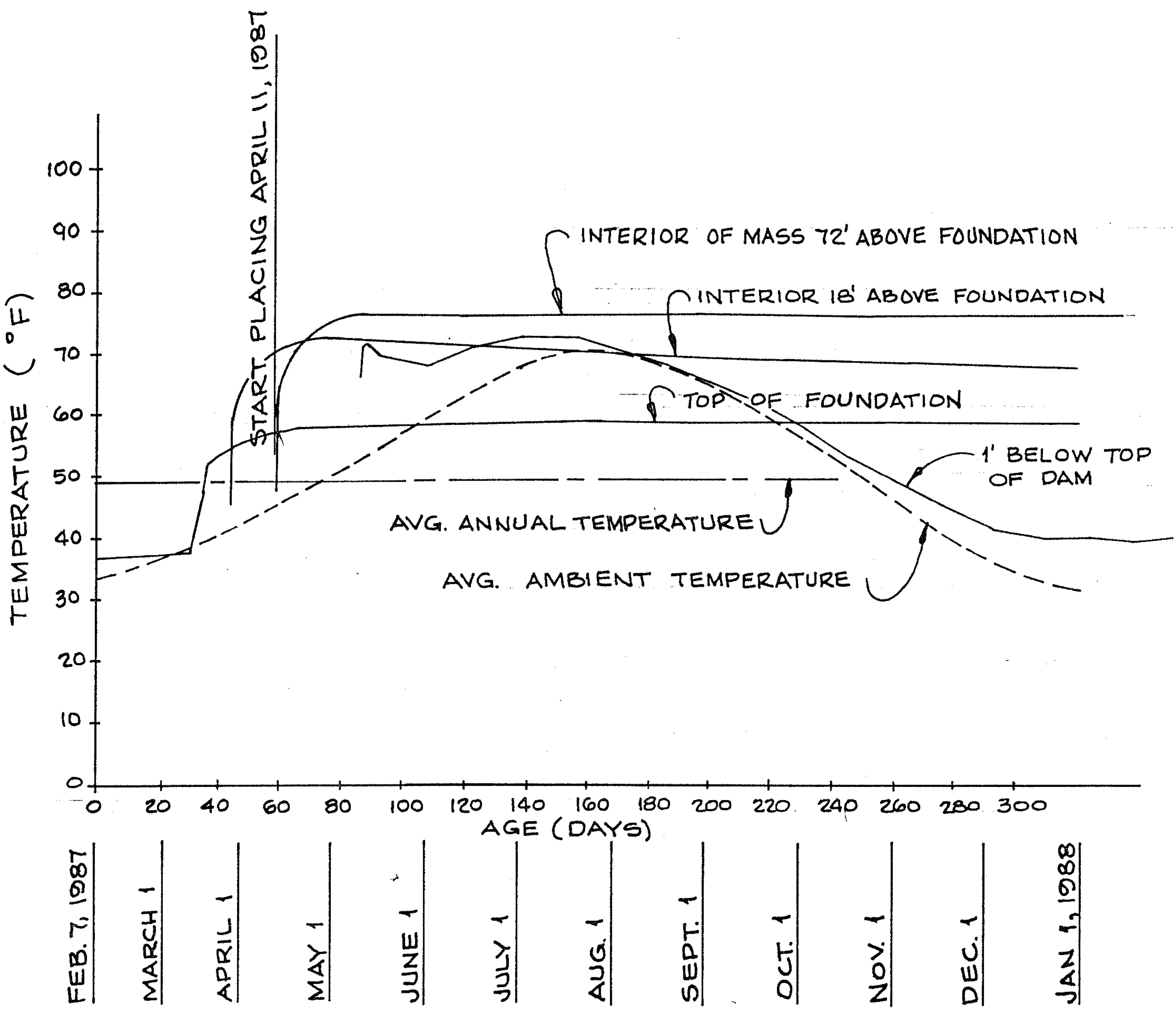

FIGURE J.3A

CONVENTIONAL MASS CONCRETE

185 LBS. TYPE II CEMENT PER CUBIC YARD
80 LBS. FLY ASH PER CUBIC YARD
TEMPERATURE OF MIX WHEN PLACED=50°F
5 DAYS BETWEEN LIFTS

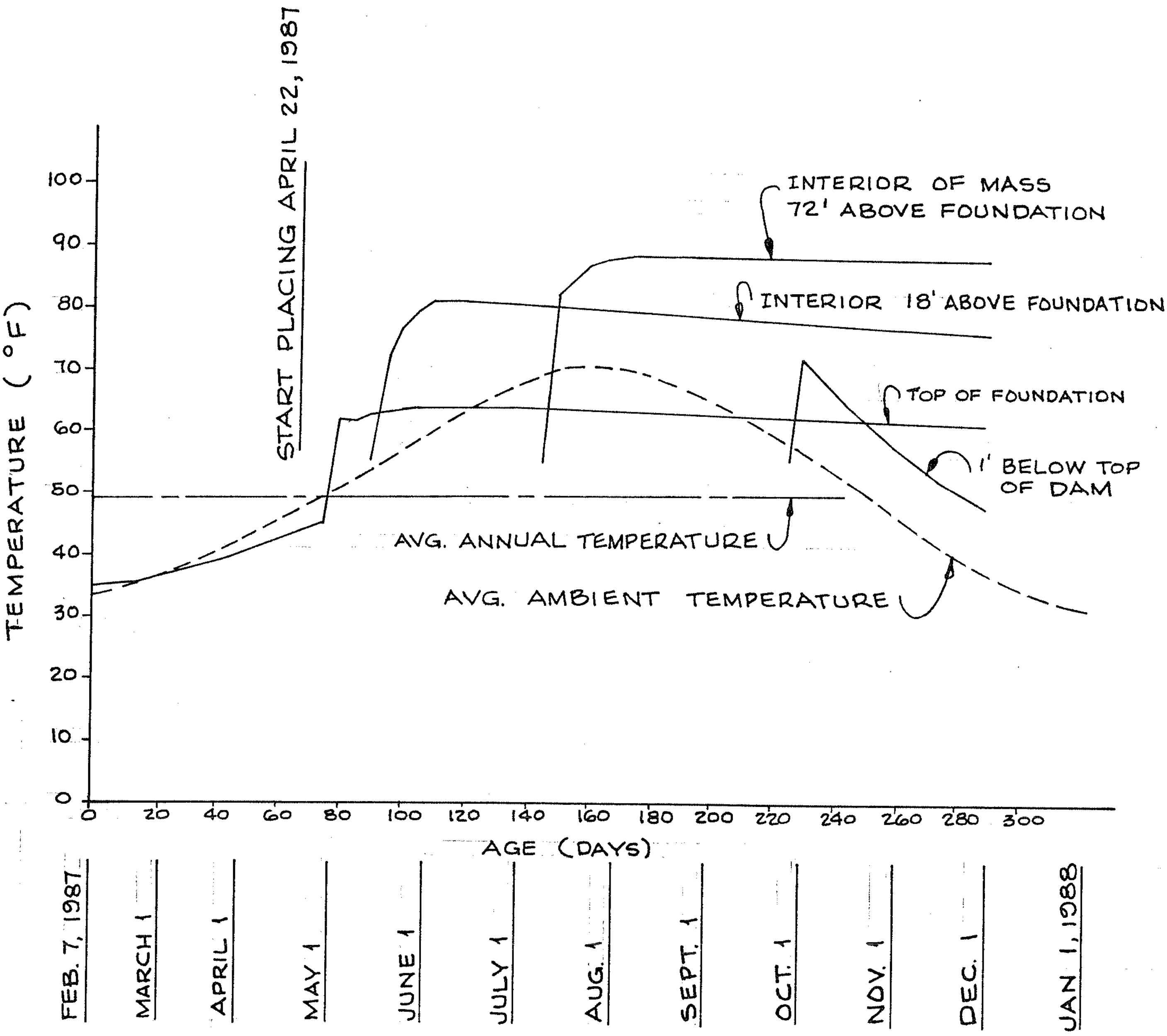

FIGURE J.3B

J.4 DAM AGGREGATES AND MIX DESIGNS

Site explorations indicate that both the gravel deposits upstream of the dam and rock from required foundation excavation can be used to make the suitable RCC aggregate. With additional processing, these sources could be used to make conventional concrete aggregate. If a Conventional Mass Concrete dam or an RCC dam requiring high strength were built, a substantial processing facility with classifiers, washing and settling ponds would be necessary. For the RCC dam as designed, a simple high production operation without washing can be used to make the RCC aggregate. A smaller, separate plant can be used to make the remaining small amount of conventional concrete aggregate for facing, walls, fill, etc. or it could be obtained from a commercial producer meeting ASTM Specifications.

Results of aggregate source investigations including petrographic reports are contained in Section E. The materials are typically hard, sound, and dense, although there are small quantities of friable particles in the gravels. The rock and the greatest constituent of the gravels are good quality basalt. The materials are similar in description and physical appearance to those used or tested at other projects which produced very excellent RCC. For example, at Willow Creek Dam, RCC aggregates were produced from a blend of about 70% excavated basalt and 30% silty sandy gravels. A URUGUA-I quartzitic sands and a sandy silt material blended with quarried basalt rock produced excellent aggregate. For these materials, no washing was necessary and, in fact, it was found that including the non-plastic fines helped the overall RCC quality. A similar operation is anticipated at Miner Flat for RCC aggregate, where probably about 50% to 70% of the material will be basalt from required rock excavation, 20% to 30% will be from gravel borrow, and 0% to 10% will be from a local borrow source of sand and/or silt. There is adequate quantity of required excavation and borrow to produce the aggregates necessary. The gradation limits and construction controls for RCC aggregates at Miner Flat are detailed in the preliminary specifications of Section J.8. Conventional Concrete Aggregate will meet normal ASTM C-33 Specification Requirements.

There is enough experience with lean RCC mixes using similar aggregate sources to confidently expect that RCC of the quality required at Miner Flat can be produced without difficulty and at a low cement factor. This experience includes several mixes at Willow Creek Dam, a number of them for URUGUA-I, and mixes for Zintel Canyon dam. Similarly, experience has also shown that other aggregates of poor quality require higher cement or cement plus fly ash rates in order to achieve reasonable strengths.

The design strength level used for Miner Flat is only 1400 psi at 1 year, but an even lower level would still provide all necessary factions of safety. Nonetheless, the intent is to provide a 1 year average strength of 1800 psi in order to conservatively account for mix variability and possible construction problems. Strength levels used in the stability analysis and that are anticipated are given in Section J.2. It is expected that 1800 psi can be achieved with about 120 pounds of Type II Cement per cubic yard or less. At this cement content, the anticipated adiabatic heat rise will be about 26 F degrees and internal thermal cracking of the mass should be avoided.

If the aggregate were questionable, if there was little experience with similar materials, if there was insufficient remaining time to make mix designs, or if the required strength level were high, it would be appropriate to have already made preliminary mix designs. However, that is not the case. The construction contract will be arranged so that the exact mix design can be determined and provided during the course of early construction work, and so that it can be adjusted if necessary. This includes the options of using pozzolan for a portion of some of the cement. This approach is not uncommon in dam construction.

During the first phases of site construction, samples of representative aggregates will be provided to the Engineer by the contractor for the purpose of mix designs. This will allow adequate time to develop optimum mix designs for economy and quality, make adjustments and, if necessary, remake the mixes. It also allows for enough time to obtain test results through six months age. Tests will be made at various ages for various cement contents such as 80, 100, 120, 150, and 170 pounds of cement per cubic yard. Ages tested will probably include 2, 7, 14, 28, 56, 90, 180 and 365 days. Tests to verify the design assumptions will include at least compression, modulus of elasticity, and indirect tensions. From this data and the results of similar mixes from other projects, other material properties can be extrapolated. This approach has been successfully used at other RCC projects.

\MINERFLATDAM\AGG&MX.DSN

DESIGN MEMORANDUM

SECTION J

J.5 RCC DAM CONSTRUCTION - SPILLWAY FACING

The facing concrete in the spillway section presents a special problem. The surface of the facing must be extremely smooth and free of defects. For that reason, we feel the formwork for the facing concrete must be internally supported. That is, it cannot have any ties through the face of the spillway. We have included a conceptual sketch (Figure J.5A) of one forming system that was successfully used on the Copperfield River Dam in Australia. That spillway has been used on more than one occasion and has performed without any problems.

The basic concept is to imbed approximately 3" diameter steel pipes into the facing concrete. These pipes are approximately 6 feet in length. Immediately before a pour, the pipes are lubricated with a heavy grease. There is a bracket that attaches to the pipes and extends out over the face of the dam to which the form is attached. The supporting bracket must have enough strength to permit the forms to kick against it, since that is the only means of support. Beneath the form, there is a scaffold provided. The scaffold provides a little additional weight and, since there are usually people on the scaffold during the pour work, it also helps hold down the bottom of the form, which has a tendency to want to float. As soon as the facing concrete has achieved enough strength, approximately five to six hours after a pour, a jack is attached to the pipes. The bolt that attaches the bracket to the pipe is loosened. The pipes are then jacked up 1 1/2 feet in preparation of the next lift. The jack is then lowered and attached to the supporting bracket. The forms are moved away from the face of the concrete by means of adjusting bolts that attach the forms to the brackets. The form is then raised to the elevation of the next pour.

With the scaffold permanently attached to the forms, as soon as the form is removed, the finishers can finish the concrete, remove any defects, and then immediately apply curing compound. The concrete is still green enough that it finishes very well. The pipes extend three lifts into the dam so that they are bearing in concrete that has acquired some amount of strength.

The spillway will be placed without contraction joints and without reinforcing steel. Although the facing mix will be formulated with the intent to eliminate shrinkage cracks, some tight cracking may still result from the combination of temperature changes and drying. These cracks would be very tight and follow directly over the drain holes left by the temporary form support pipes. They would not be transverse to the flow path and would terminate at the drain. In fact, this condition developed at Copperfield Dam where the same technique was previously used. That spillway has operated without incident.

If the velocity head from the spillway were to force water into a crack, the pressure would immediately relieve itself into the drain hole. The drains also act to prevent the potential build-up of pressure within the RCC behind the facing if for some reason there were to be a seepage path there.

\MINERFLATDAM\SPLWYFC.CON

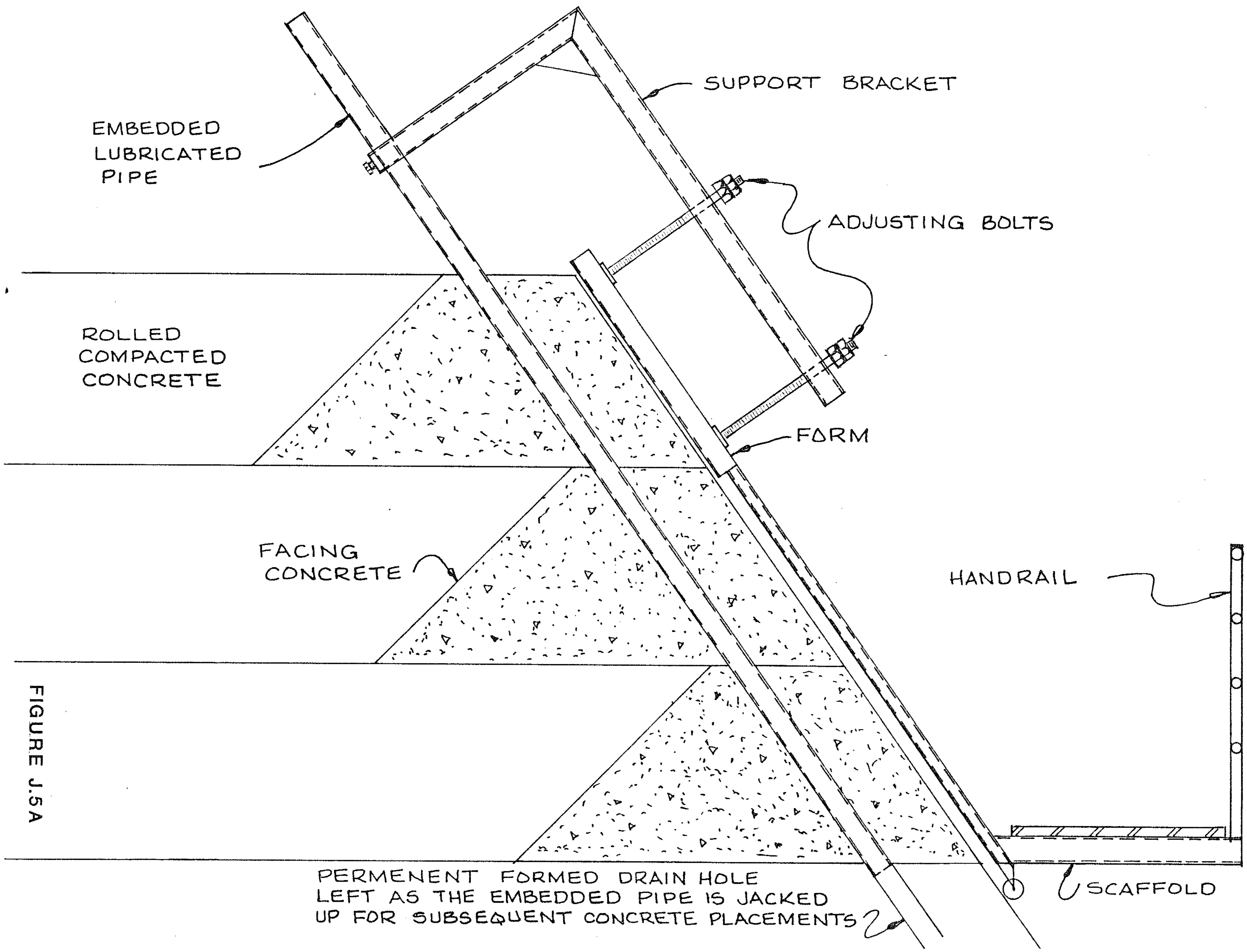
SUPPORT BRACKET
EMBEDDED LUBRICATED PIPE
ADJUSTING BOLTS
ROLLED COMPACTED CONCRETE
FORM
FACING CONCRETE
HANDRAIL
SCAFFOLD
PERMENENT FORMED DRAIN HOLE LEFT AS THE EMBEDDED PIPE IS JACKED UP FOR SUBSEQUENT CONCRETE PLACEMENTS

FIGURE J.5A

DESIGN MEMORANDUM

SECTION J

J.6. RCC DAM CONSTRUCTION - SCHEDULE

A construction schedule for the RCC Dam has been prepared based on the design rates of material placement, anticipated construction seasons, air temperatures, and construction methods used in developing the cost estimates.

The following Figures are self explanitory and critical in developing the RCC Construction Schedule. Those Figures are as follows:

Figure J.6A	-	Useable RCC Aggregate Stockpile Size
J.6B	-	Crusher Production
J.6C	-	RCC Mixer Production
J.6D	-	RCC Production (Dam Height)
J.6E	-	RCC Production (Volume Placed)
J.6F	-	RCC Dam Schedule

\MINER FLAT DAM\RCCDAM.STR

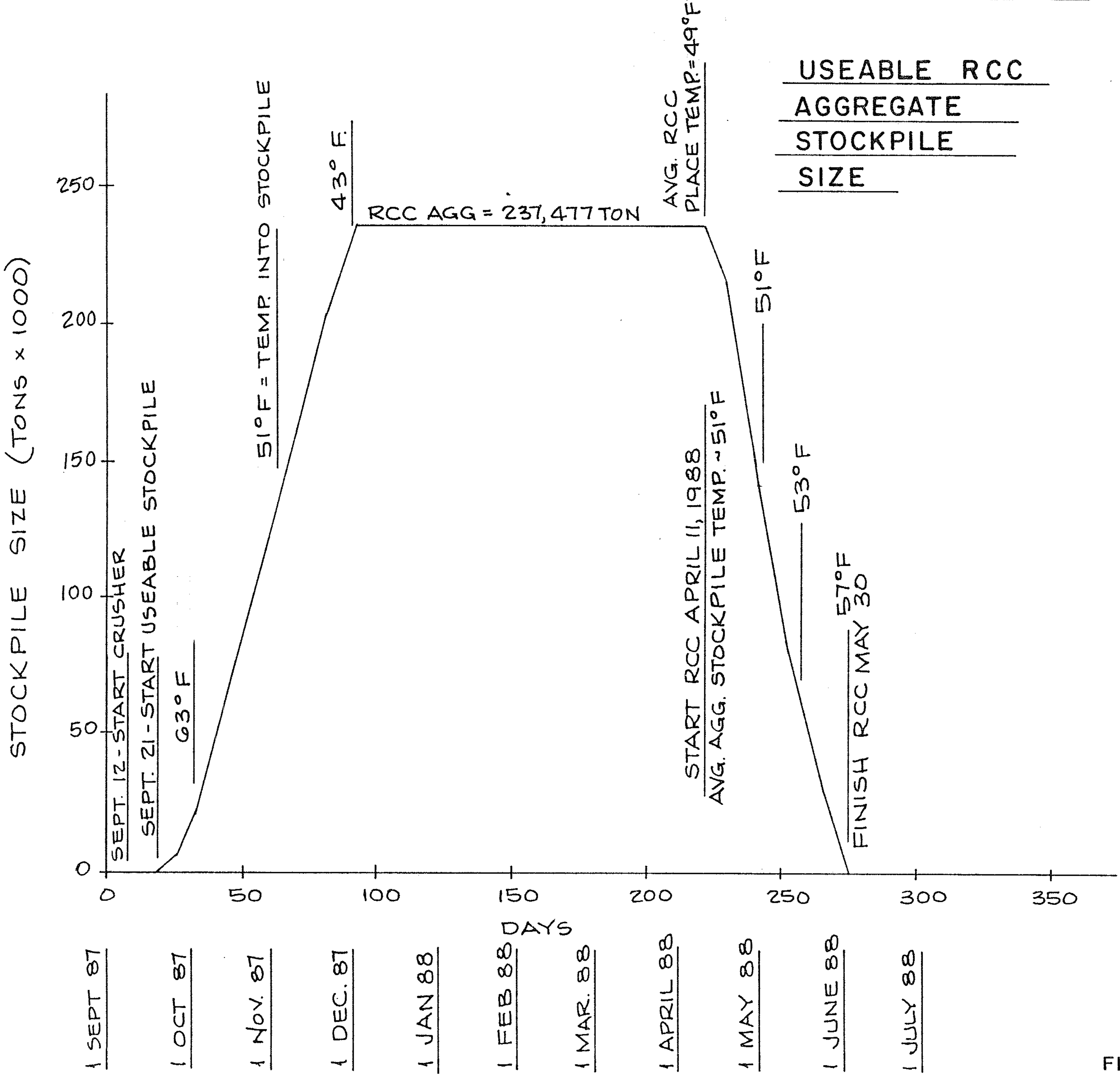
USEABLE RCC
AGGREGATE
STOCKPILE
SIZE
STOCKPILE SIZE (TONS x 1000)
DAYS
RCC AGG = 237,477 TON
SEPT. 12 - START CRUSHER
SEPT. 21 - START USEABLE STOCKPILE
63° F
51° F = TEMP. INTO STOCKPILE
43° F.
AVG. RCC
PLACE TEMP.=49°F
START RCC APRIL 11, 1988
AVG. AGG. STOCKPILE TEMP. ~ 51° F
51° F
53° F
57° F
FINISH RCC MAY 30
0
50
100
150
200
250
300
350
1 SEPT 87
1 OCT 87
1 NOV. 87
1 DEC. 87
1 JAN 88
1 FEB 88
1 MAR. 88
1 APRIL 88
1 MAY 88
1 JUNE 88
1 JULY 88

FIGURE J.6A

CRUSHER PRODUCTION

(FOR RCC AGGREGATE)

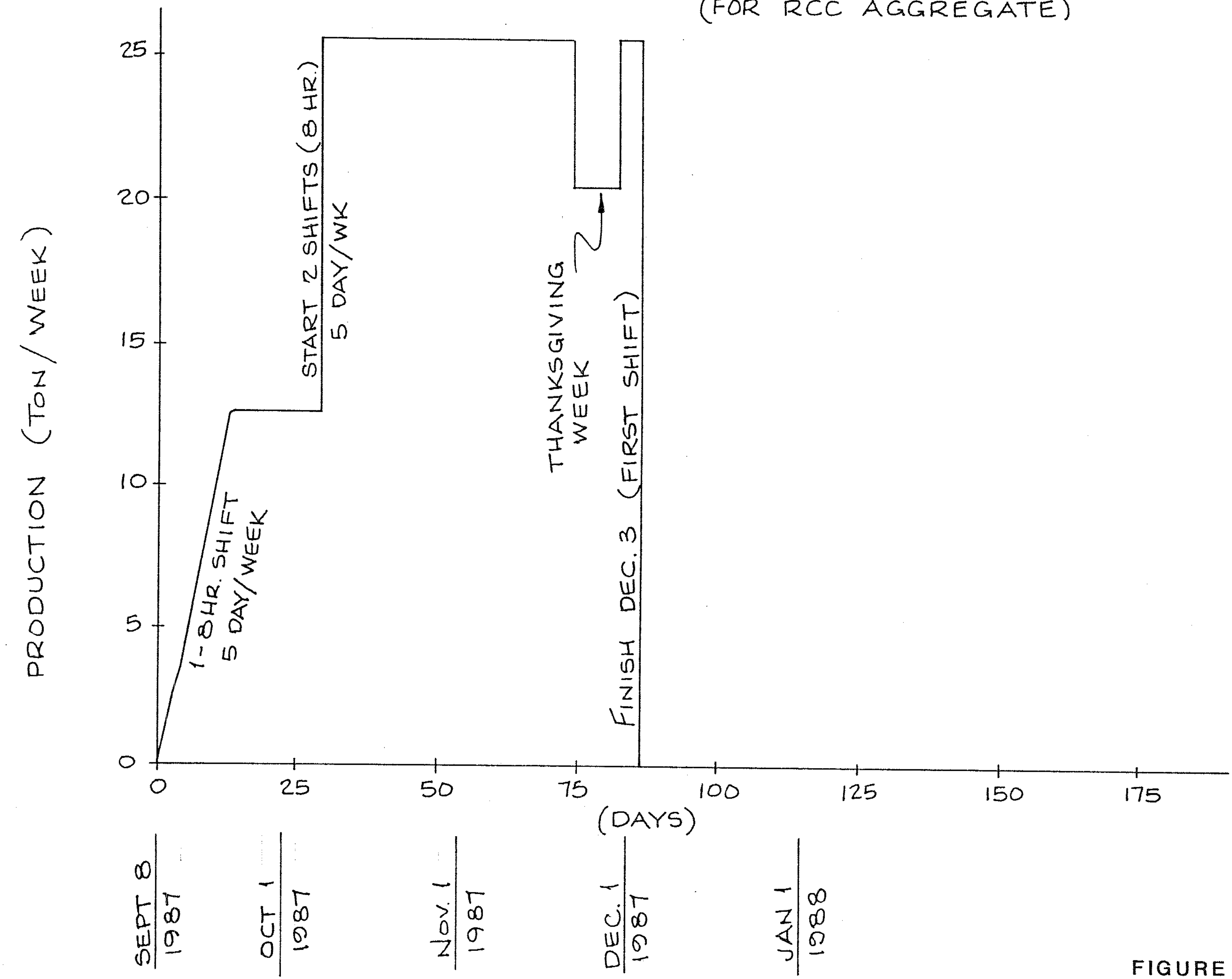

FIGURE J.6B

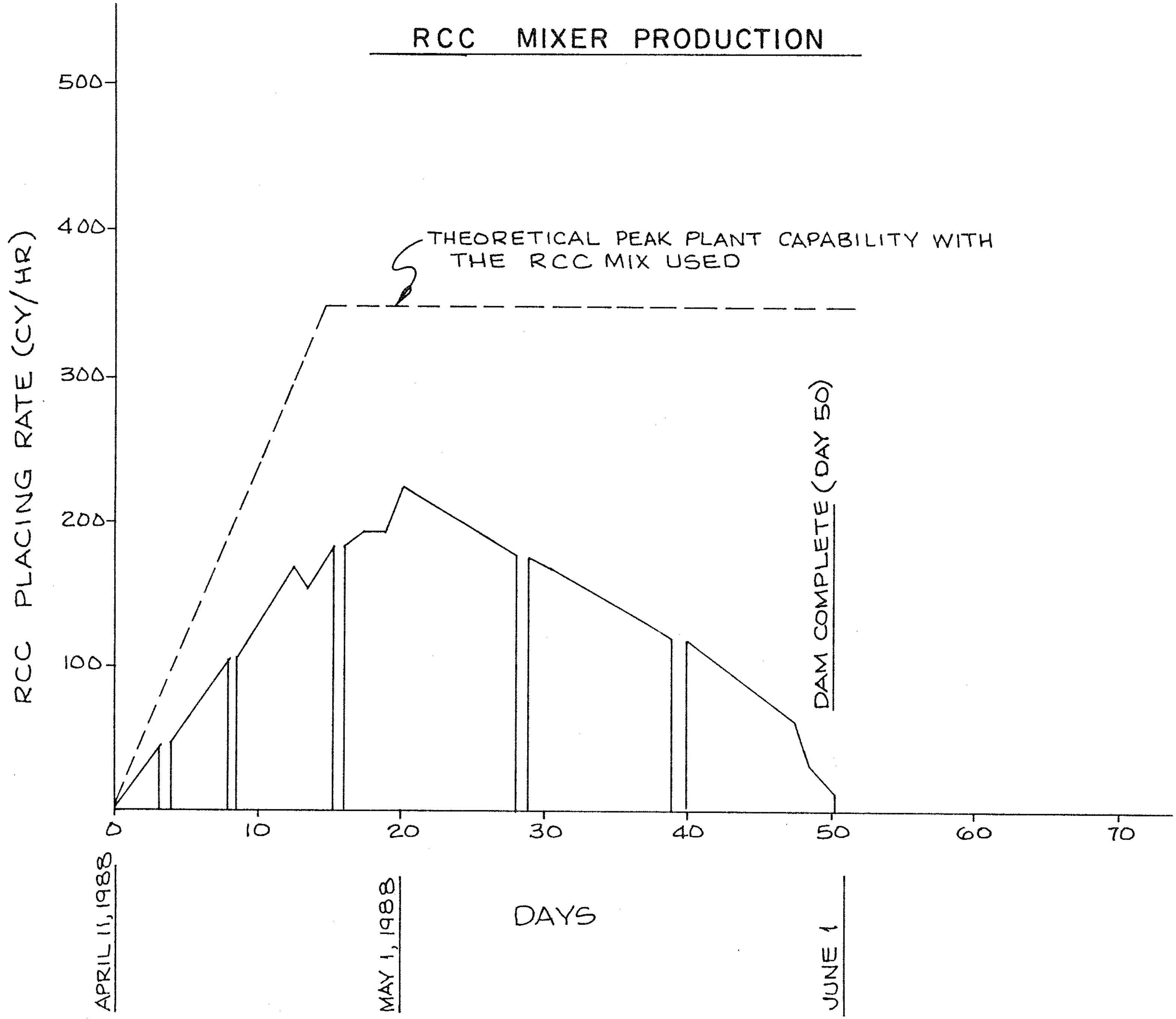
RCC MIXER PRODUCTION
THEORETICAL PEAK PLANT CAPABILITY WITH THE RCC MIX USED
DAM COMPLETE (DAY 50)
RCC PLACING RATE (CY/HR)
500
400
300
200
100
0
10
20
30
40
50
60
70
DAYS
APRIL 11, 1988
MAY 1, 1988
JUNE 1

FIGURE J.6C

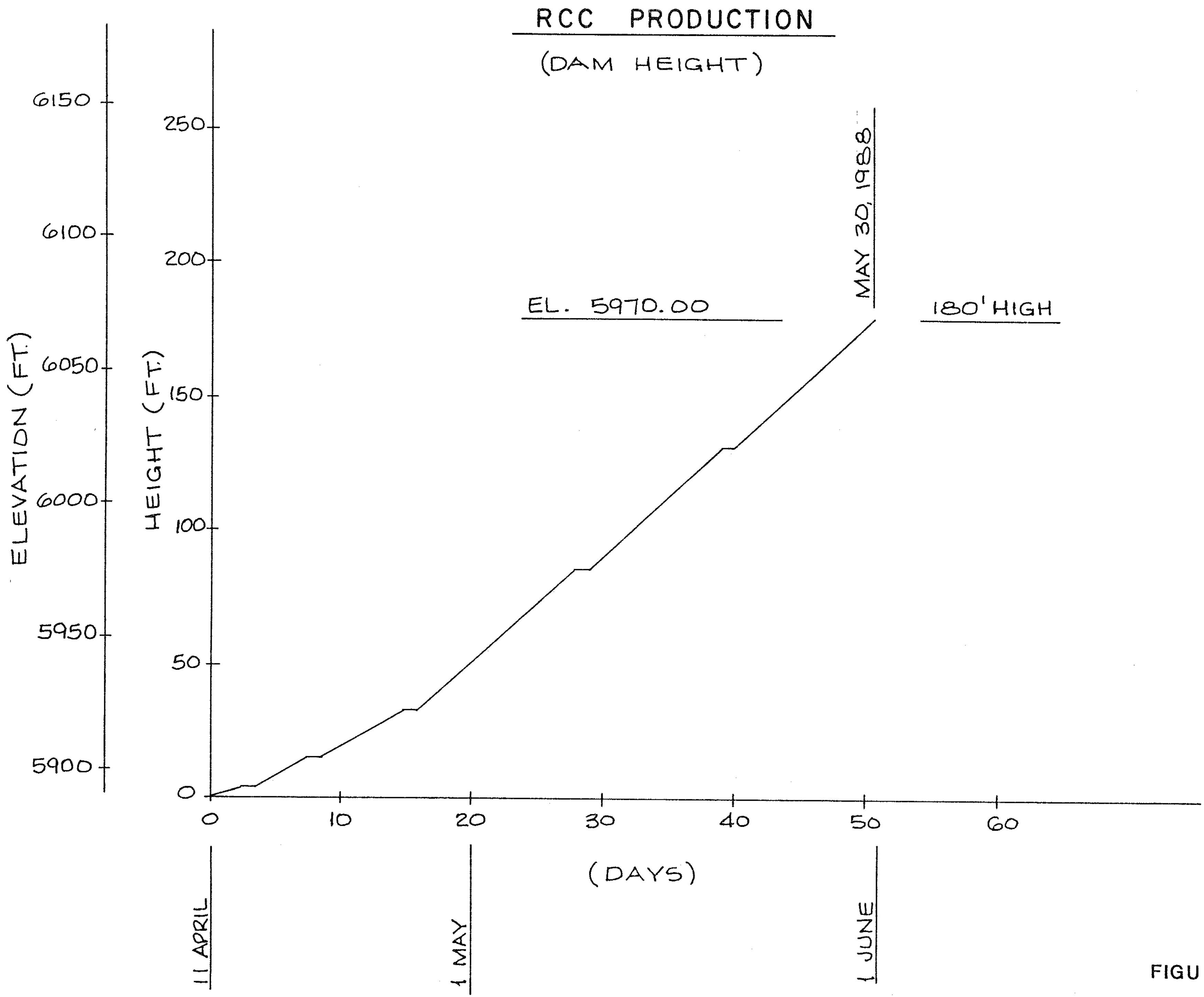
RCC PRODUCTION
(DAM HEIGHT)
ELEVATION (FT.)
6150
6100
6050
6000
5950
5900
HEIGHT (FT.)
250
200
150
100
50
0
EL. 5970.00
MAY 30, 1988
180' HIGH
0
10
20
30
40
50
60
(DAYS)
11 APRIL
1 MAY
1 JUNE

FIGURE J.6D

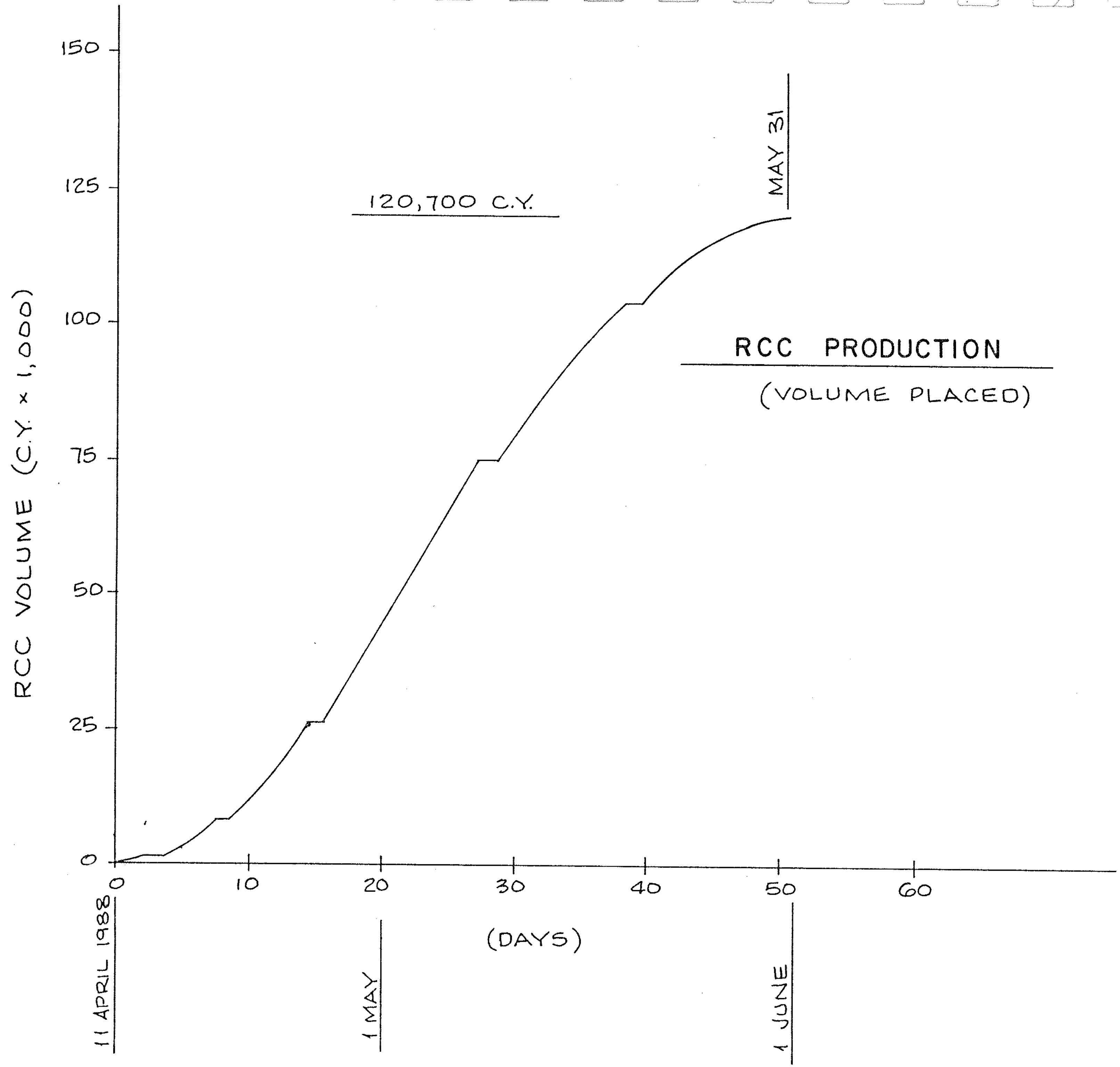
RCC PRODUCTION
(VOLUME PLACED)
120,700 C.Y.
MAY 31
RCC VOLUME (C.Y. × 1,000)
150
125
100
75
50
25
0
0
10
20
30
40
50
60
(DAYS)
11 APRIL 1988
1 MAY
1 JUNE

FIGURE J.6E

DESIGN MEMORANDUM
RCC DAM CONSTRUCTION SCHEDULE

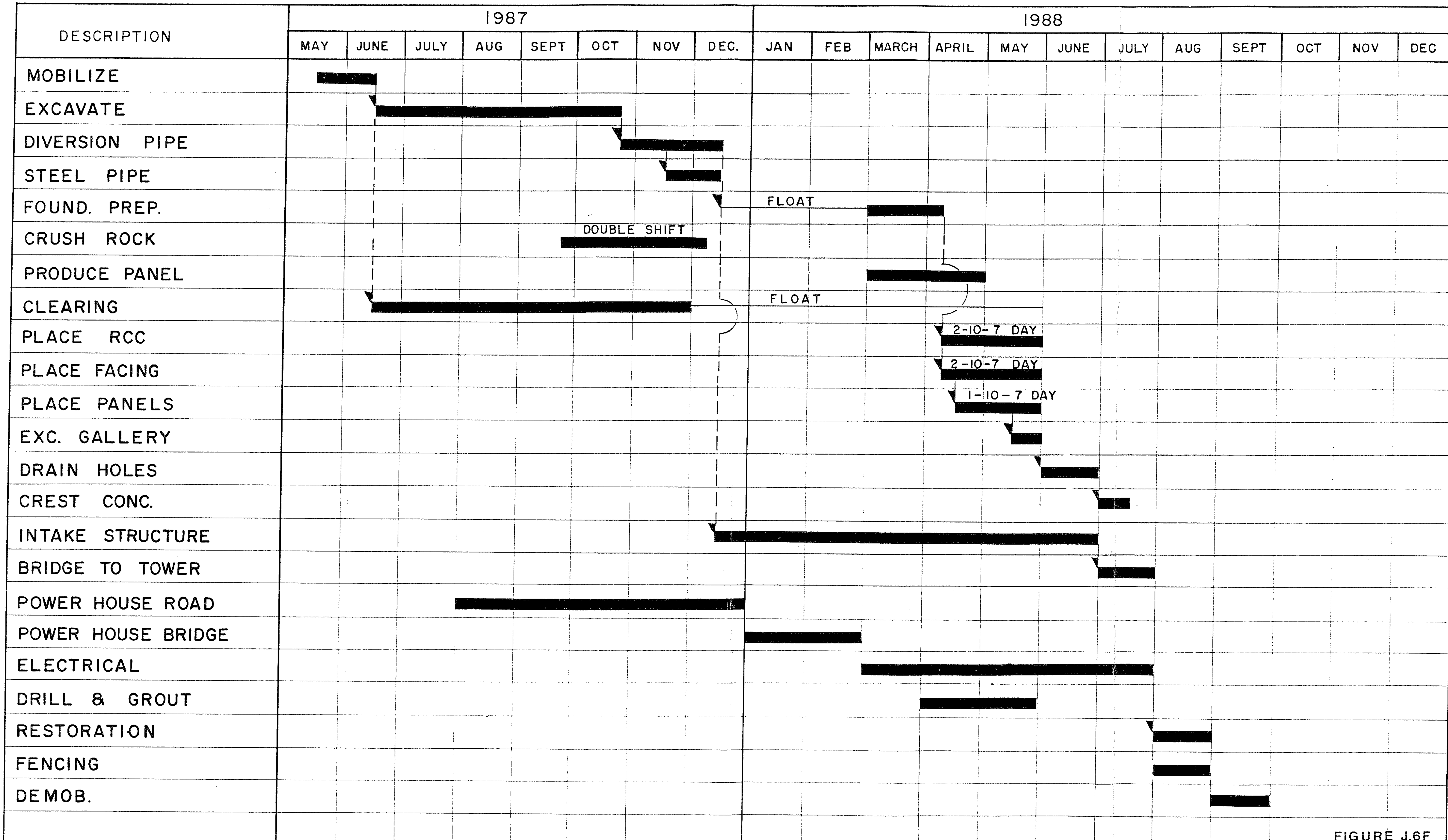

FIGURE J.6F

J.7 DAM COST ESTIMATES

INTRODUCTION

The Cost Estimate for Miner Flat Dam was prepared after an in-depth analysis of climactic conditions, scheduling considerations and logistics. Each major item of work was broken down into its component parts. The cost of each component was arrived at by applying the appropriate labor, equipment and materials costs. All production rates used in the RCC Estimate were very conservative.

Union labor rates with a 19.3% payroll burden were used.

Equipment rates were from the Cost Reference Guide for Construction Equipment published by the Equipment Guide Book Company of Palo Alto, California.

Material costs were from local suppliers.

The project layout, for purposes of the Cost Estimate. The project was laid out as follows:

1. Approximately 73,000 cubic yards of rock excavation was hauled to the crushing plant located 1,000 feet ± upstream from the dam.

2. Approximately 73,000 cubic yards of gravel was excavated from the canyon bottom to blend with the shot rock to produce required aggregates.

3. The aggregates were stockpiled on the upper right abutment.

4. The pug mill for roller compacted concrete and the conventional concrete plant were located on the upper right abutment as near the C8L as possible.

5. Both RCC and conventional concrete were delivered from the plant by conveyer and from the top of the canyon to the bottom by a spiral chute.

6. The RCC was transported on the dam by a 988B front end loader.

7. Conventional concrete was transported on the dam by transit mix truck.

8. The upstream face panels were set by crane from the canyon floor. A large crane was used so it could also hoist equipment to and from the dam for repairs as required since no other access to the dam crest was provided.

9. The office shop and carpenter yard are also located on the upper right abutment.

MAJOR COST ITEMS:

1. Excavation is the first major cost item to be discussed. The canyon is very deep and narrow making access difficult. The side walls will need to be pre-split, but are too high to take in one lift. After the first shot, it will be difficult to get back to the work area for subsequent lifts. Sequencing would probably require excavating the left abutent, moving the stream to the left side, excavating the right abutment, moving the stream back to the right side and then installing the outlet pipes and making a permanent diversion. Due to access problems and the fact that during the blasting operations, care must be taken to keep the stream flowing. Production rates are conservative. One stream crossing was provided for.

2. RCC production is low because it is always controlled by the downstream facing concrete. Since the dam is being constructed during cold weather, the facing concrete will not set quickly enough to allow for more than three lifts per day, which limits RCC production to a maximum of 250 cubic yards per hour and an average of only 118 cubic yards per hour. Limitations on production permits the utilization of a fairly small plant, 350 cubic yards per hour. The crew sizes remain virtually the same as would be the case for twice the production.

3. The quantity of facing concrete for each lift is fairly small, but there must be a forming crew, a placing crew and finishers at all times, as these functions are concurrent. Since these people are not as productive as they would be on a larger project, the unit prices are higher than might be anticipated.

4. About the same situation exists for the upstream facing panels. The maximum number of panels required per shift is 15, as opposed to a maximum of 60 per shift on past projects. The panel crew is working only a single shift, but nonetheless, due to the limited productivity, the unit costs are still a bit high. Even though all of these crews are not as productive as a person would like for them to be, since all of the operations are concurrent, it is still necessary to maintain separate RCC downstream facing concrete and panel crews.

SHIFTS OF WORK

The project is scheduled to use a single eight (8) hour per day, five (5) day per week shift except as follows:

1. The crusher is scheduled to work two (2) eight (8) hour shifts five (5) days per week.

2. The RCC and downstream facing is scheduled to work two (2) ten (10) hour shifts seven (7) days per week and the upstream facing panels is scheduled to work one (1) ten (10) hour shift seven (7) days per week.

ADVANTAGES OF RCC AS OPPOSED TO CONVENTIONAL MASS CONCRETE

If the contract were awarded in mid May in 1987 it is possible to complete the RCC structure by December 1, 1987. The following items would be necessary to achieve that schedule:

1. The Contractor would need to work two (2) ten (10) hour shifts seven (7) days a week on the excavation and mobilize immediately after award.

2. The contractor would have to make diversion no later than August 1, 1987.

3. Production of aggregates would be during June, July and August. Crushing during the hottest time of the year has some slight adverse effects on the temperatures in the structure but not enough to cause any alarm.

4. RCC placement would start about September 1st and finish by the end of October. The small ice plant might possibly be required for the facing concrete during the early stages of the work but probably not.

With the conventional mass concrete dam, on the other hand, we do not see any way of starting placement sooner than mid March of 1988. Due to thermal considerations a minimum of 180 days are required to construct the conventional concrete dam. Some potential problems that could cause further delays are as follows:

1. There are five (5) Monoliths across the dam. A lift cannot be placed on top of a previous lift sooner than the fifth day. During the colder part of the year, if the set time is retarded enough that a delay in the time the clean up crew can get back on the pour or the time the forming crew can get back on the pour, would probably cause the loss of one days time since there is no alternative place to work.

2. Placement will not be permitted from November 15 to March 15, so a minor delay problems could conceivably force the completion on the conventional structure into 1989.

3. A large batch plant with an ice plant is required to maintain acceptable production rates on the conventional mass structure. At least two (2) large cranes having over one hundred tons capacity are required for the placement. The volumes in each pour are relatively small in this structure, but none the less we still require some very large sophisticated equipment which is going to limit the number of bidders on the conventional dam.

The RCC alternative is the best choice for this location. We have applied a 15% contingency to each estimate but realistically a 10% contingency for the RCC and a 25% contingency for the conventional concrete would be more realistic.

MINER FLAT DAM

Bid Summary Roller Compacted Concrete

Description	Quantity	Adjusted Unit Price	Bid Amount
Excavation	126,874 C.Y.	9.50	1,205,303
Foundation Prep.	3,000 S.Y.	24.50	73,500
Dental Conc.	100 C.Y.	100.00	10,000
Bedding mix	2,500 C.Y.	60.00	150,000
R.C.C.	120,702 C.Y.	23.00	2,776,146
Facing Concrete	5,091 C.Y.	225.00	1,145,475
O.G. Concrete	359 C.Y.	250.00	89,750
Crest Non-Overflow	189 C.Y.	200.00	37,800
Face Panels	40,384 S.F.	12.00	484,608
Concrete AD	1,262 C.Y.	220.00	277,640
Reinforcing	69,110 LBS.	0.50	34,555
Guard Fence	110 L.F.	14.00	1,540
Gallery	Lump Sum	-0-	60,000
Misc. Metal	Lump Sum	-0-	300,000
Diversion Dam	Lump Sum	-0-	15,000
Clearing	165 Acre	2,000.00	330,000
Outlet Pipe	303 L.F.	750.00	227,250
Power House Pipe	150 L.F.	1,500.00	225,000
Bridge to Tower	Lump Sum	-0-	100,000
Bridge to Power House	Lump Sum	-0-	180,000
Drain Holes From Crest	3,050 L.F.	10.00	30,500
Drain Holes From Gallery	1,325 L.F.	30.00	39,750
Drill and Grout	930 L.F.	30.00	27,900
Electrical	Lump Sum	-0-	150,000
Security Fence	Lump Sum	-0-	30,000
Mobilization	Lump Sum	-0-	895,000
Instrumentation	Lump Sum	-0-	40,000
Restoration	Lump Sum	-0-	14,000
TOTAL BID			8,950,717

MINER FLAT DAM

Bid Summary Conventional Cast in Place Concrete

Description	Quantity	Adjusted Unit Price	Bid Amount
Excavation	138,000 C.Y.	9.50	1,311,000
Foundation Prep.	3,000 S.Y.	24.50	73,500
Dental Conc.	100 C.Y.	100.00	10,000
Mass Concrete	141,040 C.Y.	71.00	10,013,840
O.G. Concrete	359 C.Y.	250.00	89,750
Concrete AD	1,262 C.Y.	220.00	277,640
Reinforcing Steel	69,110 LBS.	0.50	34,555
Guard Fence	110 L.F.	14.00	1,540
Gallery	Lump Sum	-0-	150,000
Misc. Metal	Lump Sum	-0-	300,000
Diversion Dam	Lump Sum	-0-	15,000
Clearing	165 Acre	2,000.00	330,000
Outlet Pipe	303 L.F.	750.00	227,250
Power House Pipe	150 L.F.	1,500.00	225,000
Bridge to Tower	Lump Sum	-0-	100,000
Bridge to Power House	Lump Sum	-0-	180,000
Drain Holes From Crest	3,050 L.F.	10.00	30,500
Drain Holes From Gallery	1,325 L.F.	30.00	39,750
Drill and Grout	930 L.F.	30.00	27,900
Electrical	Lump Sum	-0-	150,000
Security Fence	Lump Sum	-0-	30,000
Mobilization	Lump Sum	-0-	1,500,000
Instrumentation	Lump Sum	-0-	40,000
Restoration	Lump Sum	-0-	14,000
TOTAL BID			15,171,225

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J.8 RCC DAM SPECIFICATIONS

A set of RCC Dam Specifications has been prepared for this Design Memorandum to provide details not covered in the previous articles for the construction of the Miner Flat RCC Dam. The specifications may be modified during the final design and used as a portion of the final design specifications.

\MINER FLAT DAM\J-8.MFD

Section ____

UPSTREAM IMPERVIOUS BARRIER

1. GENERAL

The work covered by this section consists of materials and installation for the impervious barrier (liner) at the upstream face of the dam. The liner shall be attached to the rear face of the upstream precast panels. The purpose of the barrier is to prevent seepage into the dam by providing a permanent, durable, waterproof barrier from abutment to abutment and from the top of the dam to the base of the dam. The barrier will be located between the panels and the roller compacted concrete (RCC). See Section ____ "Roller Compacted Concrete."

2. MATERIAL

2.1 Qualifications and Support

The supplier of the liner shall be a well established manufacturer and supplier specializing in this material. The company shall have at least 5 years experience with the basic product supplied, and with its use in hydrostatic water retaining structures. If supply is through or by a company located outside of the U.S.A. the company shall have at least 3 years of successful construction trade experience with the type of product to be supplied. The Supplier shall designate a highly qualified senior technical person as the responsible liasison for fabrication, shipping, installation (including field welds and repairs), any necessary field training, overall quality control, and coordination. He shall be available for consultation if needed and shall be on-site during at least the first three days of placement where joint welding of the liner is performed.

2.2 Composition and Properties

The liner may be polyvinyl chloride or high density polethylene. It shall have a minimum sheet thickness of 0.080 inch (80 mil) or 2 mm. The liner shall have sufficient flexability to be field welded and lapped as required in the field at temperatures ranging from 35 to 95 degrees F. Premolded corners may be used to facilitate installation of the added liner sheet near the foundation and abutment. The liner shall have long term resistance to deterioration under the alkali environment of damp concrete in the dam. It shall be resistant to degradation from organic and bacterial growth. The liner shall be resistant to through punctures and tears during handling and installation, and from placement and compaction of the bedding mix and roller compacted concrete. The liner shall meet the following physical property requirements.

TEST STANDARD	TEST DESCRIPTION	METRIC	U.S.
ASTM D 1505 or 792	Specific Gravity (min)	0.94	0.94
ASTM D 638 Type IV @ Speed C	Ultimate Tensile Strength (min)	3.54 Kg/mm width	200 width
ASTM D 638 Type IV	Elongation @ Break	600%	600%
ASTM D1004 Die C	Tear Resistance (min)	27 Kg	60 lbs
ASTM D 1203 (A)	Volatile Loss (max)	0.2%	0.2%
FTMS 101B	Puncture Resistance (min)	159 Kg	350 pou
ASTM D 751(A), #Proc 1	Hydrostatic Resistance	25 Kg/Cm2	500 psi
ASTM D 256, Method B	Notched Impact Resistance Thermal Expansion (max)	25x10-5 per degrees C	14x10-5 per deg F
ASTM D 696	Water Absorption (max)	0.1%	0.1%

Prior to the contractor placing any order for material, the manufacturer shall provide an affadavit guaranteeing that material supplied for this project will be tested and will meet all of the requirements specified.

2.3 Size

The liner shall be provided in sheets that are at least the panel size and that will allow for heat welding the liner from one panel to the next around the perimeter of each panel. The anticipated nominal panel size is __ft x __ft. A plan to provide one factory weld in one direction to make up the required liner size may be submitted for review and consideration. The submittal must be complete, address the issue of intersecting field and factory splices, and guarantee that the factory welds will be tested prior to shipping and be 100% water tight under a persistant pressure of at least 120 psi.

3. INSTALLATION

3.1 Onto Precast Panels

The liners shall be cast integrally with the precast panels so that they remain attached to the panels during handling an erection. An acceptable method of attachment shall be provided so that concrete for the precast panels can be cast directly onto the liner or so that the liner can be placed onto the top of the fresh mix. The liner shall remain well attached to the hardened panel during all operations including steam curing, form stripping, handling, storage, erection, joint welding, and placement of the dam concrete. Possible methods of attachment include "T" sections which are extruded as an integral part of the liner, studs thermally attached to liner without damaging it, epoxy bonding, and strips that attach to the liner and contain filaments which embedded into the concrete.

3.2 Field Welds

Joint strips and welds shall have the same qualities after welding as specified for the parent sheet itself. Welds shall be done by heat equipment specifically designated for fusing together sheets of the liner into one water tight section. Welding shall be done only by personnel trained and qualified by the Suppier. The welds shall provide at least 1 inch of lap from one sheet of liner to the next or to the weld strip. All welds and any questionable surfaces in the liner shall be tested with an approved electrical holiday or flaw detector. Any defective weld, repair, or liner shall be repaired by additional welds and may require welding of a new patch over the defective area.

3.3 Anchor Rods

Where anchor rods for the precast panels extend through the liner, the hole shall be sealed with flexible Aquatepoxy paste or approved equal, and with a washer and nut as shown on the drawings. The hole in the liner may be up to 2 times the diameter of the anchor bar. The washer shall have a diameter of 4 to 5 times the diameter of the bar. The procedure used shall be to first dip the end of the anchor bar into the epoxy, then thread it into the panel, then tighten the washer and nut so that a pressure seal is accomplished and so that the epoxy squeezes out from the spaces between the membrane and washer, the washer and nut, and the nut and bar. All work shall be finished well within the pot life or useable time of the epoxy under the temperature and conditions during placement.

Section ____

PRECAST PANELS

1. GENERAL

Except as otherwise allowed, specified, or supplemented by this SECTION: "PRECAST PANELS" all precast concrete and related work shall conform to the requirements of SECTION "CONCRETE". The precast concrete facing panels for the dam may be cast on site or in an acceptable established off-site facility naomrally engaged in commercial precast concrete manufacturing. If the precast panels are cast on site, the Contractor shall establish a specific casting area complete with casting beds, lifting and handling equipment, batch plant, cure and protection equipment, placing equipment, lighting, proper drainage, storage areas, etc. If the site facility does not reliably and consistently produce precast concrete of the required quality and at the necessary production rates, the Contractor shall replace or supplement the on-site casting plant with an "off-site" facility normally engaged in commercial production of precast concrete. At least 85 percent of the precast facing panels and related hardware, including all panels and hardware required for the placement of roller compacted concrete (RCC) to Elevation 6,062, shall be in storage on site prior to the start of production RCC placement.

2. COMPOSITION

Precast concrete may use high early strength portland cement. The concrete shall contain an air-entraining admixture, water, normal weight fine aggregate, and coarse aggregate to a maximum size of 1 inch. A water-reducing admixture conforming to ASTM C 494 may be used.

3. AGGREGATES

Aggregates for precast concrete shall come from the approved site sources or from an established and approved precast plant having a history of quality construction and durable materials. Aggregates from "off-site" shall have demonstrate a satisfactory service record under similar conditions to those which they will be subjected to under the design of this contract. Aggregates shall not be used without prior approval. If, in the opinion of the Engineer an adequate service record or adequate laboratory testing has not been demonstrated, the contractor shall perform all tests required by ASTM C 33 through a laboratory meeting the requirements of ASTM E 329 and submit this data to the Engineer for review at least 15 days prior to the first intended use of the materials. Established gradations for precast concrete will be allowed to vary slightly from those listed in SECTION "CONCRETE", providing that the gradations actually used have a history of excellent quality contrete construction. If a variation from the gradations of SECTION "CONCRETE" is desired, the Engineer shall be notified in writing and his concurrence shall be obtained prior to casting the concrete. The maximum permissible size of aggregate for precast concrete shall be 1 inch.

4. QUALITY

Mix designs for precast wall panels made with conventional concrete shall obtain design compressive strengths of 4,000 psi at 90 days, with a minimum design compressive strength of 1,000 psi prior to form stripping and of 2800 psi prior to shipping. The mix designs and strengths shall be the Contractor's responsibility. Compressive strength tests are required for all precast concrete. Strengths shall be determined by field cylinders cast and cured with the precast item they represent.

The Contractor shall stipulate his proposed cure procedure (i.e., steam, water, etc.), at the time the mix designs are submitted.

5. PLACING

Concrete placement for precast construction shall be as specified in SECTION "CONCRETE" except that internal vibration is not required for sections thinner than 7 inches if sufficient external vibration is used. Established mechanical placing equipment used to manufacture precast concrete under factory conditions shall be used. Additional finishing after consolidation of the concrete will not be necessary, unless irregularities or imperfections of the surface occur which require hand touchup with wood floats. The Contractor shall provide rounds on exposed corners and edges with an edging tool or by forming.

6. CURING AND PROTECTION

All concrete shall be cured and protected by an approved method or combination of methods as specified in SECTION "CONCRETE", or by steam curing. Steam curing, if used, must comply with the following requirements: Initial application of steam shall be started as soon as the concrete has attained its initial set. The steam shall be at 100 percnet relative humidity and shall not be applied directly to the concrete. Application shall be at such rate that the air temperature adjacent to the concrete and within the steam enclosure does not increase at a rate exceeding 40 degrees F per hour. A curing temperature of 110 to 140 degrees F shall then be maintained until the specified strength of concrete has been attained, after which the air temperature adjacent to the concrete and within the steam enclosure shall be decreased at a rate not exceeding 40 degrees F per hour until the temperature is within 20 degrees of the ambient air to which the concrete will be exposed. During the time of temperature drop or when drying shrinkage could occur, the concrete panel shall be kept free of restraint which could cause cracking.

7. FORMS

7.1 Materials

Forms shall be of wood, steel, or other approved material. The type, size, shape, quality, and strength of all materials of which the forms are made shall be subject to approval and the requirements specified in SECTION "CONCRETE".

7.2 Construction

Forms shall be true to line and grade, mortar, tight and sufficiently rigid to prevent objectionable deformation under load. The form surfaces shall be smooth, free from irregularities, dents, sags, or holes when used for permanently exposed faces. All form removals shall be accomplished in such a manner as to prevent injury to the concrete.

8. HANDLING

Points of support used in handling, transportation, storage, and erection of all precast members shall be as close as practical to the final points of load, support, and bearing. Care shall be taken during handling to prevent cracking and damage. Members damaged beyond safe usability during handling, storage, or erection shall be replaced by the Contractor at his expense. Lifting eyes and similar expedients for construction and handling may be used only if specifically approved on shop drawings. The Contractor shall be responsible for stress calculations and assuring that the use of such handling expedients does not damage the precast items. Occasional minor cracks and corner or edge spalls found in precast concrete after being set in place will be tolerated. However, consistently damaged precast concrete facing panels as determined by the Engineer shall be removed and replaced at the Contractor's expense.

9. QUALITY CONTROL

The Contractor shall establish and maintain quality control to assure compliance with contract requirements and shall maintain records of his quality control for all operations including but not limited to the following:

1) Inspection of materials as delivered to the jobsite for damage.

2) Storage and handling of materials.

3) All requirements for QUALITY CONTROL OF SECTION "CONCRETE".

SECTION __

ROLLER COMPACTED CONCRETE (RCC)

1. GENERAL

The work covered by this section consists of furnishing all plant, material and equipment, and performing all labor for the manufacturing, transporting, placing, compacting, and curing of roller compacted concrete (RCC). Roller-compacted concrete is a combination of crushed rock and/or natural sand, gravel, and/or soil having a controlled gradation to which cementing materials such as cement or cement and pozzolan is added. The materials are blended with water to damp consistency which can be hauled in dump type trucks or delivered with a conveyor, spread with earth moving equipment, and compacted with a vibratory roller.

This specification has been deliberately prepared to be general in nature and adaptable to adjustments that may become neccesary during construction.

2. APPLICABLE PUBLICATIONS

Except as otherwise allowed, specified, or supplemented by this specification section, roller compacted concrete

(RCC) is subject to the Standards and Publications listed in the Specification Section for "CONVENTIONAL CONCRETE". In addition, the following publications which do not form a part of this specification may be used for general background information.

"Roller-Compacted Concrete", ACI Committee 207 report, Journal of the American Concrete Institute, July - August 1980.

Schrader, E.K. "Roller-Compacted Concrete" The Military Engineer, September - October 1977. Also reprinted by the Portland Cement Association.

Chao, P.C. and Johnson, H.J., "Rollercrete Useage at Tarbela Dam", Concrete International, November 1979.

"Willow Creek Dam Concrete Report" U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington, Volumes 1 and 2, 1984 update.

Roller-Compacted Concrete, Symposium Volume of the American Society of Civil Engineers, May 1985.

3. COMPOSITION

3.1 General.

Roller-compacted concrete will be composed of portland cement, pozzolan (if required), aggregates, and water. Water shall meet the standard chemical requirements for ready mix concrete as established in ASTM C 94, except that water with a higher concentration of non-clayey, non-aggressive, solid particles such as silts will be allowed.

3.2 Mix Designs.

The roller-compacted concrete mix design proportions will be determined by the engineer. The mix design(s) will be based on laboratory tests of aggregate materials obtained from the project source, and on cementitious materials representative of those to be used in the project.

The general criteria for mix design(s) used in the dam will be (1) to provide adequate strength to meet structural design loads with normal or above normal factors of safety; (2) to minimize internal heat rise from hydration and the subsequently developed stress or crack potential; (3) to maximize stress relaxation through creep and elastic properties; and (4) to provide a constructable mix.

The anticipated RCC mix design(s) are approximated below based on experience at other projects and limited preliminary information on the expected aggregate source (weights are based on saturated surface dry aggregate). The actual mix design(s) will be determined from testing. It is the intent to utilize a single RCC mix throughout the dam. However, if this cannot practically and economically meet the design criteria, zoned areas of different mixes will be used as necessary between different elevations.

			(POUNDS PER CUBIC YARD)			
MIX	PRIMARY USE	AGGREGATE SIZE	CEMENT	POZZOLAN	WATER	AGGREGATE
1	All mass including the non-over flow sections	3 in.	120	0	150	3935
2	Areas requiring higher strength to meet design criteria or construction needs (if necessary)	3 in.	170	0	155	3875

Minor adjustments in exact mix proportions (such as the added moisture required to obtain optimum compaction during cool/damp weather as compared to warm/wet weather, and the exact ratios of aggregate proportions from different size groups to obtain the correct overall gradation) shall be the contractor's responsibility. Continual routine monitoring shall be used as the basis for adjustments. The cement content shall not be adjusted without written approval or direction from the engineer. Cement adjustments will only be allowed or directed after development of sufficient supporting test results indicating justification for the adjustment.

3.3 Samples for Mix Designs.

Prior to July 13, 1987 representative production samples of aggregates, cement, and pozzolan proposed for this project shall be delivered by the contractor to the laboratory. Samples of aggregates shall be taken under the supervision of a materials/concrete representative of the engineer. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by manufacturer's test reports indicating compliance with applicable specification requirements. All materials shall be identified with a tag. Minimum quantities of of materials required shall be as follows:

MATERIAL	QUANTITY
Each size group of RCC aggregate	30 ton
Cement (In barrels or sealed sacks)	1 ton
Pozzolan (In barrels or sealed sacks)	1 ton

4. CEMENTING MATERIALS

4.1 General

Portland cement (and pozzolan if needed) shall be the cementing material used in RCC. It shall be furnished in bulk to the jobsite. Cement shall conform to the requirements of ASTM C 150. If used, pozzolan shall be ASTM C 618, Class F or equivalent. Class C pozzolan may be used if the particular pozzolan proposed has no detrimental reactivity with the aggregates being used and if the 7-day heat of hydration for a blend of 65 percent cement plus 35 percent pozzolan by volume does not exceed the heat generated by the cement with no substitution. Natural pozzolan meeting the requirements of fly ash is also acceptable.

4.2 Acceptance Requirements and Tests.

The source or sources of cement and pozzolan shall consistently supply material with similar chemical and physical properties. The supplier shall routinely check the chemical and physical properties of the cementitious materials for conformance with the referenced standards. Materials not meeting the standard requirements shall not be forwarded to the project by the supplier. Copies of all test results representing material sent to the project shall be forwarded immediately to the project. Cement (and pozzolan, if used) may be subjected to check testing by the contractor or engineer from samples obtained at the mill, at transfer points, and at the project as necessary.

4.3 Transportation of Bulk Cement and Pozzolan.

When bulk cement is not unloaded from primary carriers directly into weathertight storage silos at the concrete plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in adequately designed weathertight trucks, conveyors, or other means which will completely and thoroughly protect the cement from exposure to moisture.

4.4 Temperature of Cement.

The temperature of cement when delivered to the jobsite shall not exceed 150 degrees F. The temperature of air (if that process is used) to transport cement into storage containers or silos shall not exceed 160 degrees F. The temperature of the air will be determined by measuring the temperature on the outside of the transport pipe with a surface thermometer.

4.5 Storage.

Immediately upon receipt at the concrete plant, cement and pozzolan shall be stored in a dry, weathertight and properly ventilated structure. All storage facilities shall be subject to approval and shall permit easy access for inspection and identification. Sufficient cement shall be in storage to complete at least 4 hours of placement at the typical production rate being experienced. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement which has been stored at the site for 60 days or more before using cement and pozzolan of lesser age.

4.6 Source.

The Contractor shall notify the engineer of the source or sources from which the cement and pozzolan (if used) will be obtained in advance of the time when production RCC placing with materials from those sources is expected to begin.

5. AGGREGATE

5.1 General.

Aggregate shall be produced from the designated sources and quarry areas. During daily production the material being used to produce aggregate shall consist of at least 50% quarried basalt or basalt from required excavation, and at least 30% natural gravel from the designated borrow area. The contractor may supplement these materials with borrow from approved commercial or site sources of sand, silts, or other blends. Unless otherwise specifically stated, the gradation limits given below and the percentages referred to apply to the total aggregate weight used in a unit volume of RCC, including all size groups. They do not apply to the weight of aggregate in any one size group. The resulting allowable range of material passing or retained on any sieve size is broader than would typically be required for a conventional concrete aggregate.

5.2 Production Schedule.

Not more than 10% of the aggregate shall be produced before September 28, 1987, and at least 90% shall be manufactured and stockpiled prior to April 11, 1988. All RCC aggregate shall be produced before April 25, 1988. Payment will be made for stockpiled aggregate.

5.3 Gradations and Stockpiles

The Contractor shall stockpile aggregates in two size groups. A separate stockpile for blend sand or silt will not be required but may be used.

Group I - 100% passing the 4 inch sieve and at least 97 percent retained on the 3/4 inch sieve.

Group II - 98 percent passing the 1 inch sieve.

The Contractor's aggregate production and stockpiles shall be such that when (by weight) the Group I and Group II material (plus any other size group or blend material developed by the Contractor) is combined, the resulting gradation will be within the tabulated limits.

In general, it is expected that approximately 45 percent of the total aggregate production will be Group I, and 55 percent will be Group II. The Contractor shall be responsible to provide all necessary extra aggregates to allow for overbuild, stockpile bases, and materials used for his convenience. In order to insure reasonable consistency within each stockpile, samples for the combined gradation test will be obtained from various parts of the stockpiles.

The gradation band has been widened to the maximum extent possible. Any gradation within the band and having the same basic graphed shape as indicated by the graphed gradation band will be acceptable. However, the gradation will not be allowed to go from near the maximum allowed amount passing one sieve to near the minimum amount allowed on the subsequent sieve, or vice versa.

U.S. STANDARD SIEVE	PERCENT FINER BY WEIGHT
4 inch	100
3 inch	98-100
2 inch	85-95
1-1/2 inch	74-89
1 inch	62-76
3/4 inch	55-68
3/8 inch	41-54
4	32-45
8	25-37
16	19-30
30	14-24
50	10-19
100	6-14
200	4-10

The maximum permissible amount passing the No. 200 sieve shall be determined by the following table which is dependent upon the plasticity of all of the fines (washed sample) passing the No. 40 or No. 50 sieve. Experience has shown that results are similar for either sieve. The size used can be based on convenience of testing at the discretion of the engineer.

LIQUID LIMIT	PLASTIC INDEX	MAX % PASSING NO. 200
0-25	0-5	10.0
0-25	5-10	9.0
0-25	10-15	4.0
0-25	15-20	3.0
0-25	20-25	1.5
25-35	0-5	9.0
25-35	5-10	8.0
25-35	10-15	6.5
25-35	15-20	5.0
25-35	20-25	1.5
35-45	0-5	8.5
35-45	5-10	5.5
35-45	10-15	4.0
35-45	15-20	2.0
35-45	20-25	1.5
45-55	0-5	5.5
45-55	5-10	5.0
45-55	10-15	3.5
45-55	15-20	3.0
45-55	20-25	1.5

The plasticity index will not be allowed to exceed 25 and the liquid limit will not be allowed to exceed 55 as determined on all materials passing the No. 40 or No. 50 sieve from washed aggregate. Routine daily testing of "non suspect" material may be done by dry sieving. At least once per week during aggregate production, (and for all "suspect material") the washed gradation shall be determined.

5.4 Particle Shape.

The amount of flat and elongated particles as determined by CRD C 119 shall not exceed 40 percent on any individual sieve size nor a weighted average of 30 percent total for all the sieve sizes in the total gradation. These amounts are increased from values typically used for conventional concrete, but have been found to be acceptable limits for roller compacted concrete.

5.5 Washing.

Aggregates used in other RCC projects have been produced from natural deposits and also from a combination of silty overburden with shot rock excavated from quarry areas. Washing of the aggregates at most jobs was not necessary, and in fact was found to be not desirable. It is expected that a properly designed production plant for processing aggregates will not require washing. However, some moisture spray may be necessary for dust control on conveyor belts.

5.6 Storage.

Aggregates shall be stored in stockpiles at the designated storage areas near the dam. Separators such as timbers or boards shall be used between adjacent stockpiles (if separate stockpiles are used) to prevent contamination and intermixing between the stockpiles. The Contractor shall be responsible to provide a system which reliably and consistently stockpiles the aggregates and later allows withdrawal of the aggregates from the stockpiles without contamination or segregation. The system shall also provide for intermixing or blending of aggregates delivered to and withdrawn from any individual stockpile. Segregated and/or contaminated aggregates that are not representative of the stockpiles and which do not result in the specified combined gradation will not be allowed in production of RCC. The Contractor's aggregate handling system may utilize conveyors, reclaim tunnels, face loading by front end loaders, or other acceptable methods.

5.7 Plant Layout.

The Contractor shall submit a layout and schematic drawing with a narrative description of his planned aggregate production, locations and sizes of stockpiles, transportation methods, and storage procedures to the engineer for review.
Anticipated peak production capacity, normal operational rates, and storage area volumes shall be indicated.

6.1 General.

The Contractor shall select the type of concrete "plant" to be used and shall determine its layout. The "plant" includes all necessary mixers, volumetric or weigh method controls, storage bins, feed systems, and discharge mechanisms. Prior to the start of production RCC placement the Contractor shall submit to the engineer for information a layout and schematic drawing of the concrete plant together with a narrative description giving its anticipated peak capacity and normal production rate. The submittal shall also include a narrative description and a layout of the anticipated methods of handling aggregates. The anticipated equipment for mixing, transporting, and placing RCC shall also be included in the submittal. The Contractor shall have the concrete plant on site, in-place, and in operating condition at least 14 days prior to the start of production RCC mixing and placing. The plant may be the conventional mass concrete batch type, a continuous mix rotating tilted drum, or a twin shaft paddle type continuous mix "pug mill." The plant shall be capable of routinely and consistently producing well mixed large aggregate and relatively dry RCC of the type to be used on the project. The mix plant or an equivalent shall have demonstrated satisfactory performance with similar mixes prior to being used in producing RCC at the project. Until the placement is completed to Elevation 6065, the plant shall have a minimum combined peak capacity sustainable for at least 1 hour of at least 735 tons or approximately 350 cubic yards (compacted) per hour using the designated jobiste mix design and aggregate proportions or ratios. For concrete placed above elevation 6065, the plant capacity may be reduced to 400 tons per hour. If two mix designs are used in construction of the project, the plant shall be capable of simultaneously delivering two different mix designs from separate mixers or of automatically (or semi-automatically) switching from one mix design to another in the same mixer.

6.2 Batch Type Plant.

6.2.1 Bins and Silos. Separate bins or compartments shall be provided for each size group of aggregate. Separate silos shall be provided for bulk portland cement and for pozzolan (if used). The silos and compartments shall be of ample size and so constructed that the various materials will be maintained separated under all working conditions. All compartments containing cement (and pozzolan) shall be separated from each other by a free draining air space. The aggregate bins shall have steep side slopes, large gate openings, and be capable of handling the aggregate in a damp condition without choking.

6.2.2 Weigh Batchers. Aggregate shall be weighed in separate weigh batchers with individual scales.

Bulk cement (and pozzolan) shall each be weighed on a separate scale in a separate weigh batcher. Water may be measured by weight or by volume. If measured by weight, it shall not be weighed cumulatively with another ingredient. The weigh batchers shall be arranged so as to permit the convenient addition or removal of material.

6.2.3 Water Batcher. A suitable water measuring device shall be provided which will be capable of measuring the mixing water within the specified requirements for each batch. The mechanism for delivering water to the mixers shall be free from leakage. The filling and discharge valves for the water batcher shall be interlocked so that the discharge valve cannot be opened before the filling valve is used, a suitable strainer shall be provided ahead of the metering device.

6.2.4 Gob Hopper. If necessary to control segregation and assure effective utilization of the mixer, a gob hopper or holding device of at least twice the volume of the largest hauling vehicle shall be provided for RCC temporarily accumulated after mixing and while waiting to be loaded into a hauling vehicle for transport.

6.2.5 Moisture Control. The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched if necessary.

6.2.6 Scales. Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment shall have an accuracy within 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made prior to the start up of RCC placing and at least monthly thereafter. Each weighing unit shall include a visible springless dial which shall indicate the scale load at all stages of the weighing operation or shall include a beam scale with a beam balance indicator which will show the scale in balance at zero load and at any beam setting. The indicator shall have an over and under travel equal to at least

5 percent of the capacity of the beam. The weighing equipment shall be arranged so that the plant operator can conveniently observe all dials and indicators.

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6.2.7 Batching Operation and Accuracy. The measuring operation of each material shall start when actuated by one or more starting mechanisms and stop automatically when the designated weight or volume of each material has been reached. They shall be interlocked in such a manner that the discharge device cannot be actuated until the indicated quantity of each material is within the applicable tolerance. These control requirements can be satisfied by a semi-automatic batching system as defined in the Concrete Plant Manufacturers Bureau (CPBM) "Concrete Plant Standards", with interlocks as described above or by an "automatic batching system" as defined in the "Concrete Plant Standards". The plant shall be arranged so as to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy on any individual batch and shall be within 1% accuracy of the average of any 100 consequentive batches of the same mix design.

MATERIAL	PERCENT
Pozzolan (if used)	Plus-or-minus 3%
Cement	Plus-or-minus 3%
Water	Plus-or-minus 4%
All Aggregate	Plus-or-minus 4%

6.2.8 Mixers for Batch Type Plants. Stationary batch type mixers shall be the tilting horizontal-shaft or vertical-shaft type capable of routinely and consistently mixing the coarse RCC mix without excessive maintenance. The mixers shall not be charged in excess of 95 percent of the capacity recommended by the manufacturer for conventional concrete. Mixers shall be capable of combining the materials into a uniform mixture without spillage and of discharging this mixture without segregation. Mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer or approved for RCC. If no uniformity test data are available, the initial mixing time for each batch after all materials are in the mixer shall be 1 minute for mixers having a capacity of 3-cubic yards or less. For mixers of larger capacities, the minimum mixing time shall be increased by 20 seconds for each additional cubic yard or fraction thereof of concrete mixed. These mixing periods are predicated on proper control of the speed or rotation of the mixer drum or blades, and on proper introduction of the materials into the mixer. The mixing time shall be increased when such increase is necessary to secure the required uniformity and consistency of the concrete, or when the average variability index of three series of test samples of concrete is less than any of the following uniformity requirements when tested in accordance with the test procedure described in the Appendix to this Section. The mixing time may be reduced when tests indicate that the concrete still meets all the following uniformity requirements:

TEST	VARIABILITY INDEX, MIN
Water content of full mix, % of weight	75
Coarse aggregate content of concrete (Plus No. 4),% by weight	80
Unit weight of air-free mortar, lb/cy	85
Cement content of full mix, % by weight	70

When the Contractor proposes to reduce the mixing time, a set(three) of uniformity tests shall be made at the reduced mixing time to determine whether the reduced mixing time will produce RCC which meets the requirement of these specifications. Each time a decrease or increase in mix time is indicated by test results, the mix time for the following day will be changed by 10 seconds and another series of tests will be run. This process may be repeated until the minimum mix time that still provides acceptable material is established. Mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades shall be replaced when worn down more than 20 percent of their depth. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired. Suitable facilities shall be provided for obtaining representative samples of concrete for uniformity tests. All necessary platforms, tools, and equipment for obtaining samples shall be furnished by the Contractor.

NOTES:

(1) The variability index will be based on result of samples taken from the placement after spreading and immediately before compaction. This will include the beneficial or detrimental effect of additional handling and remixing from hauling, transferring and spreading.

(2) Charging procedures of the mixer can have a significant effect on the mixer performance, and shall be considered part of the mixer proficiency test.

(3) The RCC mix in loose form contains no paste slurry, but does have considerable "bulking". Mixers

may not be able to be loaded to their full rated capacity without spilling or poor mixer performance. Establishing the maximum acceptable batch size will be part of the mixer proficiency test purpose.

6.2.9 Sampling Facilities. Suitable facilities and labor shall be provided for obtaining representative samples of materials as they enter the mixer, are discharged from gob hoppers, and from the placement area after spreading but before compaction. All necessary tools, platforms, and equipment for obtaining samples shall be furnished. Approximately 400 pounds of material will be required for each sample.

6.3 Continuous Mix Plant

6.3.1 General. Continuous mix plants shall be capable of producing concrete of the same quality and uniformity as would be produced in a conventional batch type plant.

6.3.2 Bins and Silos. Separate feed bins or compartments shall be provided for each size group of aggregate. Separate silos shall be provided for bulk portland cement and pozzolan (if used). The silos and compartments shall be of ample size and so constructed that the various materials will be maintained separate under all working conditions. All compartments containing cement (and pozzolan) shall be separated from each other by a free draining air space. The aggregate bins shall have steep side slopes, large gate openings, and be capable of handling the aggregate in a damp condition without choking.

6.3.3 Cement and Aggregate Feed. Cement and aggregates shall be uniformly, continously, and simulaneously fed at the appropriate ratios for the mix design desired into the mixer by belt or other acceptable method. Aggregate feed may be accomplished onto a single belt from feed bins for the various size groups through openings at the bottom of the bins.

Each opening shall be provided with a gate that can be locked at the necessary opening size to provide the correct feed rate. The bins shall be kept sufficiently full and shall be of sufficient size to insure a uniform flow of aggregate at an essentially constant rate. It is expected that particular attention may be needed to insure a continuous flow of the Group II aggregate (and blend sand if used) if it is very damp and contains a high content of fines. Cement (and pozzolan) shall be fed continuously in a positive manner which can be controlled by adjusting the belt speed or feed rate. Special attention shall be given to the cement (and pozzolan) feed equipment so that it consistently and uniformly delivers materials even at very low (90 lb/cy) dosage rates. The feed shall be capable of gradual adjustment while in operation. Continuously correcting automated gate openings and/or belt-feed rates by electronic feedback of weight sensor units on the belts shall be used if operation without them is not capable of providing the accuracy, consistency, and quality required by these specifications.

6.3.4 Water Dispenser. A suitable water dispenser shall be provided which is capable of dispensing the mix water within the specified requirements. The mechanism for delivering water to the mixer(s) shall be free from leakage. The meter may be an in-line volumetrically activated flow meter, but it shall be adapted to read or convert the weight of water being added in pounds per minute to pounds per cubic yard of concrete. The valve shall be capable of gradual adjustment during the mixing process to compensate for varying moisture contents in the aggregates. The valve shall be automatically controlled so that it will close if cement and/or aggregate stops entering the mixer at the required rate. This control may be bypassed for cleaning operations.

6.3.5 Gob Hopper. If necessary to control segregation and assure effective utilization of the mixer, a gob hopper or holding device of at least twice the volume of the largest hauling vehicle shall be provided for RCC temporarily accumulated after mixing and while waiting to be loaded into a hauling vehicle for transport.

6.3.6 Operation and Accuracy. The intent of operation for continuous mix plants is that they be operated as much as possible in a continuous manner at one set of feed rates. Shut downs and startups during RCC production placing shall be kept to an absolute minimum. The plant equipment shall be designed, calibrated, and operated so that all materials simultaneously begin feeding into the mixer at the correct rates when the mixer is started, and all materials simultaneously stop feeding into the mixer when it is stopped. No lag or lead time between materials will be allowed at the point where they enter the mixer. After material feeds are shut down, all remaining active material in the mixer shall be discharged. At the first startup after each daily or major shutdown (more than 30 minutes) the first cubic yard of RCC produced by the mixer shall be wasted. If a uniform mix of the required proportions is not being discharged from the mixer at that time, the material shall continue to be wasted until consistent material of the specified proportions is discharged.

Delivery of materials as they are discharged from the mixer and from any gob hoppers shall be within the following limits of accuracy:

MATERIAL	PERCENT
Pozzolan (if used)	Plus-or-minus 3%
Cement	Plus-or-minus 3%
Water	Plus-or-minus 4%
All Aggregate	Plus-or-minus 4%

6.3.7 Mixers for Continuous Type Mix Plants.

Continuous mix plants shall be a rotating tilted drum or twin shaft paddle type pug mill capable of routinely and consistently producing well mixed large aggregate and dry RCC of the type to be used on the project. The mixer (or equivalent) shall have demonstrated satisfactory performance with similar RCC mixes prior to being used in production RCC at the project, or will require a conditional approval by the engineer for the start of production. Mixers shall not be charged in excess of the capacity recommended by the manufacturer for RCC. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The minimum mix retention time in any continuous mix plant shall be 45 seconds unless mixer tests show that a suitable product can be achieved at lower retention times. Higher mix times will be required if needed to provide adequate mixing. Uniformity tests will be based on results of three random test samples from the placement during the same shift. A method of adjusting the mix time such as by adjusting the angle of tilt of a continuous mix drum shall be provided. The mixing periods are predicated on proper control of the speed of rotation of the mixer drum or paddles, and on proper introduction of the materials into the mixer. The mixing time will be increased when such increase is necessary to secure the required uniformity and consistency of the concrete, or when the average variability index of a set (three) of test samples of concrete is less than any of the following uniformity requirements when tested in accordance with the test procedure described in the Appendix to this Section. The mixing time may be reduced when tests indicate that the concrete still meets all the following uniformity requirements:

TEST	VARIABILITY INDEX, MIN.
Water content of full mix, % of weight	75
Coarse aggregate content of concrete (Plus No. 4), % by weight	80
Unit weight of air-free mortar, (lb/cy)	85
Cement content of full mix, % by weight	70

When the Contractor proposes to reduce the mixing time, a set (three) of uniformity tests shall be made at the reduce mixing time to determine whether the reduced mixing time will produce RCC which meets the requirements of these specifications. The mixers shall be maintained satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades and pugmill paddles shall be replaced when worn down more than 25 percent of their depth. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired. Each time a decrease or increase in mix time is indicated by test results, the mix time for the following day will be increased or decreased by 5 seconds and another series of tests shall be run. This process can be repeated until the minimum mix time that still provides acceptable material is established.

Notes:

a. The variability index will be based on results of samples taken from the placement after spreading and immediately before compaction. This will include the beneficial or detrimental effect of additional handling and remixing from hauling, transferring and spreading.

b. Charging procedures into the mixer can have a significant effect on the mixer performance and shall be considered part of the mixer proficiency test.

c. The RCC mixing loose form contains no paste slurry, but does have considerable "bulking". Mixers may not be able to be loaded to their full rated capacity without spilling or poor mixer performance. This will be part of the mixer proficiency test.

6.3.8 Sampling Facilities. Suitable facilities and labor shall be provided for obtaining representative samples of materials as they enter the mixer, are discharged from the mixer, are discharged from gob hoppers, and from the placement after spreading but before compacting. All necesssary platforms, tools, and equipment for obtaining samples shall be furnished. Approximately 400 pounds of material will be required for each sample.

CONVEYING/TRANSPORTING

7.1 General. Concrete shall be conveyed from mixer to placement as rapidly as practicable, by methods which control segregation, contamination, and drying. Methods and equipment for handling, hauling, and depositing the mix shall be submitted the Engineer at least three weeks prior to production opperations If necessary the Contractor shall provide baffles at the end of conveyors and within hoppers to limit free falls, and at other locations that otherwise cause excessive segregation. In general, equipment will NOT be allowed to track mud or other contamination onto previously placed RCC. This may require using clean crushed rock on haul roads, washing tires of vehicles prior to driving onto the RCC, and other special measures. Unavoidable localized contamination such as at the entrance of access or haul roads onto the RCC may occur but must be cleaned from the RCC prior to placing the next lift. The total length of time from the start of mixing until completion of compaction shall not exceed 40 minutes under any circumstances.

7.2 Temporary Storage Containers. Interim storage at gob hoppers (such as at a central dispatch point on the dam) shall be provided when vehicles are used for hauling, and when direct conveyor systems do not otherwise provide continuous unsegrated delivery to the final placement location. The gob hoppers shall be constructed with adequate capacity (at least twice the largest hauling vehicle load) so that the mixing sequence normally is not stopped or slowed during production if the hauling vehicles are delayed. Gob hoppers shall be constructed with side slopes and gates that allow for the free flow of RCC without segregation or choking. Telephone or radio communication shall be provided between gob hoppers, the batch plant, and the placement site. If more than one RCC mix is used, gob hoppers shall be emptied of all of one mix before being filled with a mix of a different design.

7.3 Belts. Conveyor belts shall be operated at high speeds which meet production requirements and do not segregate materials. All belts shall be continuously protected to prevent drying by the wind and sun, and overwetting from rain. The equipment shall be designed for low maintenance continuous operation with clean return belt surfaces using no slump low cement factor large aggregate mass concrete, RCC, and structural concrete. Vertical lifts of the RCC mix may be accomplished with bucketed conveyors. Conveyor belt systems shall be designed by personnel fully experienced with belt delivery of mass concrete and familiar with material similar to large aggregate low cement factor RCC. The anticipated system shall be submitted for prior to the start of RCC production operation.

7.4 Chutes. Unless specifically authorized in writing, chutes will not be permitted. The contractor may propose a chute or "controlled drop" system which may be given conditional initial approval by the engineer, and which will be given conditional approval only after satisfactory field demonstration under sustained production conditions.

7.5 Hauling Vehicles. RCC may be hauled using trucks, large front end loaders, or scrapers.Trucks should be the bottom-dump type, except that end-dump trucks may be used to deposit RCC in confined areas, and trucks with special tailgates or drop control methods which demonstrate an ability to handle dumping without excessive segregation may be used. Experience has shown that conventional end dumps have a tendency to cause segregation at the edge of the deposited material. Any segregation that results from the vertical drop when the truck bed is tipped shall be removed by hand and/or effective reworking during spreading. Hauling vehicles shall be maintained in good operating condition and will not be allowed to spill or drip oil, grease, or other visible and obvious contamination onto the RCC. All hauling vehicles shall be operated in a manner which precludes tight turns, sudden stops, or other procedures that damages previously compacted RCC. If a surface is damaged by vehicle operation (tight turns, driving over a wet area that pumps, etc.) the damaged surface whall be cleaned or the damaged material shall be removed.

8. PLACING AND SPREADING

8.1 General. It is the intent of this specification to construct the RCC mass in as nearly a continuous operation as is practical. Above elevation 5900, the rate of rise shall be at least 2 ft per day, but not over 6 ft per day. The Contractor shall work at least 7 days per week, two shifts per day during placement of RCC. Placement of RCC shall begin by April 11, 1988, and all RCC in the dam structure shall be completely placed to elevation 6063 before June 6, 1988. All RCC shall be completed by June 17, 1988.

NOTE: Meeting these dates and production rates (including the aggregate production requirements of subparagraph: "Production Schedule" of paragraph "Aggregate" is necessary to obtain the desired in-place material properties and to minimize cracking potential from internally developed thermal stresses. If the contractor fails to meet these requirements, an engineering analysis will be made showing what if any, additional restrictions and requirements must be enforced in order to produce a similar quality final in-place material. The Contractor shall comply with these restrictions and requirements and shall be responsible for all related costs. The special restrictions and requirements will depend on a variety of conditions and technical factors that exist at that time. This includes Contractor's actual start date for RCC placement and his RCC production rate, the time of the year and weather conditions, the ambient and mix temperatures, the stockpiled temperature of the aggregate, and the location within the dam that is effected. The additional restrictions and requirements may include but are not necessarily limited to reduced or accelerated placement rates, use of surface insulation, use of chilled mix water, and placing only during specified hours of the day.

8.2 Weather. Roller compacted concrete shall not be placed when ambient temperatures drop to below 32 degrees F, except that if the surface of the compacted RCC and the temperature of the mix itself stays above 35 degree F, the engineer will permit placing of RCC during temporary periods if the ambient temperature remains above 25 degrees F. If the ambient temperature drops to below 30 degrees F and the surface of any RCC less than seven days old drops to below 35 degrees F, the surface shall be covered with heavy tarps, blankets, straw or other acceptable temporary protection until after the ambient temperature raises to above 32 degrees F. RCC shall not be placed during heavy rains (more than 0.2 inch per hour or 0.03 inch in six minutes as defined by the U.S. Weather Bureau Glossary of Meteorology). Depending on the

Contractor's equipment and placing method, placing may have to be suspended during light rains. Experience has shown that placing RCC during a temporary light mist can usually be accomplished with care, but that if hauling vehicles rather than conveyors are used for delivery; it is relatively easy to damage the surface and subsequently have to clean it. Production shall stop when free surface water begins to accumulate on the compacted RCC or when pumping, tracking or other unacceptable damage begins to develop. If unusual adverse weather such as heavy rain is forecast to occur during placment, an interruption in placing operations for that time period shall be planned.

8.3 Layout of the Placement Area.

It is the intent of this contract to raise the dam at essentially the same level across its entire area, except for the slight upward incline in the downstream direction as indicated on the drawings. After all RCC has been placed to the spillway crest level, RCC may be placed on either side of the spillway training walls independently. As nearly as is practical the Contractors shall expose at one time the surfaces of only one layer, the preceding layer, and the succeeding layer. One additional layer may be exposed under special circumstances such as crossing the gallery and conduit areas. As placement of a lift progresses the exposed edges shall be kept "live" by progressively placing out from them. Whenever a cold joint at any edge of any lift does occur, it shall be located at least 10 feet from the location of other cold joints that may have previously occurred in the same direction. The joint shall be prepared as required by contract for "cold joints" prior to resumption of RCC placement. No cold joint shall be allowed along the edge of a lift in the upstream-downstream direction for more than one-third of the upstream/downstream dimension of the dam at that elevation.

8.4 Depositing.

Roller-compacted concrete shall be deposited at the location at which it is to be spread. For truck and scraper delivery, depositing will generally be accomplished with a dump-spread action while the vehicle is moving. When it is necessary to dump RCC in a pile from rear end dumps, the pile shall be deposited on top of the fresh RCC layer being advanced, not on the old layer being covered. If belt delivery is used, the belt shall discharge in a manner that does not cause unacceptable segregation.

8.5 Spreading.

Within 10 minutes of deposition, the mix shall be spread into an even layer that will, after compaction, be a nominal 18 inches thick. However, a thicker layer up to 24 inches can be used if the Contractor demonstrates that it can be spread and compacted without segregation and with a consistent average density similar to that achieved for the 18 inch thickness. Where RCC is spread onto or into bedding mix, the RCC mix shall be spread and compacted within three hours of the time the bedding mix was batched, prior to the time that it begins to set or dry from exposure, and within 40 minutes of when the bedding mix was first deposited. Spreading shall be accomplished with tracked equipment supplemented if desired by a grader. Tracked equipment for spreading shall be limited to a maximum D-7 Caterpillar or equivalent size. Dozers shall have hydraulic tilt and/or angle capability of the blade. In general tracked spreading equipment shall operate only on uncompacted material and will not be allowed to crab or turn on compacted RCC. A front end loader with operator shall be available to assist with deposition and spreading of materials as needed in confined areas, at irregular foundation conditions, and at other locations as needed. Spreading shall be accomplished in a manner that does not cause segregation. It is expected that this will necessitate spreading two successive layers approximately 9 inches deep before compacting the material as one lift 18 inches deep. If large aggregate revels, rolls or segregates to the outside edge of a spread layer of RCC, it shall be reblended into the RCC or removed. Experience has shown that this may occur when the mix becomes drier than desired and/or when care is not used during dumping and spreading. Large aggregate that rolls to the outside edge of a spread layer can be picked up by laborers with flat shovels and be broadcast over the uncompacted surface so that it is compacted into it without segregation by the roller. All equipment shall be maintained in good operating conditions which does not leak or drip oil, grease, or other obvious visible contamination onto the fill. No concrete shall be placed on a previous layer which is suspect and is being considered for testing or rejection.

9. COMPACTION

9.1 General.

Within 10 minutes of spreading, each layer of RCC shall be compacted with a minimum of four passes of a self-propelled double drum or eight passes of a self propelled single drum vibratory compactor. (A round trip is two passes). A minimum average wet density per lift of 153 pounds per cubic foot shall be achieved. This is the density used in the dam stability analysis. It also is approximately 98% of the practical achievable density using good practice and equipment, and it is approximately 95% of the theoretical air free density. No individual reading of less than 150 pounds per cubic foot will be allowed. This is approximately 93% of the theoretical air free density. The largest size equipment specified below and capable of physical and practical operation in the area to be compacted shall be used. Large width self-propelled vibratory rollers shall be used in open areas. Small walk behind vibratory rollers and/or hand-guided power tampers shall be used for compaction at the abutments and in any areas that cannot be reached with the drum of a large vibratory roller. Rollers shall not be operated in the vibratory mode until they are moving. All compacting equipment shall be kept in good operating condition at all times and will not be allowed to drip or spill oil or other obvious visible contamination onto the RCC. The edge of all compacted layers against which adjacent RCC is not placed within 25 minutes shall be broken down or trimmed, and rolled so that the edge is thoroughly compacted and does not contain loose segregated aggregate.

9.2 Large Self Propelled Rollers. Self-propelled vibratory rollers shall be of the single or double drum type. They shall transmit a dynamic impact to the surface through a smooth steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. The compactor shall have a gross weight of not less than 20,000 lbs and shall produce a minimum dynamic force of at least 475 lbs per inch of drum width at the operating frequency which is used during construction. The roller shall have a vibrating frequency of at least 1500 cpm (cycles per minute). The roller drum shall be between 4 and 5-1/2 feet in diameter and 5-1/2 to 8 feet in width. The roller shall be operated at speeds not exceeding 1-1/2 miles per hour. The engine driving the eccentric mass shall have a rating of not less than 125 horsepower. Within the range of operational capability of the equipment, variations to the frequency and speed of operation which result in maximum density at the fastest production rate will be allowed. At least one self-propelled vibratory roller in good operating condition and meeting these requirements shall be maintained full time (with operator) on the placement area at all times during production placement. Standby replacement equipment shall be available for functional operation on the placement within 30 minutes time.

9.3 Power Tampers and Small Rollers.

Power tampers and small vibratory rollers similar to the Dynapac CM20, Dynapac LC70, and Case Model W100, which can operate within a few inches of a veritcal face shall be used to compact the RCC adjacent to form work, near the abutment face, up to the downstream face, and at other areas where the large vibratory rollers specified above cannot manuever. The dynamic force produced by small rollers shall be at least 250 lbs/in of drum width for each drum of a doubledrum unit and at least 350 lbs/in of drum width for a single-drum unit. Rammers shall be similar to the Dynapac LC70 and shall develop a force per blow of at least 3500 pounds per square foot. At least one small roller, one rammer, and one plate tamper in good condition shall be on the dam. The amount of rolling and tamping required shall be whatever is necessary for the particular equipment to provide an average density of at least 97 percent of the average density that is attained with the large self-propelled vibratory roller. It is expected that this normally will not require more than six passes of any combination of small vibratory roller and compactor. It is also expected that some very localized and acceptable void space between large aggregate particles may occur immediately adjacent to the upstream face precast panels. This would only be apparent if the panels are removed. At least one small roller and three tampers in good operating condition shal be maintained on the placement area during all production operations. Standby replacement equipment shall be available for functional operation on the placement within 30 minutes time. Not more than six passes of any combination of vibratory roller or compactor should be required.

9.4 Compaction at Interface with Conventional Concrete Facing.

Contractor shall be responsible for achieving an intimate contact between the conventional concrete facing mix and the RCC with no discernable joint line by whatever method is most suitable and economical to the Contractor. Acceptability will be determined by horizontally drilled cores. Cores shall be drilled from the formed face of the facing mix and at least 12 inches into the RCC. The total depth of core hole shall be 3 ft. If the Contractor can demonstrate by a test section (including cores) that he can achieve consolidation of the face concrete with a flowable mix by using a high range water reducing admixtrue and the vibration of the rollers, then internal consolidation of the conventional concrete facing mix will not be necessary. Otherwise consolidation shall be achieved by the vibratory rollers supplemented with internal vibration.

10. JOINTS

10.1 General.

It is the intent of this contract to place the entire roller-compacted concrete mass with sufficient continuity so that it hardens and acts as one monolithic block without discontinuous joints or potential planes of separation. The length of time between placement of successive layers of RCC which can be tolerated is dependent upon temperature. Joint quality is also dependent upon cleanliness and surface moisture. When the time limits between successive placements of RCC layers exceeds those described below, a cold joint will be considered to have occurred, and the procedures described below for cold joints shall be followed. Joint surfaces shall be kept in a clean, uncontaminated, and continuously moist condition until placement of the succeeding concrete. Compacted RCC surfaces to receive bedding mix at the upstream face shall be especially clean. RCC surfaces at the upstream half of the dam shall be essentially uncontaminated where the RCC is placed on them. The downstream half of each layer shall also be kept clean and damp, but occasional isolated rocky or small (one square foot) contaminated areas will not be reason to stop placing. An adequate number of operable nozzles from water trucks or a water distribution line which provide overlapping water mists shall be maintained at the placement area at all times. They shall be used as necessary to prevent joint surfaces from drying and shall be supplemented as necessary by mists from hand-held hoses to reach inaccessible areas. The mist or spray shall not be applied in a channeled or pressurized manner that erodes the fresh RCC surface. It also shall not be applied at a rate which causes ponding at the surface. Trucks shall not be allowed to drip obviously visible oil or other contaminant on the RCC surface. At least one person 24 hours per day, seven days per week shall be on duty on the placement with the sole responsibility of operating the water system to maintain the entire surface moist but not overwatered. He may be allowed to perform routine maintenance of nozzles and move hoses only if these activities do not prevent him from fully accomplishing his responsibility of keeping the entire exposed surface in a continuously damp condition.

10.2 Cold Joint Classification.

Cold joints will be classified as needing a Type I or Type II treatment based on the following criteria. If a joint does not fall into the category of Type I or II, it shall not be considered as a cold joint and no special treatment is required unless the Contractor fails to meet other requirements of this specification such as keeping the joint, and preventing damage to the surface by equipment operations.

Type I: More than 2000 degree hours have passed before placement of the successive layer of RCC, but not more than 54 hours have elapsed. Degree hours shall be determined by accumulating the average temperature in degrees Fahrenheit at the lift surface during each one-hour increment after the surface has been compacted. A continuous clock-type temperature recording device as commonly used in precast concrete construction or other suitable method shall be used for determining and recording the time and temperatures. At least two clocks shall be running and recording at all times during the period that joints have not yet reached the 2000 degree hour or 54-hour cutoff point.

Type II: More than 54 hours have passed before placement of the successive layer.

10.3 Type I Cold Joint Treatment

Cold joints that fall into the category of Type I shall be clean at the time of placement of subsequent concrete on them. No dry areas or ponded water will be allowed. A nominal 1 inch thickness of conventional concrete bedding mix shall be spread over the upstream third of the lift joint surface before placement of the next RCC layer. No additional payment shall be made for any bedding mix or its constituents unless the cold joint was directed by the Engineer for his convenience. The bedding mix shall be spread so that the entire surface area requiring the bedding mix is covered with some of the mix, the maximum thickness determined by dividing the volume used by the area covered is between 3/4 and 1-3/4 inch.

10.4 Type II Cold Joint Treatment:

Cold joints that fall into the category of Type II shall be prepared for the subsequent lift by removing all laitance, loose debris, and contaminants. The cleaning procedure shall expose but not undercut the aggregate. At this stage of maturity, water jetting will be used if air alone does not satisfactorily prepare the surface. After preparation the surface shall be left in a damp condition and treated as a Type I joint, except that the bedding mix shall be spread over the upstream 35% of the joint surface. No additional payment shall be made for any joint preparation, cleaning, or placement of any bedding mix or its constituents unless the cold joint was directed by the engineer.

10.5 Upstream Joint Treatment.

All horizontal joints shall receive bedding mix near the upstream face as indicated on the drawings. The surface to receive this bedding shall be cleared by air blowing prior to placing the bedding mix.

10.6 Horizontal Joints Between Facing Mix Layers.

The top surface of each layer (lift) of conventional concrete facing mix (spillway, training walls, etc.) shall be kept continuously moist until placement of the next layer. The surface shall be cleaned by air blowing prior to placing the next lift, supplemented as necessary by hand picking or shovel scraping to remove loose and/or segregated material along the interface of the RCC and conventional concrete at the top surface. If the conventional mix has set for more than 24 hours and developed extensive hard laitance that is not removed by air blowing, water jetting shall be used in combination with air to clean the surface.

11. REINFORCING STEEL BARS INCLUDING ANCHOR BARS

11.1 General.

Reinforcing steel and anchor bars if used in the RCC shall conform to the requirements of Section "Conventional Concrete," except that placement shall be as modified herein.

11.2 Anchor Bars.

Holes for anchors may be drilled by diamond-core or rotary-percussion equipment. Anchors shall be grouted in place by filling the hole with grout, forcing the anchor bar into the hole, vibrating the bar by holding a concrete vibrator against it until no further settlement of the grout occurs, and protecting the bar from further movement or disturbance for a least the next 6 hours. The bar shall be inserted into the grout and vibrated within 35 minutes after initial mixing of the grout. Prior to grouting, each hole shall be washed until return water from a line running to the bottom of the hole is clean, followed by blowing with the air until the water is expelled from the hole. Cleaned holes shall be plugged to prevent contamination before grouting.

11.3 Placing RCC at Steel Bars.

Reinforcing steel, including the bent legs of anchor bars, shall be located with not less than 1 inch nor more than 4 inch clear distance between the bar and the surface of the RCC below it.

12. GALLERY

12.1 General.

The gallery shall be constructed by using one of the following schemes, the details of which shall be the Contractor's responsibility and shall be submitted for information: (1) precast gallery segments, (2) removable rigid forms against which the RCC is placed, (3) stay-in-place precast-interlocking panels similar to the upstream face panel construction, held in place with straps or anchor bars embedded in the RCC and with a ceiling section made of precast slabs, and (4) using a noncementing fill (such as the RCC mix without cement) as a temporary filler in the gallery area, and then removing it after the RCC has gained sufficient strength to be self-supporting. Regardless of which procedure is used, the bottom of the gallery shall be the exposed surface of an RCC lift, and shall be sloped to drain. In no case will an invert surface be allowed to pond more than 3 inches of water if flooded.

12.1 Precast Gallery Segments.

Precast sections shall be designed by the Contractor to carry the full load of a vibratory roller over the first lift of fresh RCC above the ceiling section with a sector of safety of 4, and shall be designed to carry the vibrating load of subsequent compaction without deflection that could damage the previously placed layers. Temporary internal bracing to carry vertical loads until after the first three lifts of RCC are placed above the gallery section shall be supplied by the Contractor. The design shall be the responsibility of the Contractor and submitted to the Engineer. The bottom of the gallery shall be the exposed surface of the RCC lift upon which the gallery segments are placed.

12.3 Noncementing Fill Methods.

The gallery section may be constructed by placing a nomcementitious fill in the area where the gallery is to be located, compacting it in layers at the same time that the adjacent RCC is compacted, and later removing the fill. Boards, styrofoam panels or other separators shall be used between the surfaces of the RCC and noncementitious fill to prevent the majority of fill material from bonding to the RCC. Details of how this procedure will be followed, what the noncementitious fill will consist of, and how the fill will be removed later, shall be submitted for information. An acceptable system shall be established to assure that no noncementing material is placed elsewhere in the structure. In order to visually distinguish this mix from the standard RCC mixes, and to help facilitate later excavation, either Type I or Type II aggregate, or sand shall be used. Excavation of the gallery fill shall not start until the RCC has gained sufficient strength (estimated to be 25 days) to be self-supporting and until at least 30 feet of RCC have been placed above the gallery section. As soon as the strength and cover requirements have been met, the Contractor shall begin the removal of the noncementitious material so as to facilitate any grout and drain hole drilling and other work which should be completed prior to raising the reservoir. Blasting will not be permitted in removal of material from the gallery. As it progresses, excavation shall include removal of separators, scaling for removal of loose aggregate projecting into the gallery area, and trimming of sharp edges of RCC which may have formed at the top or bottom of the separator boards. Scaling may be accomplished with hand tools and small chipping guns. It is intended only to remove loose and semi-detached material and sharp projections which constitute a safety hazard. It is not the intent to leave a smooth or attractive finish or to do any extensive structural shaping.

13. CURING AND PROTECTION

13.1 General.

The surface of all RCC layers upon which subsequent concrete will be placed shall be kept continously damp and at a temperature above 35 degrees F until it is covered with the next layer. The final top surface of RCC in the spillway and nonoverflow sections shall be continuously moist cured until covered with conventional concrete when it is required, or until an age of 60 days when it is not to be covered with conventional concrete. Curing compounds will not be permitted on the RCC. The exposed face of all other RCC surfaces (such as the downstream face of the dam) will not require cure or protection. The surfaces of RCC layers upon which subsequent layers will be placed shall be protected from erosion by heavy rain and damage by water trucks. Any surface that is damaged by erosion that undercuts coarse aggregates shall be treated as a Type II joint.

14. PRECAST FACING PANELS

14.1 General.

If used, precast panels shall comply with the requirements of Technical Section "Precast Panels." As much as possible, large rollers shall be used for compaction near the panels. Hand-operated tampers and rollers shall be used for compaction adjacent to the panels and where large rollers cannot safely maneuver. Minor chips and occasional hairline cracks that occur accidentally in the panels during erection and construction will be tolerated. Panels with major spalls or cracks shall be replaced.

14.2 Anchors.

Tie-back anchor bars shall be located with at least 2 inches clear space above or below horizontal joints of RCC layers. The end of the bar shall be dipped in "aquatepoxy" paste as produced by American Chemical Company prior to being threaded into the panel insert. The washer and nut shall be tightened against the impervious liner on the back of the panel before the epoxy sets and so that it fills the void space and seals the washer to the membrane.

14.3 Joints Between Panels.

Joints between precast panels may be shimmed up to 1/4 inch in any direction for alignment. Shims for horizontal joints shall have a bearing area of at least 4 square inches. Prior to placing concrete against the panels, the impervious membranes at adjacent panels shall be heat welded in the field with a lap splice as shown on the drawings. All heat welding shall be done by trained personnel approved by the Supplier using mechanical heat splicing equipment specifically designed for that purpose. Any weld suspected of not being fully fused shall be redone or tested using a holiday detector.

15. CONVENTIONAL CONCRETE FACING

15.1 General.

Except as modified or supplemented herein, conventional concrete for the spillway face, training walls, and any other location where conventional concrete is to be placed monolithic with the RCC, shall comply with the requirements of Section "Conventional Concrete."

15.2 Mix Proportions.

The exact mix design shall be developed and proven by tests. Materials used in the tests shall be representative of those to be used in the dam. The mix design shall conform to ASTM C94 and shall be within the following general guidelines:

Maximum aggregate size	1-1/2 inch
Maximum amount of 1-1/2 Agg.	20%
Initial air content	4%-10%
Air content after 30 minutes	4%-7%
Water reducing admixture	(hi range) or (hi and normal range)
Maximum water-cement ratio	0.45
Maximum water content	220 Lb/cy
Minimum cement content	375 Lb/cy
Design strength (90 days)	4000 psi
Retarder	optional

All admixtures except the high range water reducer (super plasticizer) shall be added to the mix at the batch plant.

15.3 Placing Procedure.

The high range water reducer shall be added to the mix at the placement location when the area is ready to receive concrete and when RCC is being readied for adjacent placement. The high range water reducer shall be forced from a pressurized tank into the mixer of the mixer truck. A predetermined quantity of admixture, appropriate for the batch size, shall be used. The concrete shall then be thoroughly mixed and immediately discharged. Additional admixture may be added by hand on occasion if necessary to further improve workability. Extra water shall not be added at the placement location, except for that amount necessary to briefly (five seconds by truck hose) flush or rinse down the back of the mixer drum after addition of superplasticizer. The concrete shall be discharged against the form. The RCC shall immediately be spread into the conventional facing mix, and compaction shall immediately follow that. Timing shall be arranged so that the RCC is compacted into the facing mix as it begins to stiffen from slump loss, but before it begins to achieve an initial set. This normally will require compaction within 15 to 40 minutes after addition of the superplasticizer. Compaction will be by large roller as much as is possible, supplemented by hand-guided tampers. It is anticipated that the facing mix will have a slump in the range of 1/2 to 2 inch prior to addition of the superplasticizer and 4 to 8 inches immediately after mixing it with the superplasticizer. It is also anticipated (and desired) for the facing mix to rapidly lose slump (but not set) so that the RCC can be spread into it and it will tend to support compaction equipment. Internal vibration shall supplement the compaction equipment as necessary to insure full consolidation of the facing mix. The compaction procedure shall effectively force the RCC into the facing so that the two mixes hydrate into a monolithic mass.

15.4 Finishing the Facing Mix.

The facing mix of the spillway shall be kept continually moist starting immediately after the form is pulled away from it. As soon as it is practical after the form is raised, the surface shall be finished to remove any imperfections and ridges, and to fill any holes with "dry-pack" mortar. Immediately after finishing, the surface shall be coated with curing compound.

16. FOUNDATION PREPARATION

16.1 General.

Prior to placing roller compacted concrete on the foundation and against abutments, the exposed rock shall be cleaned, filled with dental concrete (if necessary), shaped (if necessary), and prepared. No foundation or abutment area will be covered with any concrete, bedding mix, or dental fill until it has been accepted by the designated field representative. A bedding mix consisting of a lean conventional wet mix shall be placed at the interface between the rock foundation and RCC mixes.

16.2 Bedding Mix.

The bedding mix shall be the same between the foundation or abutment and the RCC and wherever required between layers of RCC. The bedding mix shall be retarded so that its initial set time exceeds 3 hours at 95 degrees F. It may be retempered within this time period to add moisture lost by evaporation. The bedding mix shall be spread so that all of the surface to receive bedding is covered with some material, and so that the average thickness over rock foundations does not exceed about 2 inches. The RCC shall be spread over the bedding and compacted into it before it reaches its initial set and within 45 minutes of when it was discharged. The exact mix porportions shall be developed by the Engineer. Materials used in the tests shall be representative of those to be used in the dam. The mix design shall be within the following general guidelines:

Slump	5 - 9 inch
Maximum aggregate size	1 or 1-1/2 inch
Maximum amount of coarse Agg.	55%
Air content	0%-10%
Water reducing admixture	Required
Minimum cement content	400 Lbs/cy
Design strength (90 day)	2000 psi
Retarder	As required to achieve the required delayed set time

Admixtures may be reintroduced into the mix to maintain its workability. The mix should be a very workable and highly sanded mix with some coarse aggregate. It shall be proportioned so that it does not segregate.

16.2 Shaping and Filling.

Shaping by minor rock excavation (trimming) of obtrusive high points and overhangs, and by filling with conventional dental fill concrete of depressions into which RCC cannot be thoroughly compacted, will be required. Depending on the location, size, shape, and rock quality, trimming may necessitate any one or a combination of the following methods: mechanical ripping, scaling by hand pry bars, jackhammers, surface charges, or small shots of stemmed dynamite in drilled holes. If any large areas or volumes of unacceptable quality or shape rock are encountered, they shall be treated as ROCK EXCAVATION before receiving the foundation preparation required herein. Dental fill concrete may require rough face forming. Vibration and curing of bedding mixes and for dental concrete placed for filling voids in the foundation and placed for panel leveling pads are not required.

16.4 Final Cleanup.

Prior to placing any concrete or bedding mix, the surface shall be cleaned of loose, unkeyed, and deteriorated rock; all mud, silt accumulations, vegetation, grease and spilled oils; and frozen materials, accumulations of gravels, sands, and loose rock fragments; laitance that may have accumulated on dental concrete, and any other detrimental material. It is expected that most of this can be accomplished with air blowing, high-volume water washing, and/or air/water jetting using equipment normally designed for this purpose and used in large scale foundation cleanups. A clean sound surface is required, but it is not the intent of this specification to require a perfect and polished surface with no exposed rock having visible fractures. All surfaces upon which RCC or any bedding mix is placed shall be damp and at a surface temperature in excess of 35 degree F. The Contractor shall have available adequate equipment for necessary air, air/water, and pressure water jetting of the foundation.

17. SHAPING AND CLEANUP OF THE UNFORMED DOWNSTREAM FACE

17.1 General.

During construction, spillage over the downstream face is expected to occur which will result in an accumulation of loose, uncompacted RCC at the face and along the toe. It will probably have little or no cemented value. During construction, the unformed downstream face shall be routinely trimmed with hand tools to provide a relatively uniform surface and to improve its appearance. However, it will remain rough and not fully compacted. During or after construction, the face shall be cleared of protrusions and obvious major discontinuities that may exist. It shall then be dragged with a caterpillar-track or other suitable device. Loose gravel or buildup at the toe of the dam which is not advantageous from an aesthetic and/or drainage standpoint shall be removed. Suitable material removed during construction may be used for haul roads or the Contractor's convenience.

18. INSTRUMENTAION

18.1 General.

The Contractor shall be prepared to install instrumentation such as thermal couples and Carlson strain gages (crack meters) if required by the Engineer. The locations and type of instruments will be estimated in general prior to construction, but exact locations and types of instruments will be determined as the job progresses. All instrumentation will be available in sufficient time to be installed at its desired location without delaying construction progress.

19. TEST SECTION

19.1 General.

The Contractor shall construct a test section more than one panel high and containing at least 175 cubic yards of RCC prior to placing RCC in the dam. The test section shall include various techniques and materials to be used in construction of the dam such as the precast panels, joint cleaning, compaction, density testing, bedding mix, facing mix, etc. The test section shall serve as a practice, training, and orientation area, and it may be used to help evaluate the practical effectiveness of various construction methods and pieces of equipment. It will also serve as a practice area for inspection. The Engineer will closely monitor activities during construction of the test fill and provide an informal critique and review session afterward for all those involved, including supervision, inspection, engineering, and craft personnel.

20. TOLERANCES

20.1 General.

Except as supplemented or modified below, tolerances shall be as required in the specification sections for "CONVENTIONAL CONCRETE" and (if applicable) "PRECAST CONCRETE."

20.2 Specific Requirements.

(1) Offsets between adjacent precast facing panels shall not exceed 3/8 inch in finished construction.

(2) Gradual variation of erected precast facing panel lines shall not exceed 1 inch in 10 feet, 2 inch in 30 feet, and 3 inch in 100 feet.

(3) Offsets of adjacent precast gallery segments or panels (if used) shall not exceed 1-1/2 inch.

(4) Variation from the lines and grades of the gallery walls and ceiling from that shown on the contract drawings shall not exceed plus or minus 6 inch (2 inch for the floor), except that tolerances at the gallery

entrances shall be kept within the limits necessary for doorways to fit and function properly.

(5) Allowable gradual overbuild of the downstream face of the dam shall be limited to 5 feet. Underbuild will not be allowed.

(6) Variation in the downstream face of the dam from a straight line shall not exceed 1 foot in 40 feet, 2 feet in 100 feet, and 3 feet in 200 feet.

(7) The thickness of individual compacted layers of RCC shall be within plus or minus 2 inches of that stipulated.

(8) The elevation of the surfaces of roller compacted concrete layers upon which subsequent concrete is placed shall not vary by more than 6 inches from the design elevation, except that the elevation of the top three lifts shall be within 2 inches of that shown on the drawings.

21. QUALITY CONTROL

21.1 General

The Contractor shall establish and maintain an effective quality control program with the Engineer for the roller compacted concrete. It will be the means of ensuring compliance with contract requirements and of maintaining records of control, including all tests and inspections, their findings, and the remedial actions taken when necessary.

The Contractor's program will be established and run under the supervision of a full time RCC Quality Control Engineer who will review and approve all activities concerning the production of materials, planning and scheduling of construction activities for placing RCC, and the running and evaluation of RCC tests. The RCC Quality Control Engineer shall work closely with the Engineer and shall keep the Engineer advised of planned construction procedures, the placing schedule, the testing schedule, and results obtained from tests. The Contractor will designate an RCC Quality Control Engineer for each shift and may have several personnel in the various areas of activity monitoring, testing, and reporting. All information and test results will be made available to the Engineer. The Engineer will be permitted full access to all construction and Contractor quality control activities.

The RCC Quality Control Program shall include but not be limited to the following: aggregate manufacture and gradation, moisture, batching requirements and mix proportions at the batch plant, mix delivery, compaction, joints, insuring adequate materials are on hand, embedded items, erection of precast facings, and all other tests and inspections required by these specifications. The program shall be similar to that described in the following paragraphs.

21.2 Aggregate Gradations.

21.2.1 Testing: At least once during each shift that concrete is placed and once during each shift that aggregates are produced, gradations shall be checked for each aggregate size used or produced, and for the combined gradation of all aggregates batched at the designated proportions. A recheck sample is required for any combined gradation test out of specifications. The location from which samples are taken may be selected by the Contractor providing that they give an accurate indication of gradations of materials as they enter the mixer. However, provisions must be made for accurate sampling of aggregates on feed belts to the concrete plant.

21.2.2 Action Required: Whenever a test result is outside of the specification limits, the recheck sample shall be taken. If the recheck sample is outside of the specification limits, the process shall be considered out of control, and positive steps shall be taken by the Contractor to rectify the situation. The Engineer and the Contractor's Quality Control Engineer will jointly decide if production and placement of concrete shall be stopped at that time. Except in extreme cases that represent a serious design concern, construcion will be permitted to continue during the shift after the gradation problem was identified and while it is being corrected. It is expected that the problem will be corrected by the end of the second shift after it is identified. The Contractor will be responsible for all costs incurred as a result of stopping any concreting operations due to out-of-specification materials.

21.3 Aggregate Moisture Determination.

21.3.1 Testing: At least once during each day of placement for each aggregate size used, moisture content determinations shall be made in accordance with ASTM C 566 (ASTM C 70 where appropriate for fine aggregate if it is stockpiled separately). The location from which the sample is selected may be determined by the Contractor providing that it is typical of materials entering the mixer.

21.3.2 Action Required: When moisture content determinations indicate a change in water entering the mix with the aggregates, the placement foreman shall be contacted to see if a corresponding adjustment in water added at the mixer is necessary to obtain adequate compaction at the placement site and improve placing conditions.

21.4 Particle Shape.

21.4.1 Testing: During the period of initial aggregate production and initial stockpiling, frequent tests shall be made in accordance with CRD-C 119 to determine the amount of flat and elongated particles. After it has been established that a problem does not exist, and if production procedures remain constant, continued testing shall be required only once per week.

21.4.2 Action: Two consecutive failures in the same sieve size or for the overall gradation shall require action to be taken to correct the deficiency. Except in extreme cases that represent a serious design concern, aggregate production will be permitted to continue during the shift after the problem was identified and while it is being corrected. It is expected that the problem will be corrected by the end of second shift after it was identified. Materials produced "out of spec" shall be blended with materials "in spec" so that the composite as used in RCC meets specification requirements.

21.5 Material Finer than the No. 200 Sieve.

21.5.1 Testing: During the period of initial aggregate production and stockpiling, frequent tests shall be made to determine the amount of material passing the No. 200 sieve for the combined gradation requirement. Washing of the coarse aggregates shall be used to accumulate all minus 200 material in the combined gradation. Liquid limit and plasticity indexes shall be determined for the minus

50 materials. After it has been established that a problem does not exist, and if production remain constant, continued testing will be required once per week.

21.5.2 Action: When testing for material finer than the No. 200 sieve indicates excessive quantity or plasticity, corrective action shall be taken to correct the deficiency. Except in extreme cases, aggregate production will be permitted to continue during the shift after the problem was identified and while it is being corrected. It is expected that the problem will be corrected by the end of the second shift after it was identified. Materials produced "out of spec" shall be blended with materials "in spec" so that the composite as used in RCC meets specification requirements.

21.6.1 Aggregate Quantities.

21.6.1 Monitoring: The Contractor shall accurately monitor and record the quantity of each aggregate produced and used during each shift. A record of the cumulative amount of each aggregate shall be maintained. Quantities shall be based on saturated surface dry (SSD) moisture conditions.

21.7 Concrete Plant Control.

21.7.1 Routine Control and Reporting. When the concrete plant is operating, the amount of all constituent materials including cement, pozzolan, each size of aggregage, water and admixtures shall be continuously controlled. The aggregate weights and amount of water to compensate for free moisture in the aggregates shall be adjusted as necessary. A daily report shall be prepared indicating the type and source of cement used during that day, aggregate size groups used, required mix proportions per cubic yard each mix design used, the amount of water as free moisture (above SSD) in each size of aggregate, and the aggregate weights per cubic yard for each mix design of concrete made during plant operation. The report shall include the total amount of each material used per shift for each mix.

21.8 Scales (if used) for Weight Batching.

21.8.1 Tests and Checking: The accuracy of scales shall be checked by test weights prior to the startup of concreting operations. Rechecks shall be made at least every 60 shifts of operation thereafter. Such tests shall also be made whenever there are variations in properties of the RCC that could result from batching errors. The accuracy of each batching device when weigh batching procedures are used shall be checked frequently during the startup of operations by noting and recording the required weight and the weight actually batched.

21.8.2 Action Required: Whenever either the weighing accuracy or batching accuracy is found not to comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made.

21.9 Volumetric Feed Calibrations.

21.9.1 Tests and Checking: The accuracy of volumetric feeds shall be checked by collecting all material delivered during a unit of time to the mixer and also by washout tests of material exiting from the mixer. Suitable methods and equipment shall be provided for obtaining and handling samples at the concrete plant. The weight of material corresponding to a standard time interval, and the resulting proportions of materials per cubic yard shall be determined. The accuracy of volumetric feeds shall be determined at least three times during checkout of the concrete plant prior to production operations and RCC placement. Rechecks shall be made at least every 60 shifts of operation thereafter and whenever there are variations in the properties or control of RCC that could be the result of volumetric feed errors. The sample shall be of sufficient size to give accurate determinations. This may require weights in excess of 400 pounds per item checked.

21.10 Testing Concrete Mixers.

21.10.1 General: Fresh concrete shall be sampled and tested for compliance with the specifications at the placing location. The Contractor shall provide a method of readily obtaining representative RCC samples from the plant and gobhopper locations.

21.10.2 Mixer Performance: A complete mixer performance test of three different batches of concrete or runs through a volumetric plant shall be made on each mix prior to the start of concrete placing. Additional tests may be made at any time to support a Contractor's request for reduction of mixing time. Whenever mixer adjustments are necessary because of failure of a mixer to comply, the mixer shall be retested after adjustment.

21.11 Temperature.

21.11.1 Testing: Near the start and end of each shift, at least one test of temperature shall be made at the batch plant and at the placement on randomly selected batches of each mix design of concrete used per shift of placement. Additional tests shall be made when rapid set time or workability loss is reported by the placing foreman or Engineer, or when hot or cold weather problems occur. The temperature of air and concrete shall be recorded during the period of cure and cold weather protection when those restrictions are applicable.

21.11.2. Action Required: Temperatures shall be included as standard data in the quality control reports.

21.12 Moisture Content.

21.12.1 Tests and Checking: At least once during each 4 hours of production placement at the batch plant, and once every 4 hours at the placement site, the moisture content shall be determined on the RCC mix. Moistures determined at the placement shall be made using a nuclear gage in the direct transmission mode immediately after compaction. The probe shall be driven to the full depth of the lift for each reading. The gage shall be calibrated against oven-dry samples of each mix design used. The calibration shall be verified to oven dry materials at least once per 20 shifts. At least three tests shall be made in different areas of each layer of RCC placed. The placing foreman shall continuously monitor the apparent effectiveness of compaction equipment from a visual standpoint, and shall notify the batch plant whenever the mix becomes too dry or too wet.

21.12.2 Action Required: Whenever moisture content tests indicate a significant change from what has been established as the optimum batching and placing moisture, the placing foreman shall be notified and the behavior of the mix under conditions at that time shall be observed. Whenever the placing foreman observes a condition of moisture which begins to consistently allow the vibratory rollers to sink excessively in the mix, cause excessive paste to develop at the surface, or leave an open appearing unconsolidated surface, an adjustment shall be made in the mix water added at the plant and the adjustment shall be noted.

21.13 Cement.

Samples of the RCC mix will be obtained from the placement area for determination of cement contents using a chemical calcium analyzer or other acceptable procedure. All testing will be done jointly with personnel from both the Contractor and Engineer.

21.14 Concrete Specimens for Compressive Strength Tests.

The Engineer will furnish molds for nominal 6 x 12 inch RCC test cylinders. Forms for cylinders will be rigid reusable type with disposable liners. The Contractor (with the assistance of the Engineer)

will make all test samples, transport them, cure them, test them, and extract them from the molds.

21.15 Density.

21.15.1 Tests and Checking: At least once every 2 hours during placement, the density of RCC after compaction shall be determined with a nuclear density gage previously calibrated against each mix design used. At least two double probe nuclear gages in good working condition shall be available, and at least one gage shall be on the placement area at all times. The Contractor will provide and operate the gage. Each layer of RCC shall be tested by the nuclear gage in at least six separate locations for density. The direct transmission mode shall be used. The gage shall penetrate the full depth of the lift.

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Readings shallbe taken in each quadrant of a circle made by rotating the gage 90 degrees around the transmission probe after each reading. The probe shall be driven to the full depth of the RCC layer for each reading, and may also be driven to lesser depths for supplemental information.

21.15.2 Action Required. Whenever the nuclear gage indicates a wet density of less than ___ Lbs per cubic yards, a retest shall be made. If the retest indicates incomplete compaction, additional rolling shall be immediately provided, and a determination shall be made as to whether the lower density resulted from insufficient passes of the roller or a change in the mix properties. If the mix properties have changed, adjustments such as increasing or decreasing the moisture content shall be made at the batch plant. If the problem persists and if the lower density is the result of incomplete rolling, the operator shall be notified and the Engineer may require removal of the incompletely compacted material. If the same operator repeatedly rolls less than the required number of passes, he shall be replaced with a different operator.

21.16 Compaction Equipment

21.16.1 Tests and Checking. Before any compactor is used in RCC construction, it shall be checked for correct dimensions, weight, and vibratory capacity. At least once per 12 shifts of use, a spot recheck of frequency shall be made. At least once per each shift of placement for the first 5 days of operation by any new operator, his performance shall be spot checked for the correct number of passes, correct spread, coverage of the area being rolled, and good rolling practice. Thereafter, spot checks shall be made on each operator at least weekly, and the results shall be noted in the quality control reports.

21.16.2 Action Required. Compaction equipment not meeting the physical dimensions and weights required shall be removed from the project. Any roller having improper frequency shall be corrected before being used for RCC compaction. Roller operators running at speeds in excess of specification requirements shall be immediately notified and shall correct any noted improper practices or be replaced by another operator.

21.17 Dumping and Spreading.

21.17.1 Tests and Checking. The placing foreman or other designated representative shall continually observe and monitor dumping and spreading operations to insure that they are done in a manner that minimizes segregation. Each layer of RCC shall be routinely checked in its spread condition for evenness and thickness so that smooth, even, compacted layers within the specified thickness tolerances result after compaction. A laser or optical level shall be used in conjunction with hand-carried vertical rods to determine the elevation of (and subsequently the thickness) of each layer. It shall be the type that emits a rotating or constant light beam in a fixed plane.

21.17.2 Action Required. Whenever thickness checks on uncompacted RCC indicate an excess or shortage of material, the layer shall be immediately bladed off or supplemented as needed. Whenever the thickness or elevation exceeds the allowable tolerances, the Engineer shall be notified and determine with the Contractor what corrective action, if any, is necessary.

21.18 Preparation for Concrete Placement.

21.18.1 General. Foundations, construction joints, forms, and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to assure that the area is ready to receive concrete. Forms and facing panels shall be checked closely for condition, support, alignment, and dimensions. The placing foreman shall be the first level of supervision of all placing operations. The RCC Quality Control Engineer shall determine that the correct mix design of concrete is placed in each location. The designated quality control man shall be responsible for measuring and recording concrete temperatures, ambient temperatures, weather conditions, time of placement, yardage placed, and method of placement. The placing foreman shall not permit placing to begin until he has verified that an adequate numer of vibratory rollers and spreading equipment of the right size, in working order, and with competent operators are available.

21.19 Curing, Protection, and Joint Surfaces.

21.19.1 Moist Curing. At least every four hours, around the clock, 7 days per week, an inspection shall be made of all areas subject to moist curing and joint protection. The surface moisture condition shall be noted and recorded. If an isolated area has been allowed to dry, that area shall be considered as improperly cured. The Contractor shall IMMEDIATELY wet the area and take positive steps to insure that the problem does not reoccur.

21.19.2 Protection. At least every eight hours, around the clock, 7 days per week, an inspection shall be made of all areas subject to cold-weather protection or protection against damage. Deficiencies shall be noted. During removal of cold-weather protection, measurement of concrete and ambient temperature shall be made at least every two hours.

21.20.1 General. Concrete Plant control records and all results (both passing and failing) of tests conducted at the project site shall be recorded daily and shall be formally transmitted to a designated representative of the Engineer within two days after the end of each weekly reporting period. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in the preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports.

MIXER AND PLACING PERFORMANCE TEST PROCEDURE FOR ROLLER COMPACTED CONCRETE

1. SCOPE

1.1 The procedures described here are used to evaluate how thoroughly roller compacted concrete (RCC) is mixed prior to compaction but after it has been placed during construction. They determine water content, cement content, and coarse aggregate content for the full mix, and unit weight of the air-free mortar. By comparison of results from three samples taken throughout a shift of placing, the ability of the mixing and placing procedure to provide consistent material is determined.The Engineer may authorise deletion of the cement test portion of the procedure or use of an alternate method.

2. GENERAL

2.1 Mixer performance tests are used to establish minimum allowed mix times for conventional concrete or to determine the variability of a mix after a specified duration of mixing. Normally, the procedure consists of mixing a specified batch size for the designated length of time, obtaining samples of material from different locations in the mixer, and comparing results of tests on each sample to see how much they vary.

2.2 The procedure usually follows Corps of Engineers Test Method CRD-C 55 or the method allowed in ASTM C-94, Annex A1. A brief description of each test follows:

CRD-C 55 is based on three samples taken from a single batch. It checks for water content, cement content, unit weight of the air-free mortar, and coarse aggregate content. It requires about 1 week before results from all of the tests are analyzed and data by the chemical method of cement determination on hardened mortar is available. Most of the testing is performed on the mortar portion of the mix after after sieving from the full mix.

ASTM C-94 is based on two samples taken from a single batch. It tests for slump, air content, coarse aggregate content, unit weight of the 1-1/2 inch minus portion of the mix, compressive strength at 7 days, and unit weight of the air-free mortar. It requires 1 week before all results are available, and it does not use the full mix in all of the test procedures.

2.3 Each of these procedures (ASTM & CRD) were developed for conventional concrete mixes, and each checks only the effectiveness of the mixer itself. Blending of roller compacted concrete materials can be significantly affected during transporting, rehandling, and spreading operations. Generally this can be expected to provide additionl beneficial mixing, although with improper practices, it could adversely cause segregation. This additional mixing can be used to advantage by taking samples from the placing area at differnt times during a shift rather than taking them from a single batch in the mixer. Using this technique, different batches of concrete are intermixed and the composite effect of "batch-to-batch" variability as well as "within batch" variability is taken into account. Accordingly, the maximum permissible variability of the tested samples is increased from typical values used when only within batch testing is done.

2.4 An additional significant advantage of sampling from the placement instead of taking samples from one batch at the mixer is that fresh samples are used in the tests. In CRD-C 55, three samples are obtained at the same time for testing. In practice, the third sample may be hours old before it is subjected to the tests, and results can be adversely affected.

2.5 Another major advantage of obtaining samples from the placement is its compatibility with continuous mixers.

2.6 The procedure described here also uses a rapid chemical analysis for determining the cement content, and results of the entire test procedure are normally available by the start of the day following the tests.

3. SAMPLING

3.1 After an agreed initial and conservative mix time has been established, a shift of placement shall be permitted at that mix time while teting is performed. If no guidance is provided in the contract documents for an initial mix time, it shall be 1 minute for mixers with a capacity of 3 cubic yards. For larger mixers, the time shall be increased by 15 seconds for each additional cubic yard or fraction thereof. The mix time shall begin after all ingredients have entered the mixer and shall stop after the discharge cycle begins. For continuous mix plants, the mix time applies to equivalent discharge rates in cubic yards per minute.

3.2 During the shift of placement, samples shall be obtained during the first, second, and third portions of the shift. However, the first sample shall not be taken until after the plant has been in operation for at least the first 5 percent of the shift. The second sample shall not be obtained until after testing on the first sample has progressed to the point that it will be essentially completed and so that full attention can be given to the second sample as soon as it arrives at the laboratory. Similarly, the third sample shall not be obtained until testing on the second sample is essentially complete. All testing (except waiting for final drying where applicable) shall be completed within 2 hours after obtaining each sample.

3.3 The samples shall be obtained at random under the direction of the laboratory chief. They shall be excavated from the approximate center of a zone of RCC that has been spread for compaction by production methods, but prior to compaction. The sample size shall be approximately 5 cubic feet or 650 pounds. It shall include essentially all material through the full depth of the spread RCC layer. A recommended method of obtaining the sample is with a 1-ton 4x4 pickup truck and front-end loader assisted by two laborers with shovels. The sample shall be covered with a tarp and protected from wind, rain, sun, etc. while being transported. The sample shall be kept in, and all testing shall be done in, a protected environment out of the wind and sun and within a temperature range of 40 to 80 F degrees.

4. WATER CONTENT

4.1 Obtain approximately 1/2 cubic foot or 75 pounds of the full RCC mix and determine the sample weight to the nearest 0.1 pound. This sample should be taken and weighed as soon as possible after the bulk material is delivered to the laboratory. After weighing, spread the RCC material loosely in a series of pans that will fit into an oven. Be careful not to lose any of the sample. Preferably the sample should be initially weighed in the drying pans.

4.2 Dry the sample to constant weight, keeping it loosely separated to facilitate drying. Initial drying for 1 to 6 hours shall be accomplished by simple exposure to the dry atmosphere of an enclosed room, the sun, a breeze from an electric fan, etc. After initial drying, separate the material with a trowel or hoe to assure that it is still loosely separated and not hydrating into a solid mass. Then dry the sample to constant weight in an oven at 230 plus or minus 9 F degrees. Drying for 12 hours in the oven after the initial drying period is usually sufficient to obtain constant moisture.

4.3 Compute the total moisture content as follows:

$$P = \frac{W - D}{D} \times 100$$

Where:

P = The total moisture content in the mix (%)

W = The weight of the sample prior to drying (lbs)

D = The weight of the sample after drying (lbs)

5. UNIT WEIGHT OF AIR-FREE MORTAR

5.1 Sieve approximately 1 cubic foot or 150 pounds of the full RCC mix sample over a 2-inch screen. The sieving action shall be vigorous enough so that lumps of pasty material, mortar, and smaller aggregate fall through the screen. This can be accomplished by raking the sample back and forth over the screen as it is suspended above a platform or wheelbarrow. The retained coarse aggregate particles should not be washed and will have a slight coating of cement paste with fines. Discard the retained coarse aggregate.

5.2 Compact the material passing the 2-inch screen into a minimum 1/4 cubic foot pressure-type air pot and determine the compacted weight of the sample. Compaction should be accomplished in three lifts, compacting each lift with a pneumatic tamper prior to placing the next lift. The pneumatic tamper shall be equivalent to an Ingersoll-Rand Model SPG-30 with a 5-3/4 inch lock-type butt. The butt shall have a flat (not eliptical) striking surface, but the outside edge may be rounded. As the last lift is compacted in the mold, a helper should simultaneously add material so that the final compacted surface is essentially level with the top of the container. (A collar that fits over the container is recommended to allow initial overfilling of the loose material and to protect the edge of the container from damage during compaction.)

5.3 Determine the air content of the compacted sample using the ASTM C-138 (Gravimetric Method) or ASTM C-231 (Pressure Method).

5.4 Wash the entire air-content test sample over a No. 4 sieve so that all material including paste and fines adhering to the plus No. 4 material is removed. Waste the minus No. 4 material. Obtain the saturated surface dry weight of the aggregate from the air content test sample that is retained on the No. 4 sieve. Towels and a fan will expedite drying the aggregate back to a saturated surface-dry condition.

5.5 Calculate the unit weight of air-free mortar as follows:

$$M = \frac{b - c}{V - \left(\frac{V \times A}{100} + \frac{c}{G \times W} \right)}$$

Where:

M = Unit weight of air-free mortar (lb/cu ft)

b = Weight of the concrete sample compacted into the air content test container (lb)

c = Saturated surface-dry weight of aggregate from the air content test container that is retained on the No. 4 sieve (lb)

V = Volume of the air content test container (cu ft)

A = Air content of the test sample (%)

G = Specific gravity of the coarse aggregate

W = Unit weight of water (62.3 lb/cu ft)

6. PERCENTAGE OF COARSE AGGREGATE

6.1 Obtain approximately 1-1/2 cubic feet or 200 pounds of the full mix RCC sample and accurately determine its weight. Wash the sample to remove all material passing the No. 4 sieve, including all coatings on the coarse aggregate particles. To facilitate the washing operation, the weighted sample should be washed in smaller increments of approximately 20 to 30 pounds each, and a series of nested screens should be used above the

No. 4 screen to avoid overloading. Discard everything passing the No. 4 sieve. Save everything retained on the No. 4 sieve.

6.2 Dry all washed material retained on the No. 4 sieve to a saturated surface-dry condition and obtain the weight. Towels and an electric fan will expedite drying the aggregate back to a saturated surface-dry condition.

6.3 Compute the percentage of coarse aggregate (as percentage of the total mix by weight) as follows:

$$C = \frac{W - w}{W} \times 100$$

Where:

C = Percentage of the full mix that is coarse aggregate (%)

W = Weight of the full mix sample that is taken for sieving (lbs)

w = Weight of saturated surface-dry aggregate retained on the No. 4 sieve (lbs)

7. CEMENT CONTENT

7.1 Cement contents of each sample shall be determined for the full mix using the calcium analyzer and suspension tank (washing machine) of the concrete quality monitor (CQM). The CQM as used for conventional concrete is described in Publication TR M-293 titled "Corps of Engineers Concrete Quality Monitor: Operations Guide," dated May 1981. It is available from the U. S. Army Corps of Engineers Engineer Research Laborotory, Champaign, Illinois. Modifications for use with RCC include adding Calgon to the wash water, using a larger sample, and providing more sieves to facilitate the washing operation. Extra care must be taken and extra effort is normally required when using roller compacted concrete as compared to conventional concrete because of the typially lower cement factors and higher fines content.

7.2 Fill the suspension tank with tap water to the 10-gallon mark on the side of the tank.

7.3 Provide a nest of the following stainless steel sieves above the suspension tank: 3/4 inch, No. 4, No. 30, No. 50, No. 100. (The sieves may be modified to best suit the gradation of the RCC and to facilitate washing, but the bottom sieve must be the No. 100).

7.4 Turn on the recirculating pump for the suspension tank and add 1/2 pound of Calgon Water Softener to the water. Be careful to keep the recirculating hose above the screens. Do NOT lose any of the recirculated water. If the hose slips from above the screens and water is lost or pumped out of the system at any time, the test procedure shall be restarted.

7.5 Obtain approximately 8 pounds of the full RCC mix and place it into one or more polyethylene open-top tubs. Special attention must be given to obtaining representative samples, especially if they contain large aggregate in excess of 1-1/2 inches. Accurately determine the total sample weight.

7.6 Transfer the sample to the nest of sieves over the suspension tank, taking care not to overload the sieves or restrict the flow of water through them. Depending on the gradation of the mix and the amount of fines, it may be advantageous to wash about 4 pounds of the sample at a time. Carefully wash the aggregate, using water from the recirculating pump hose. It may be necessary to individually hand rub or scrub the aggregate particles with a fine wire bristle brush to remove all adhering cement and fines. After material retained on the top sieve has been washed, the material and sieve may be removed so that washing can proceed for the material retained on the next sieve, etc. Special care shall be taken to thoroughly rinse the finer aggregates that cannot be individually scrubbed. Rubbing them over the screen will help.

7.8 Obtain a sample of the recirculated water from the suspension tank. With the recirculating pump operating, insert a stirring spoon and vigorously stir the 10 gallon solution. Immediately extract a sample of the solution with a 30 ml syringe pipet. Place the suspended material in a 500 ml Erlenmeyer flask. Refill the syringe pipet with 5 percent nitric acid and then discharging it into the contents of the Erlenmeyer flask. While discharging the acid solution from the syringe pipet, shake it occasionally to ensure that all cement that settled out when the samples was taken has dissolved and is flushed out with the acid solution. Use a volumetric flask to add 250 ml of top water to the Erlenmeyer flask.

7.9 Put a magnetic stirring bar in the Erlenmeyer flask and place it on a magnetic stirrer. Turn on the stirring motor and stir for at least 3 minutes before taking the first sample from the flask for analysis. Continue stirring until the last sample has been taken from the flask.

7.10 Turn the calcium analyzer power switch to "on."

7.11 (This step is required each time the calcium analyzer cuvette is filled with new potassium hydroxide solution. A single cuvette filling is sufficient for 15 to 20 readings.) Fill the cuvette to the indicated mark with 1.0 N (Normal) potassium hydroxide and 100 μl (Eppendorf) of reconstituted calcein reagent. Put the cuvette in the analyzer, add 100 (Eppendorf) of calcium standard solution and push the titration button to condition the cuvette for analysis.

7.12 Begin the analysis by placing the m Eq/mg% toggle switch on the mg% position and adding 100 μl (Eppendorf) of the calcium standard to the cuvette. Press the titration button. Record the result and repeat the test by adding another 100 sample. Continue repeating until consecutive results are less than 1.5 percent apart. Push the calibration button and run an additional 100 sample of the calcium standard to ensure that the calcium standard readout value is 10 plus or minus 0.1 mg percent.

7.13 Determine the strength of the cement solution in the Erlenmeyer flask by analyzing a 20 μl sample in the calcium analyzer. Repeat by adding more 20 μl samples from the Erlenmeyer flask until the values are less than 1.5 percent apart. If the calcium meter readings are less than 5, the sample size and basis for calibration may be increased to a 100 sample.

7.14 Determine the cement content by entering the calibration graph with the stabilized calcium analyzer reading. If the sample size (approximately 8 lbs) is different from the size on which the calibration chart is based, the readings should be mathematically adjusted by proportioning to correct for the difference.

7.15 (This procedure is necessary prior to running any production tests.) Establish a calibration graph indicating the cement content in pounds per cubic yard as a function of the calcium analyzer reading (sample attached). This is accomplished by making small batches of thoroughly mixed RCC in the laboratory using accurately weighed ingredients ingredients and variable cement contents. For each mix, the calcium analyzer reading corresponding to the known cement factor is determined. The points are plotted and a straight line graph is drawn.

7.15.1 The batch size should be not less than 2-1/2 cubic feet mixed in a mixer of at least 3 cubic feet capacity. Dampen the mixer drum prior to mixing, preblend the weighed materials (except water) by shovel on a hard floor prior to adding them to the mixer. Add the dry materials intermittently with the water while the drum is rotating. Use the last of the water to rinse down the inside edge of the mixer drum while it is rotating. After all ingredients have been added, mix for 3 minutes at the flattest drum angle that does not spill material out of the mixer. Rest for 3 minutes and scrape the inside surfaces of the mixer drum and blades. Mix again for 2 minutes and discharge onto a damp hard floor. Scrape all materials from within the mixer drum and remix the material on the floor by shovel. Obtain a representative sample and run the calcium analyzer test on the mix. It is desirable to use exactly the same sample size (8 pounds) for each calibration test. If different sample sizes are used, the results must be mathematically adjusted to normalize them to the same initial sample size on which the calibration chart is based.

7.15.2 As a minimum, four mixes shall be used to establish the calibration curve for each cement factor and for each set of mix proportions used in production. For each mix, all batch quantities except cement shall remain constant. One mix shall be at a cement factor of zero (none) pounds per cubic yard. One mix shall be at the designated cement factor. One mix shall be at approximately 15 percent less than the designated cement factor. One mix shall be at approximately 15 percent more than the designated cement factor.

8. REPORT

8.1 A report including the variability index for each test shall be prepared following the format shown on the attached sample sheet.

ROLLER COMPACTED CONCRETE

MIXING AND PLACING PERFORMANCE

PROJECT ______________________________ DATE ______________________

RESPONSIBLE OWNER/ENGINEER REPRESENTATIVE ___________________________

MIX DESIGNATION ________________________ AGGREGATE __________________

BATCH SIZE _____________________________ __________________

MIXING DURATION ________________________

TEST RESULTS

	Sample 1	Sample 2	Sample 3	Variability Index*	Minimum Allowed	Result
Cement (kg/m3)	74.8	70.0	61.1	81.7	70	Pass
Water (%)	8.2	8.0	7.7	93.9	75	Pass
Unit Weight of Air-Free Mortar (kg/m3)	80.8	79.8	79.7	98.6	85	Pass
Coarse Aggregate	48	44	52	84.6	80	Pass

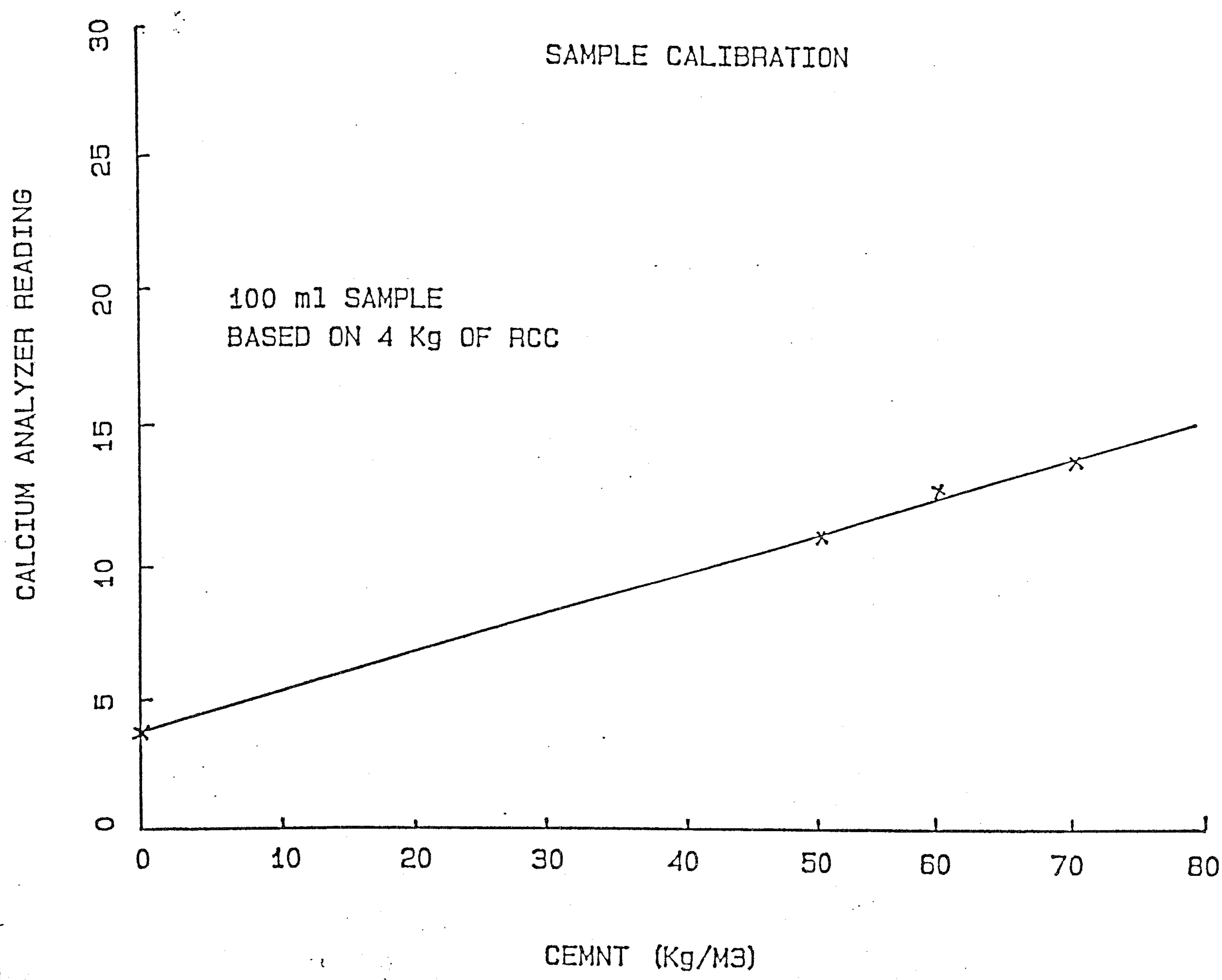
* (smaller value/largest value) x 100

ADDITIONAL INFORMATION

Compacted Unit Weight (kg/m3)	2446	2400	2373
Air Content (%)	0.9	1.0	1.4

REMARKS

Test passed. Contractor permitted to operate the next shift at 80 seconds mix time if testing is performed again during that shift.


SAMPLE CALIBRATION
100 ml SAMPLE
BASED ON 4 Kg OF RCC
CALCIUM ANALYZER READING
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
CEMNT (Kg/M3)

J.9 DAM ACCESS ROADS

Power Plant Access

Power plant access is provided by a 20' X 120' bridge from the plant to the west side of the river and an 18' wide gravel surfaced road from the bridge to State Highway 73. The road is 1500 feet long with a maximum grade of 12%. After leaving the bridge, the road immediately begins to ascend the nearly vertical rock walls of the west bank requiring approximately 34,000 C.Y. of rock excavation. Guard rail will be required for approximately 1000 feet.

The selected alternative will provide quick access from the power plant to the state highway which is maintained year-round by ADOT.

This alternative was selected after a review of other possible alternatives including:

1. Following the river downstream to a point where the rock walls are not so steep. This alternative was not selected because it was found that, on either side of the river, significant rock cuts and/or fills would still be required to follow the river bank. Maximum grades would be 14% and the roadway length would be increased significantly.

2. Eliminating the new bridge by bringing the access road up the east bank of the river. This alternative would require a similar amount of rock excavation and would require a total roadway length of approximately 6 miles (possibly along the existing Lower Log Road using the existing bridge) to a maintained, all-weather road (S.H. 73). Any savings gained by elimination of the new bridge would be offset by the increased roadway length.

3. Constructing a bridge over the spillway of the dam then descending the rock walls on the east side of the river. This alternative was eliminated by the high cost of constructing a bridge over the spillway.

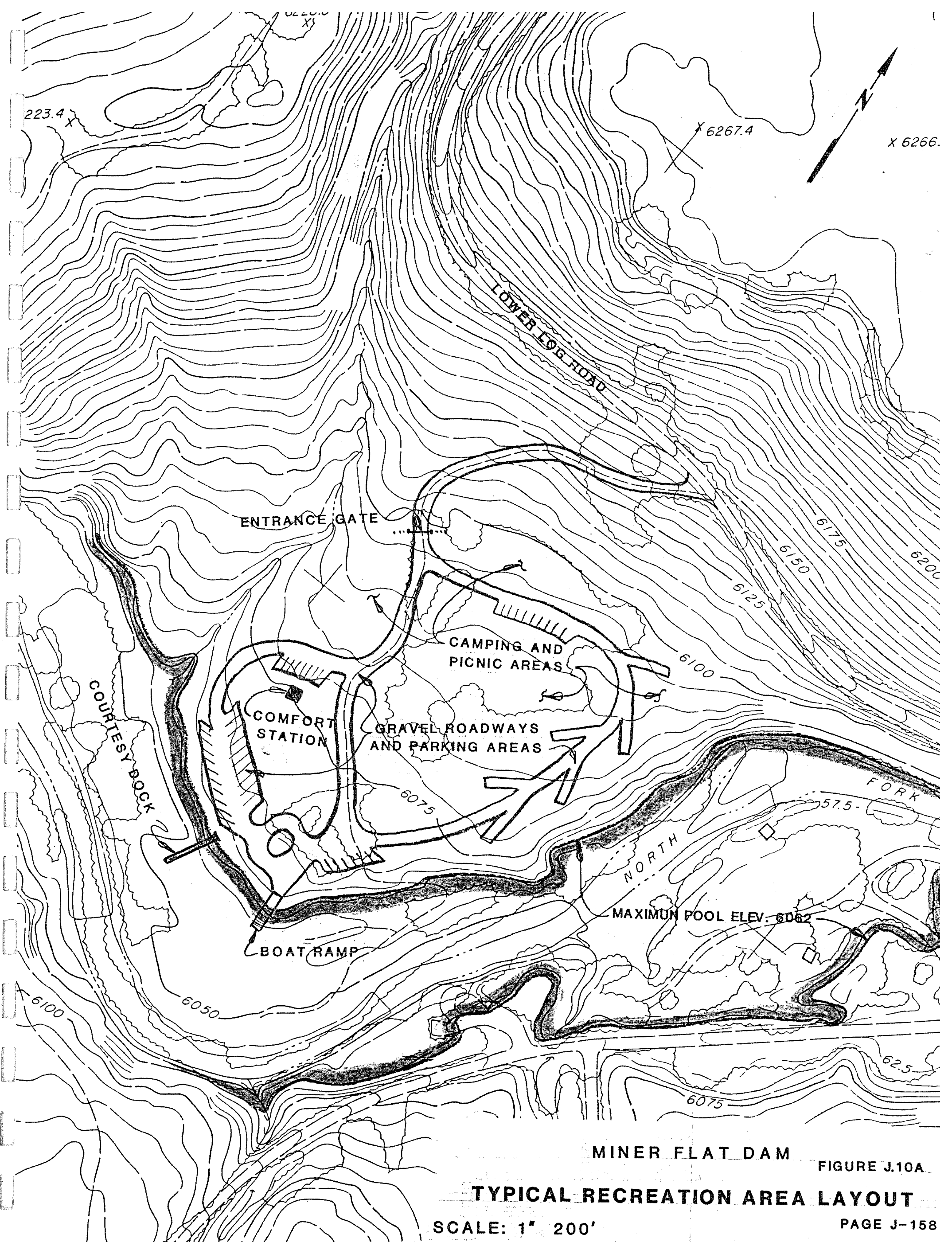
East Side Access Road to Top of Dam

Access for infrequent travel to the top of the dam on the east side will be provided by constructing some new road and by using the existing Lower Log Road. Gravel surfacing would be added. Driving distance from the top of the dam to State Highway 73 is approximately 6 miles.

J.10 RECREATION FACILITIES

Recreation facilities are keyed to probable reservoir access. Several possible points of shoreline access have been illustrated on General Map "B" (Sheet No. A2). The majority of the shoreline is virtually inaccessible due to very steep abutting terrain. However, there are several areas that do have terrain that will afford enough area for development of road ramps, courtesy docks, picnic areas and associated parking. There is some possibility that a few overnight camping spots could be constructed if they are desired. Although initial construction may call for gravel surfacing of roads and parking areas, substantial future use may necessitate payment on roads and parking.

A sketch of a "Typical Recreation Area Layout" (Figure J.10A) has been included to illustrate one possible development at an area of shoreline access.



MINER FLAT DAM

FIGURE J.10A

TYPICAL RECREATION AREA LAYOUT

SCALE: 1" 200'

DESIGN MEMORANDUM

SECTION J

J.11 PUBLIC SAFETY AND VISITOR FACILITIES

To provide for public safety at the dam, the visitor view point, dam crest access and dam access roads shall have six foot and four foot security fences along with locked control gates. Warning signs shall be installed in these areas to assist in controlling public access. The location of the fencing and gates are shown on Drawings No. J1 and J5.

The Visitor Facility shall consist of one view point located at the right abutment of the dam. This shall be a fenced area with graveled parking for approximately ten cars. Access from the highway will be along an existing road as shown on Drawings Nos. A2 and J1. The view point road will be improved with a gravel surface and adequate drainage facilities.

J.12 RESERVOIR CLEARING

The reservoir area below Elevation 6062 feet as shown on Drawing No. C-3 shall be cleared of all trees, stumps, and brush five feet or more in height, regardless of diameter, and two inches or more in diameter, regardless of height.

Trees and stumps in the reservoir area shall either be uprooted or cut off so that the maximum allowable stump height shall be six inches as measured on the uphill side of the stump. Brushy in the reservoir area shall be cut off approximately flush with the ground level.

All down timber, branches, and other floatable and combustible material five feet or more in length, regardless of diameter, and two inches or more in diameter, regardless of length, shall be cleared.

No trees shall be cut outside of areas mentioned above without specific approval, and all trees designated by the contracting authority shall be protected from damage by the contractor's construction operations.

J.13 HYDROPOWER FACILITY

Hydropower requirements for the Miner Flat Dam remain essentially the same as detailed in the report "Miner Flat Dam and Canyon Day Irrigation Project - February, 1986" and as reiterated herein with minor changes.

To provide more efficient and economical control of water flow into the powerhouse a separate six foot diameter supply pipe is to be provided in lieu of combining the ten foot diameter outlet pipe with the power supply and associated complex control valves as was suggested in the 1986 Report.

The power plant will be designed to provide an annual electrical power supply (Million Watt Hours) of approximately 5,220 MWH which is 88 MWH in excess of that required for the Canyon Day Irrigation Project.

The Miner Flat damsite is situated immediately to the east of existing 14.4 and 69 kilovolt (KV) transmission lines that parallel highway 73 between Pinetop and Whiteriver. These existing transmission lines are less than 5,000 feet to the west of the damsite. Consequently, only minor construction is necessary to interconnect the proposed hydropower facilities with the transmission system of the local electrical cooperative. Minor amounts of hydroelectric generation will be used at the damsite for operation of the outlet controls and lighting.

DESIGN MEMORANDUM

SECTION J

J.14 CONSTRUCTION COST ESTIMATE SUMMARY

The following is a Construction Cost Summary for the Miner Flat Dam Project based on the preceding preliminary design, final design criteria, construction schedules and drawings developed for the Memorandum.

These construction cost estimates do not include costs of construction inspection, testing and quality control. Those requirements will be performed by the owner or his contracted representatives.

1. Power Plant Access Road
(Drawing J5)

Unit	Description	Quantity	Unit Price	Amount	Totals
C.Y.	Unclass. Excavation (Incl. Borrow)	35,000	$10.00	$350,000	
L.F.	18" CMP Culvert	32	25.00	800	
L.F.	36" CMP Culvert	40	45.00	1,800	
Ton	Crushed Top Surfacing, Ty, B, Gr.2	1,378	8.00	11,024	
L.F.	Guard Rail	925	12.00	11,100	
Each	Guard Rail End Anchor	2	600.00	1,200	
L.F.	Metal Gate	25	16.00	400	
Each	Signing	10	300.00	3,000	
				379,324	
	Contingency of 20%			75,865	
					$455,189

2. East Side Access Road To Top Of Dam
(Length = 9,000', Width = 18)
(Drawing J6 and J7)

Unit	Description	Quantity	Unit Price	Amount	Totals
C.Y.	Unclass. Excavation	67,500	$ 3.00	$202,500	
L.F.	18" CMP Culvert	400	25.00	10,000	
Ton	Crushed Top Surfacing	4,500	8.00	36,000	
L.F.	Guard Rail	500	12.00	6,000	
Each	Signing	3	300.00	900	
				255,400	
	Contingency of 20%			51,080	
					$306,480

3. Recreation Site
(Section J.10)

Unit	Description	Quantity	Unit Price	Amount	Totals
1	24 Car Parking Lot w/Trailer Spaces	LS	$ -	$ 6,000	
1	Entrance Gate	LS	-	1,500	
1	Concrete Boat Ramp	LS	-	4,500	
1	Floating Dock and Landing	LS	-	9,000	
1	Double Latrine and Holding Tank	LS	-	5,000	
1	Well Pump Controls	LS	-	6,000	
Each	Fire Rings	10	250.00	2,500	
1	Post Barriers	LS	-	2,000	
Each	Picnic Tables	10	250.00	2,500	
					$ 39,000

4. Visitor Viewing Area
(Section J.11)
(Drawing A2 and J1)

Unit	Description	Quantity	Unit Price	Amount	Totals
C.Y.	Excavation	160	$ 4.00	$ 640	
C.Y.	1-1/2"Aggregate Surface	160	18.00	2,880	
Each	16' Gates (4' high)	2	750.00	1,500	
Each	4' Pedestrian (6' high)	1	100.00	100	
L.F.	4' Fence	430	8.00	3,440	
L.F.	6' Fence	70	12.00	840	
L.F.	18" C.M.P. Culvert	30	20.00	600	
					$ 10,000

5. Hydropower Facility
(Section J.13)
(Drawing J1)

Unit	Description	Quantity	Unit Price	Amount	Totals
L.S.	Turbine	1	$800,000	$800,000	
L.S.	Switchyard	1	80,000	80,000	
L.S.	Station Electrical	1	235,000	235,000	
L.S.	Miscellaneous	1	57,000	57,000	
Miles	Electrical Interconnection	1	15,000	15,000	
L.S.	Valving	1	50,000	50,000	
				$1,237,000	
	Contingency at 20%			247,400	
					$1,484,400

Total Costs for Items 1, 2, 3, 4 & 5	=	$2,295,069
Total Costs for RCC Dam (Section J.7)	=	$8,950,717
Total RCC Dam Project Construction Cost	=	$11,245,786
Total Costs for Items 1, 2, 3, 4 &5	=	$ 2,295,069
Total Cost for Conventional Concrete Dam (Section J.7)	=	$15,171,225
Total Conventional Concrete Dam Project Construction Cost	=	$17,466,294

SHEET TITLE
PLAN
R.C.C. GRAVITY DAM

SCALE: 1"=20'

PROJECT NUMBER 1780-14-02(34)
SHEET NUMBER J1

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

NAVAJO COUNTY, ARIZONA

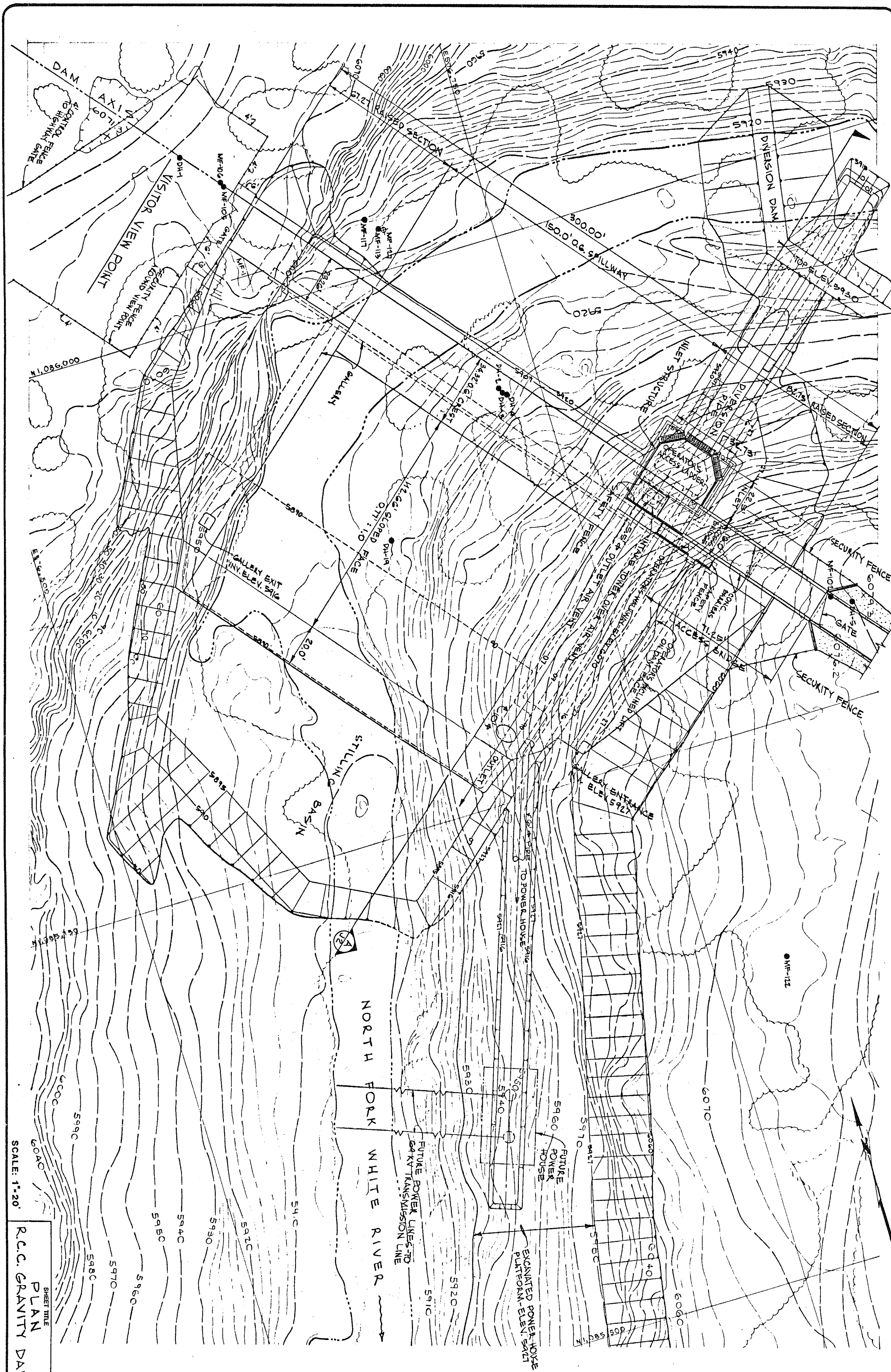
DRAWN BY: CJA
CHK'D. BY: BK
APPR. BY: CWK
DATE: 12-10-86
Q.A.
PEER REVIEW

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
910 HELENA AVE. P.O. BOX 6147
HELENA, MONTANA 59604

CORPORATE OFFICE HELENA, MONTANA
BRANCH OFFICES: BILLINGS, MONTANA; KALISPELL, MONTANA; BOZEMAN, MONTANA; RIVERTON, WYOMING

NO.	DESCRIPTION	DATE	BY:

REVISIONS



SHEET TITLE
PLAN
R.C.C. GRAVITY DAM

PROJECT NUMBER 1780-14-02(34)
SHEET NUMBER J1

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

NAVAJO COUNTY, ARIZONA

DRAWN BY: CJA
CHK'D. BY: BK
APPR. BY: CWK
DATE: 12-10-86
Q.A.
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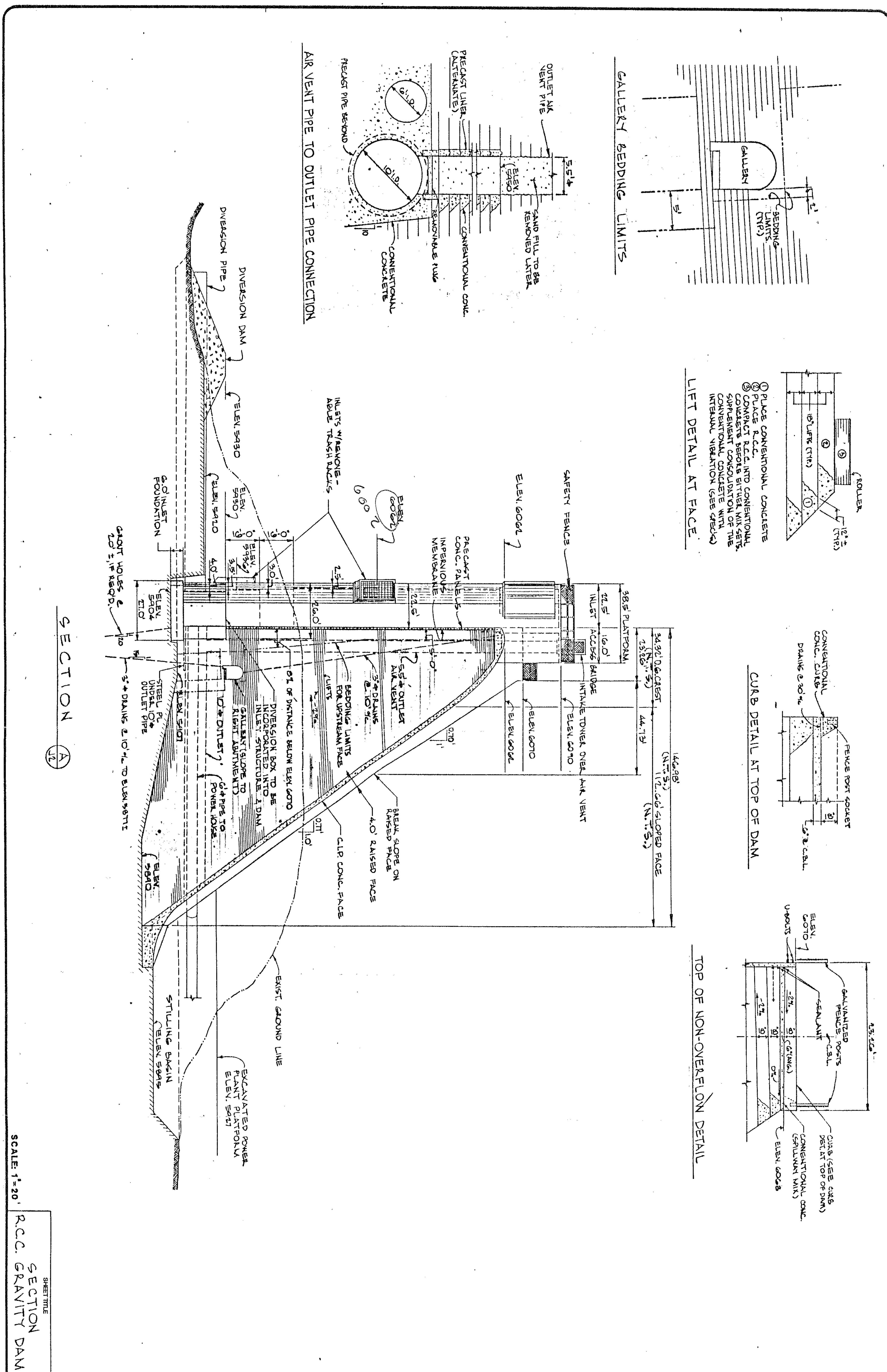
HELENA, MONTANA 59604
CORPORATE OFFICE HELENA, MONTANA
BRANCH OFFICES: BILLINGS, MONTANA; KALISPELL, MONTANA; BOZEMAN, MONTANA; RIVERTON, WYOMING

NO.	DESCRIPTION	DATE	BY:

REVISIONS



SCALE: 1"=20'

SHEET TITLE
SECTION
R.C.C. GRAVITY DAM

PROJECT NUMBER 1780-14-02(34)
SHEET NUMBER J2

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

NAVAJO COUNTY, ARIZONA

DRAWN BY: GJA
CHK'D BY: BK
APPR BY: GWK
DATE: 12-10-86
Q.A.
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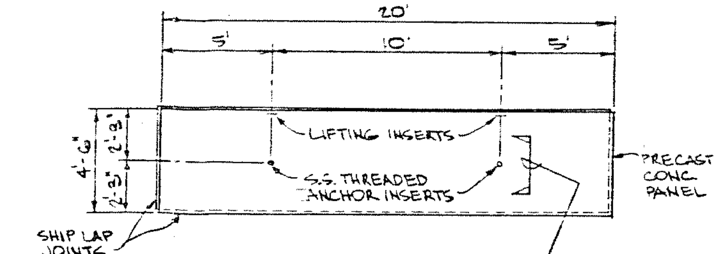
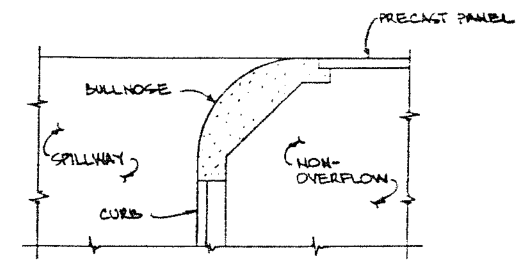
BRANCH OFFICES BILLINGS, MONTANA KALISPELL, MONTANA BOZEMAN, MONTANA RIVERTON, WYOMING

NO.	DESCRIPTION	DATE	BY

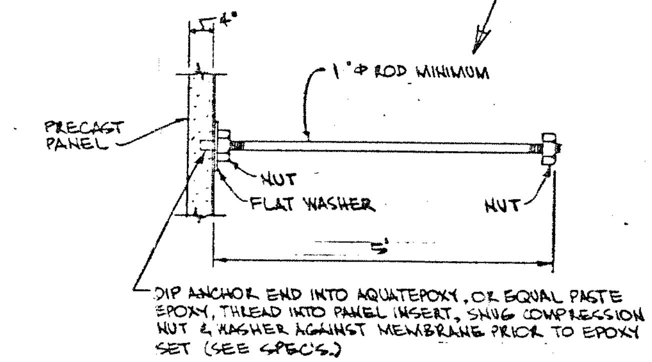
REVISIONS



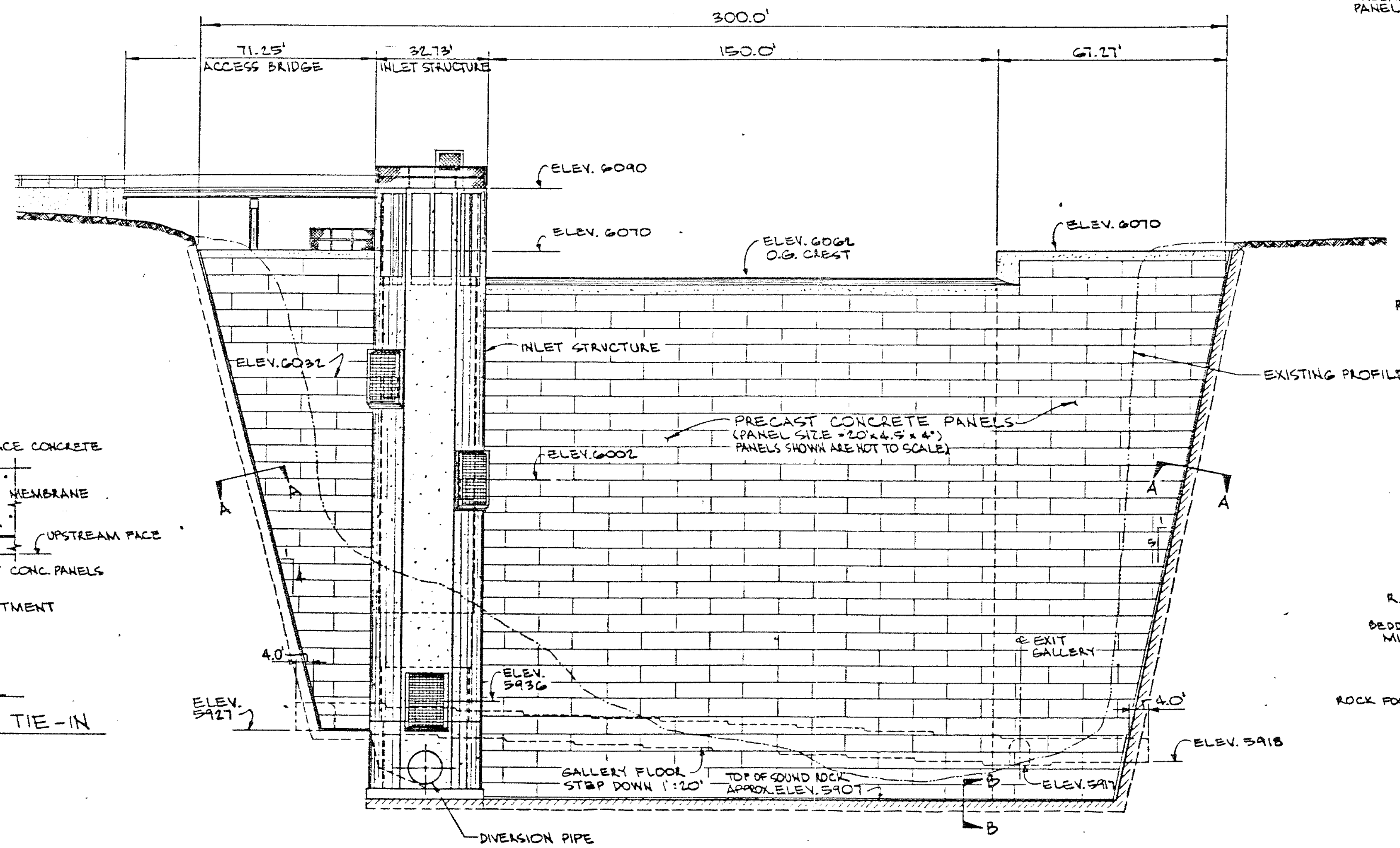
ELEVATION VIEW



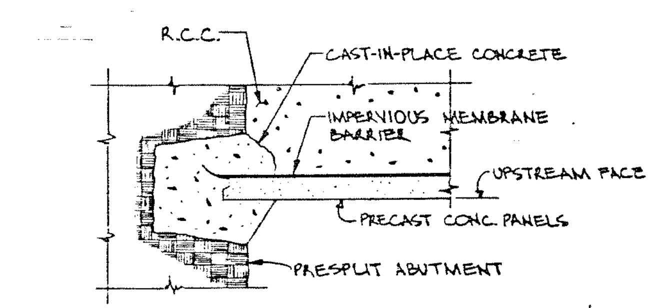
BULLNOSE DETAIL



TYP. PRECAST PANEL DETAILS

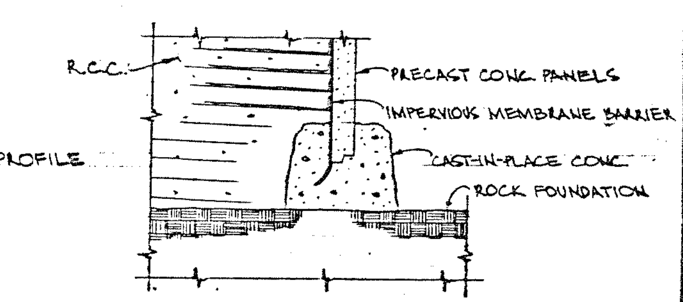


UPSTREAM ELEVATION



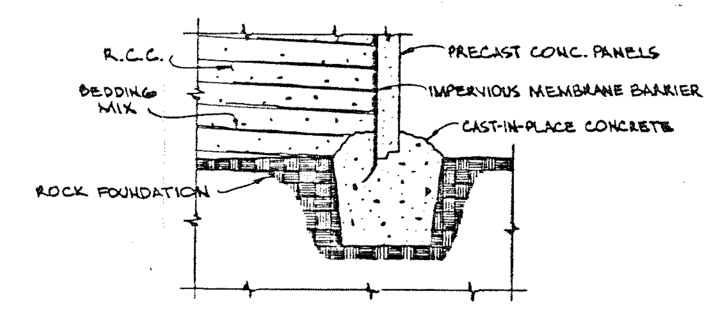
SECTION A-A

R.C.C. DAM ABUTMENT WALL TIE-IN



SECTION B-B

(WHERE ROCK IS BELOW BASE OF CONC. PANEL)



SECTION B-B

R.C.C. DAM FOUNDATION TIE-IN

SCALE: 1" = 20'

SHEET TITLE

UPSTREAM ELEVATION
R.C.C. GRAVITY DAM

NO	DESCRIPTION	DATE	BY

REVISIONS

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
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HELENA, MONTANA 59604

DRAWN BY: CJA
CHK'D BY: BK
APPR BY: GWR
DATE: 12-10-86
Q.A.
PEER REVIEW

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

NAVAJO COUNTY, ARIZONA

PROJECT NUMBER 1780-14-02(34)

SHEET NUMBER J2A

SHEET TITLE
PLAN
CONC. GRAVITY DAM

PROJECT NUMBER 1780-14-02(34)
SHEET NUMBER J3

MINER FLAT DAM
WHITE MOUNTAIN APACHE RESERVATION
NAVAJO COUNTY, ARIZONA

DRAWN BY: CJA
CHK'D BY: BK
APPR. BY: CWK
DATE: 12-10-86
Q.A.
PEER REVIEW

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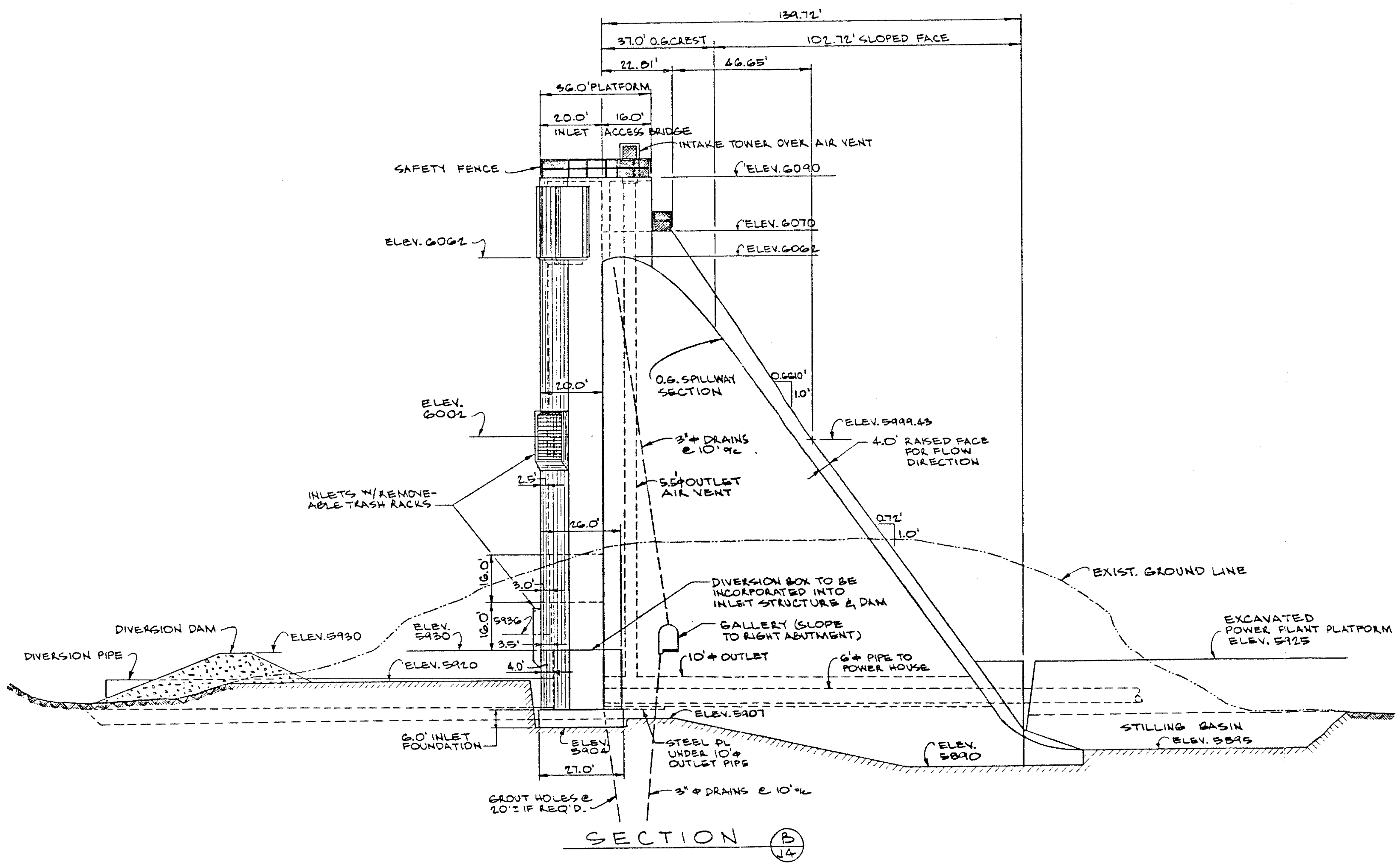
CORPORATE OFFICE HELENA, MONTANA
BRANCH OFFICES BILLINGS, MONTANA KALISPELL, MONTANA BOZEMAN, MONTANA RIVERTON, WYOMING

NO	DESCRIPTION	DATE	BY

REVISIONS



SCALE: 1"=20'

SHEET TITLE
SECTION
CONC. GRAVITY DAM

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

NAVAJO COUNTY, ARIZONA

DRAWN BY: CJA
CHK'D. BY: BK
APPR. BY: CVVK
DATE: 12-10-86
Q.A.
PEER REVIEW

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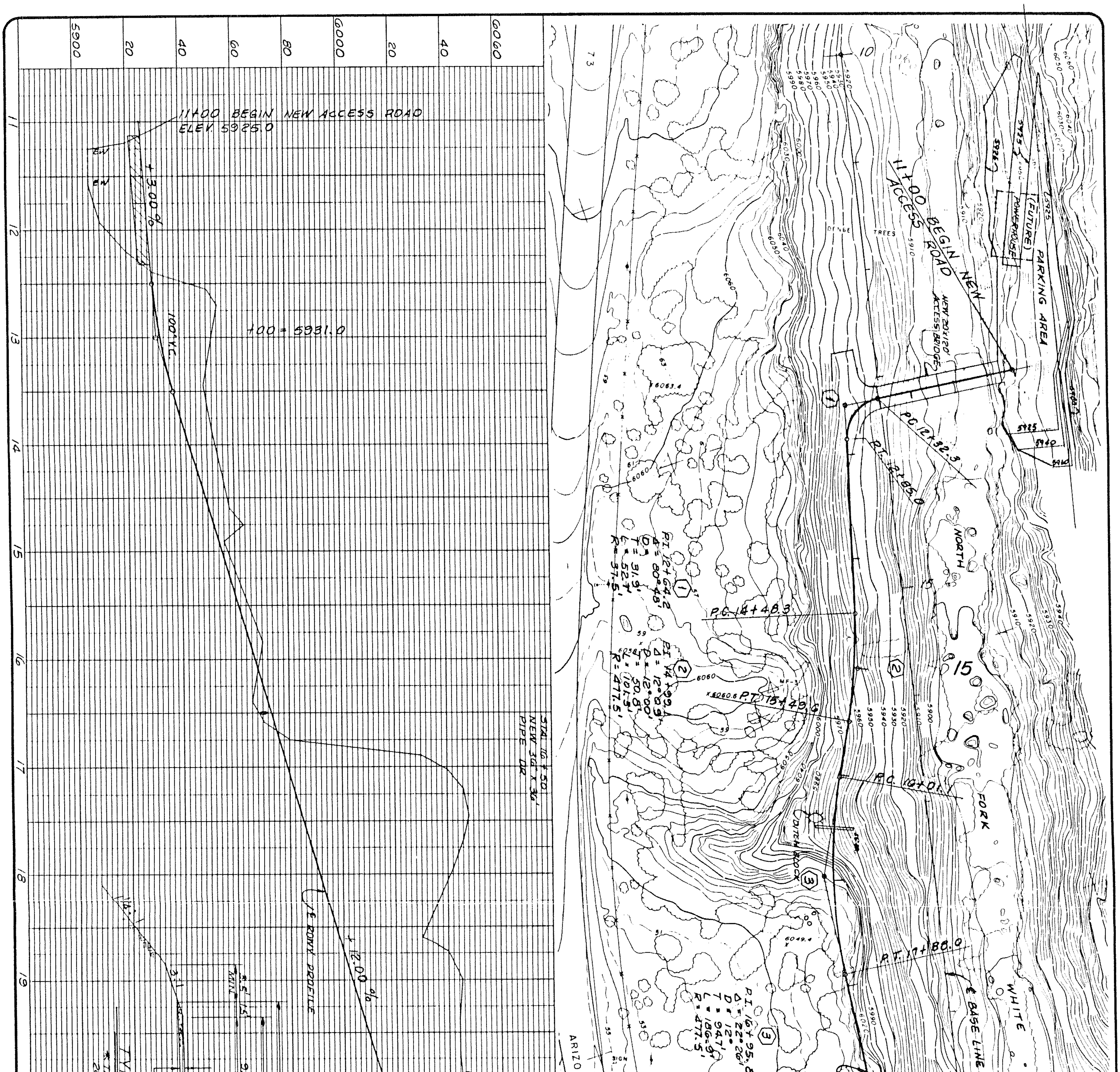
BRANCH OFFICES BILLINGS, MONTANA KALISPELL, MONTANA BOZEMAN, MONTANA RIVERTON, WYOMING

NO.	DESCRIPTION	DATE	BY:

REVISIONS

PROJECT NUMBER 1780-14-02(34)

SHEET NUMBER J4



PROJECT NUMBER	1780-14-02(34)
SHEET NUMBER	J5

MINER FLAT DAM

WHITE MOUNTAIN APACHE RESERVATION

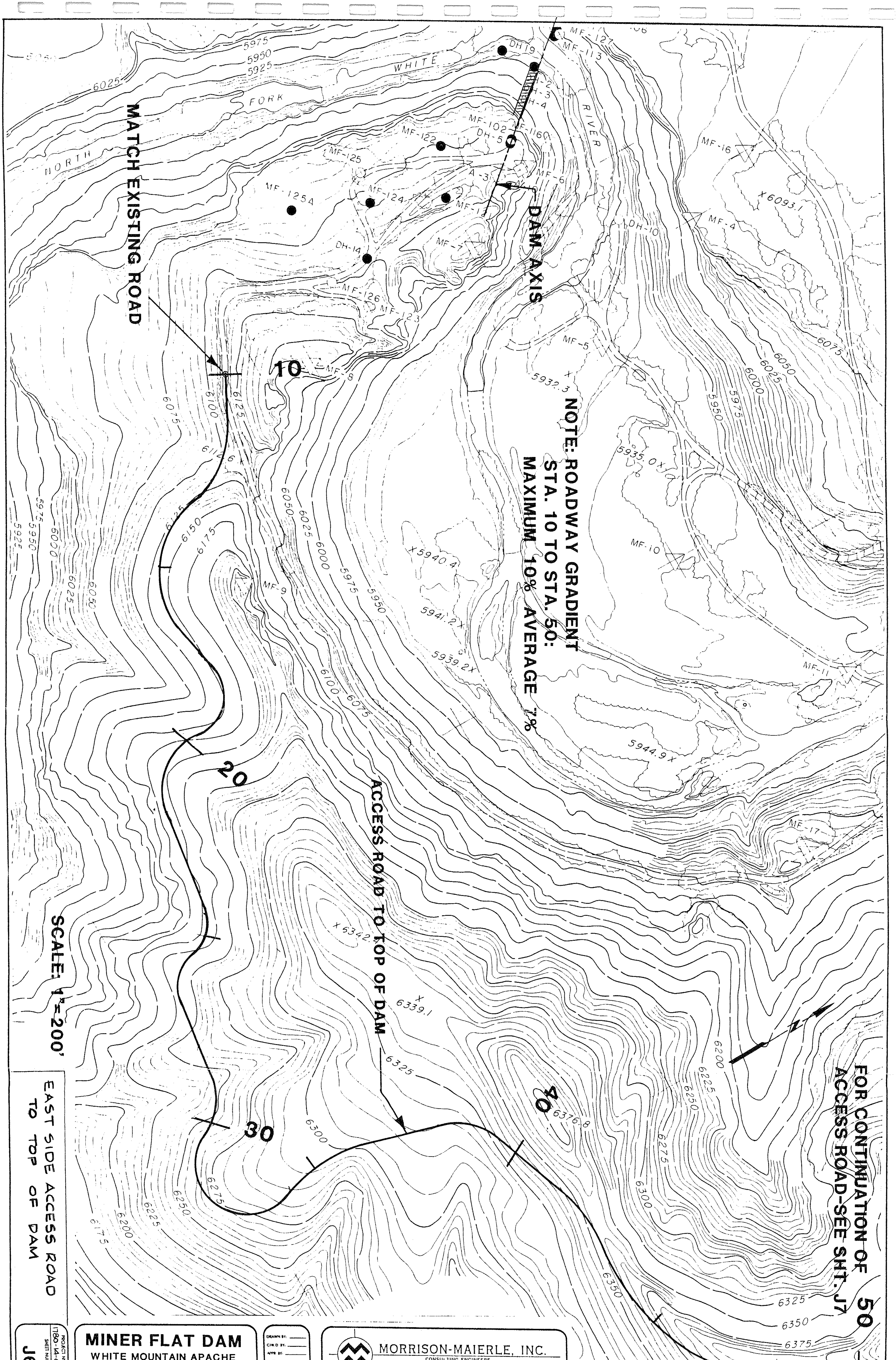
NAVAJO COUNTY, ARIZONA

DRAWN BY: KHL
CHK'D. BY: RJP
APPR. BY: CWK
DATE: 12-10-86
Q.A.
PEER REVIEW

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
910 HELENA AVE. P.O. BOX 6147
HELENA, MONTANA 59604

NO.	DESCRIPTION	DATE	BY

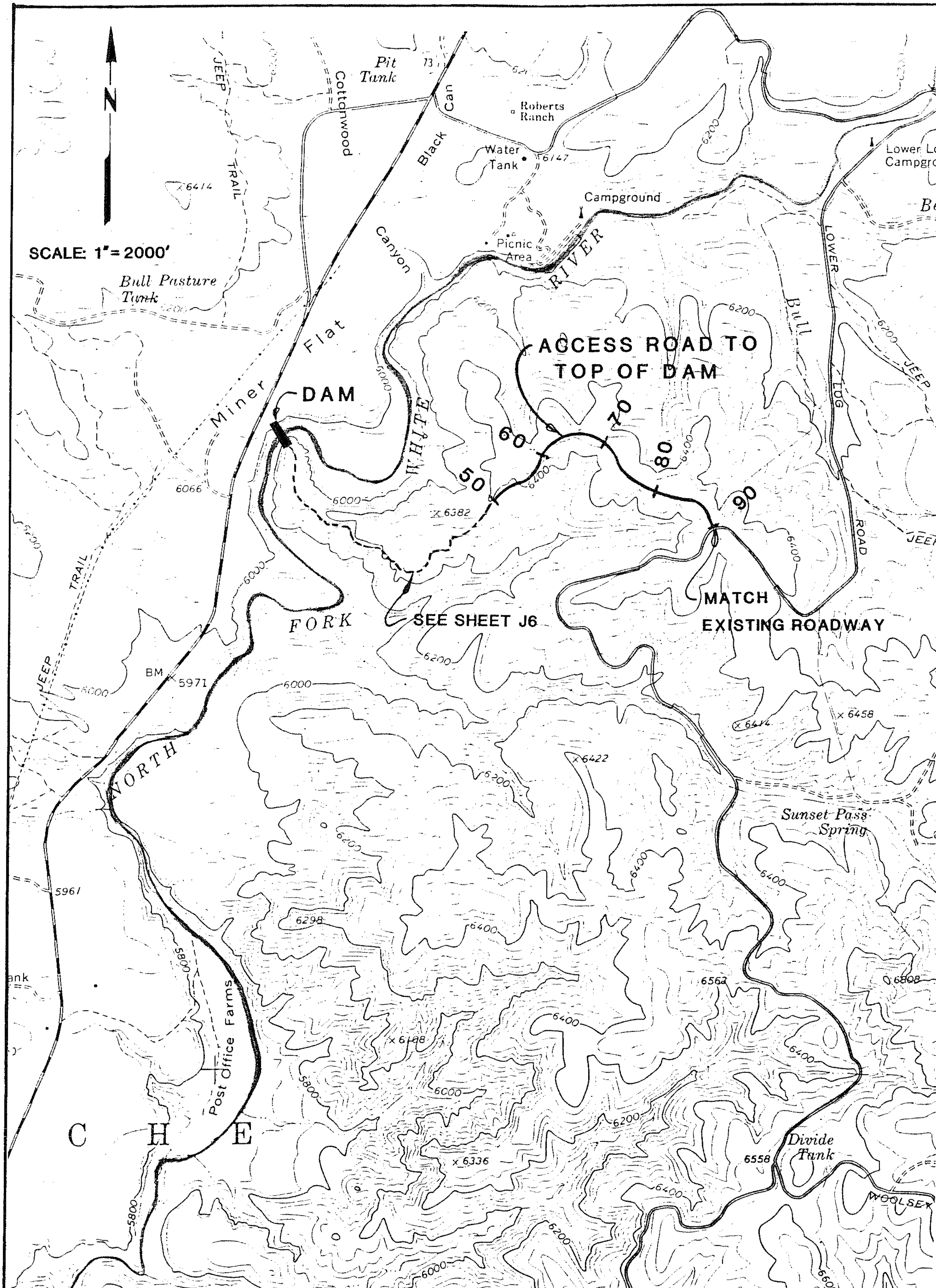
REVISIONS



MINER FLAT DAM
WHITE MOUNTAIN APACHE
RESERVATION
NAVAJO COUNTY, ARIZONA

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
910 HELENA AVE. P.O. BOX 6147
HELENA, MONTANA 59604

PROJECT NUMBER 1180-14-02(34)
SHEET NUMBER J6



NOTE:
ROADWAY GRADIENT STA. 50 TO STA. 90:
MAXIMUM = 5% AVERAGE = 2%

EAST SIDE ACCESS ROAD
TO TOP OF DAM

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
910 HELENA AVE P.O. BOX 6147
HELENA, MONTANA 59604

DRAWN BY:
CHK'D BY:
APP'D BY:
DATE:
Q.A.
PEER REVIEW

MINER FLAT DAM
WHITE MOUNTAIN APACHE RESERVATION
NAVAJO COUNTY, ARIZONA

PROJECT NUMBER
1780-14-02 (34)
SHEET NUMBER
J7