RECOMMENDATION REPORT

COLTER CHANNEL PROJECT

November, 1992

FCD 92-02

Prepared by:

CRSS Civil Engineers, Inc.
4041 North Central Avenue
Suite 650
Phoenix, AZ 85012

Wood, Patel & Associates, Inc.
4105 North 20th Street
Suite 130
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Registered Professional Engineer (Civil) Certificate No. 20207 GEORGE K. COTTON Date Signed 11/30/93 ARIZONA, U.S.A.

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Registered Professional Engineer (Civil) CERTIFICATE NO. 20207 GEORGE K. COTTON Date Signed 11/30/92 ARIZONA, U.S.A.

Registered Professional Engineer (Civil) CERTIFICATE NO. 10512 ASHOK C. PATEL Date Signed 11/30/92 ARIZONA, U.S.A.

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RECOMMENDED PLAN

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Registered Professional Engineer (Civil)
CERTIFICATE NO.
20207
GEORGE K.
COTTON
Date Signed 11/30/92
ARIZONA, U.S.A.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
10512
ASHOK C.
PATEL
Date Signed 11/3...
ARIZONA, U.S.A.

ACKNOWLEDGEMENTS

The CRSS & Wood-Patel team is pleased to have participated in the preparation of this **Recommendation Report** on the **Colter Channel Project.** Development of this report presented many interesting and unique challenges requiring creative solutions.

Mr. Don Rerick of the Flood Control District of Maricopa County and Mr. Kent McLain, P.E. of the Maricopa County Department of Transportation provided critical technical support and decision-making guidance throughout the study phase. They made themselves available with short notice to discuss the study progress and potential solutions. Their contributions represent a key role in the successful and timely completion of this report.

Further team support was obtained from the firms of SHB-Agra, Inc. (Geotechnical) and Alpha Engineering Group, Inc. (Structural) who provided consultant services and assistance in data collection and data interpretation.

We sincerely enjoyed these relationships throughout the completion of this exciting project.

George Cotton, P.E.
CRSS Civil Engineers, Inc.

Ashok C. Patel, P.E.
Wood, Patel & Associates, Inc.

SUMMARY STATEMENT

A preliminary concept design has been developed for the Colter Channel based on the Flood Control District of Maricopa County's (District's) hydrology together with detailed field topographic data and soil analysis developed for this study. All figures and maps are prepared based on the future condition flows in Colter Channel. An analysis was also made to evaluate the existing condition flows and its impact on right-of-way requirements and improvement costs. The following conclusions were drawn:

1. The channel as depicted on the recommended plan sheets 1, 2, and 3 is feasible along the District's proposed alignment.

2. Some adjustments to the right-of-way requirement are needed. Generally, the right-of-way can be reduced along the westerly end within the Hyde and Corpstein properties. However, additional right-of-way is necessary within the Agua Fria River overbank area.

3. An alternative new alignment was evaluated that followed the north boundary of the Corpstein Parcel and then along the west edge of Dale Creek Wash. This alignment was found to be feasible, as well as cost-effective. However, it created some negative impact in terms of increase in flow contribution to the Dysart and Camelback Road intersection. As a result, it was rejected from any further considerations.

4. Side inflows can be collected and introduced into the channel by means of several side swales and side weirs. For minimizing erosion of the north bank and reducing more frequent maintenance, a collection system of side swales is proposed. These side swales are capable of handling a 10-year storm with additional capacity within freeboard . The proposed side weirs are capable of handling the 100-year storm peak flows.

5. For collection of side inflows, a complex situation exists at the confluence of Dale Creek Wash and Colter Channel because the approach angle of Dale Creek and tributary is nearly 90 degrees. This, combined with the magnitude of side inflow and the long reach over which the side inflow takes place, requires that an interceptor side ditch be used instead of a single side weir. Because of the large width of the Dale

Creek/tributary floodplain, a concrete lining is needed to eliminate erosion to the north collector channel bank. A confluence angle of 20 degrees is used to introduce the large interceptor channel flow into the main channel. Since the side channel serves as a collector channel, no freeboard is provided.

6. A cost feasibility of bridge crossings were made for both Dysart and El Mirage Roads. It was concluded that a box culvert type of structure will be less expensive than the conventional flat slab type of bridge.

7. To evaluate cost effectiveness for a drop structure at Station 99+00, two types of drops were evaluated. Accordingly, a straight concrete drop and a sloping grouted rip-rap drop were analyzed. A detailed hydraulic analysis for these drops were performed to establish the structure size parameters.

   Based on estimated wall thicknesses, the straight drop structure was found to be about 40% less expensive than the sloping drop structure. Because of the cost effectiveness together with durability, longer life span and maintenance reasons, the straight drop structure was selected for further considerations.

8. The Airline Canal and two existing maintenance roads can be accommodated on a 45 foot wide box culvert. While the existing concrete irrigation ditch can either be relocated by widening the box by 5 feet at a cost of $3,600, or by providing a steel pipe flume across the channel at a cost of $7,500.00.

   To upgrade the box culvert width from the 45-foot to the 60-foot size to accommodate a future collector road, the cost increase would be $10,675.

9. Relocation of utilities are needed at Dysart, El Mirage, at 129th Avenue and at Station 67+40. No major problems are anticipated for these relocations.

10. There are several irrigation and tailwater ditches in the vicinity of El Mirage Road. Relocation by means of piping, realigning or by providing a flume will be required. No unusual problems are anticipated for these relocations.

11. Based on the detailed hydraulic analysis of Agua Fria River and Colter Channel confluence, it was concluded that:

    a. The 100-year diverted flow can be conveyed within the incised cross-section of Colter Channel.

    b. The tailwater condition caused by 10-year post-New Waddell Dam flows creates a backwater condition within Colter Channel. However, coincidental flow from a 10-year storm within Colter Channel will be conveyed within the incised section of Colter Channel.

    c. By using the 25-year water surface elevation as a starting water surface at Station 122+00, based on the New Waddell Dam condition within the Agua Fria River west overbank, the Colter Channel flow is contained within the incised cross-section.

    For the above reasons, the Colter Channel flow would not breakout for the stated conditions. Therefore, it is our opinion that a flowage easement is not needed within the west overbank of Agua Fria River.

12. The differences in costs and right-of-way requirements for the future and existing hydrology condition are summarized below and are detailed in Tables 3E and 3F:

	Improvement Costs	Right-of-Way Needs
Future Condition	$2,191,500	81.7 Acres
Existing Condition	$1,989,000	75.1 Acres
Difference in Cost/ROW	$ 202,500	6.6 Acres

1.0 INTRODUCTION

The proposed Colter Channel is an earthen channel, located along the Colter Street alignment, beginning approximately one-quarter mile east of Litchfield Road and extending east approximately 14,000 feet to the Agua Fria River. The channel alignment, shown on Figure 1, crosses Dysart Road, Airline Canal, El Mirage Road, an access road to ABC Sand and Rock, and an access road to a high voltage transmission tower corridor.

The purpose of Colter Channel is to intercept and convey diverted 100-year storm flows from the watershed north of the Colter Channel alignment and from the area of the old Murphy Dam to the Agua Fria River. Hydrology results from the White Tanks -Agua Fria River Area Drainage Master Study by the Flood Control District of Maricopa County (District) are used as the basis of this report. The channel section has been designed to convey storm flows within the predetermined project corridor.

The purpose of this Recommendation Report is:

1. Set the final channel alignment and profile
2. Prepare a conceptual design of the channel section
3. Evaluate the additional channel features of the channel section including those necessary to control side flows
4. Address sediment yield, transport, and deposition within the channel
5. Provide information on bridge crossing type and size for Dysart Road & El Mirage Road for the Maricopa County Department of Transportation (MCDOT)
6. Prepare concept cost estimates including right-of-way needs
7. Evaluate cost and land requirements associated with upgrading the concept design to handle additional flow (future condition design) as a result of relaxation in retention requirements
8. Make recommendations concerning the channel's impact on the Agua Fria River hydrology and floodplain.
9. Summarize the impact on the 404 and 401 permitting process.

2.0 FIELD SURVEY, LAND OWNERSHIP AND RIGHT-OF-WAY

Field Surveys were performed along the Colter Channel project corridor to prepare topographic base maps with one-foot contour intervals. Sufficient topographic mapping was obtained to identify locations of concentrated flow along the north project corridor limit. The topographic mapping extends into the Agua Fria River floodplain to enable a determination to be made for locating the outfall of the channel. Horizontal control is based on the State Plane coordinate system of 1927; vertical control is based on NGVD 1929 datum.

At the El Mirage and Dysart Road crossings, cross-sections of the existing road right-of-way were obtained by ground survey as follows:

a. Cross-sections were spaced at 50 feet for a minimum of 500 feet north and south of the channel centerline.
b. Cross-sections were taken to the full width of the existing road right-of-way.
c. Elevations to an accuracy of 0.01 foot were obtained on all existing concrete, asphalt, and drainage and irrigation pipes and ditches.

3.0 UTILITIES

This section provides information on the location of utilities in the vicinity of the Colter Channel project corridor. The locations of known conflicting utilities have been identified. In the case of some underground utilities the location was verified by "potholing" the line during the field survey phase of the preliminary design. "Pothole" excavations were conducted by SHB Agra, Inc. (SHB), the geotechnical subconsultant, together with soil test pits.

3.1 Ownership

The following table identifies by owner utilities that cross the Colter Channel corridor.

Owner	Facility
Santa Fe Pacific Pipeline Partners, L.P.	6-inch high pressure refined petroleum products pipeline
Tierra Buenna Water (Valley Utilities Water)	6-inch waterline
Arizona Public Service Company (APS)	Dysart Road - Overhead power line Agua Fria River - 69KV line
U S WEST	Dysart Road Buried telephone line (4PC-4" conduits with cable)

There are several utilities adjacent to the proposed Colter Channel corridor which were contacted who indicated that they will not be impacted by channel construction.

SunCor Development Co. - There are several utilities located in the Litchfield Road right-of-way, including a 10-inch sewer line extension from Litchfield Park.

Arizona Public Service Co. - There are power poles along Colter Street, east and west of Dysart Road.

U S WEST - There are buried telephone conduits along Litchfield Road west of the proposed channel termination. There are buried telephone conduits along El Mirage Road from Camelback Road that do not extend across the proposed channel alignment.

Southwest Gas Corp. - There is a high pressure gas line along Litchfield Road west of the proposed channel termination.

The following utilities were contacted who indicated that they do not have service or facilities in the project area:

El Paso Natural Gas Company	City of Glendale
Salt River Project	City of Phoenix
AT&T	City of Avondale
US Sprint	Dimension Cable
MCI	Insight Cable

3.2 Location

The following table summarizes the locations of major utilities that cross the channel corridor.

Company	Facility	Location
Santa Fe Pacific Pipeline Partners, L.P.	6-inch High Pressure Petroleum Line	Station 54+65
APS	Overhead Power Line	Station 54+80
U S WEST	Underground Telephone	Station 55+20
U S WEST	Underground Telephone	Station 55+50
Tierra Buena	6-inch Waterline	Station 67+40
APS	Overhead Power Line	Station 106+60

In addition, there are six locations where irrigation canals or ditches intersect or cross the channel corridor. The following table summarizes the locations of irrigation ditches that cross the channel corridor.

Facility	Location
Airline Canal	Station 82+75
Supply Ditch	Station 83+50
Tailwater Ditch	Station 105+50
Tailwater Return Ditch	Station 109+80
Tailwater Ditch	Station 110+20
Supply Ditch	Station 127+00

3.3 Conflicts With Channel

Construction of Colter Channel will require relocation of the major utilities that cross the channel corridor. Telephone and power utilities will need to be reset vertically to span the channel. Coordination for relocation of these utilities should be routine and should not result in any period of lost service for local customers. Relocation of the Tierra Buena waterline may require a brief temporary closure of the line since another water supply is not available for the service area.

Relocation of the high pressure gas line will require significant coordination during the design phase of the project. Service to Luke Air Force base is intermittent, a temporary shutdown for relocation will involve a number of parties and will require close coordination during construction.

Irrigation canals, supply ditches and return flow ditches will need to cross the Colter Channel to maintain water distribution to farmland by means of realignment of ditches or by flumes. Tail water ditches will drain to the Colter Channel.

4.0 GEOTECHNICAL DATA AND SOILS

4.1 Introduction & Project Description

This section is prepared pursuant to performance of a geotechnical investigation performed by SHB AGRA, Inc. (SHB) of the Colter Channel. The purpose of the investigation was to examine the subsurface profile along the 2.89 mile alignment of the proposed channel. This information has been used to provide recommendations concerning excavation, slope stability and erosion protection of the channel. A further objective of the investigation was to provide recommendations for bridge or box culvert foundations at El Mirage Road, Dysart Road and the Airline Canal crossings of the Colter Channel.

It is understood and serves as a basis for our recommendation that a flood control channel will be built north of Camelback Road between Litchfield Road and the Agua Fria River north and east of the community of Litchfield Park.

The channel begins about 0.2 miles east of Litchfield Road in Section 15, T2N, R1W. The channel alignment is oriented approximately due east in a corridor which is located between 1/4 and 1/2 mile north of Camelback Road to a point 1/4 mile east of El Mirage Road. At that location, the alignment bends slightly to the south and terminates at the west bank of the Agua Fria River about 0.2 miles north of Camelback Road.

The channel invert will generally be about 4 to 5 feet below existing grade and will be as deep as 8 feet below surrounding grade in certain locations. The existing ground surface falls from elevation 1066 feet to about elevation 1020 feet, which is approximately 0.3 percent over the 2.89 miles.

Structures will be required to allow Dysart Road and El Mirage Road to cross over the channel. Both bridges and box culverts will be considered for these two locations. A new box culvert will convey the Airline Canal under the Colter Channel.

4.2 Investigation

4.2.1 Subsurface Investigation

Backhoe Test Pits

Exploratory test pits were excavated with a Case 580K backhoe at 26 locations along the 2.89 mile alignment. For location of the test pits, see Recommended Plan, Sheets 1,2, & 3. Most of the test pits were advanced to a depth of about 12 feet below existing grade in the area. At one location, the backhoe experienced refusal on a strongly cemented stratum. At a few other locations, particularly east of El Mirage Road near the Agua Fria River channel, the pits were terminated at shallower depths due to severe trench caving of the cohesionless "river-run" deposits.

Excavation of the test pits was directed and continuously observed by our field engineer, Roman Y. Jauregui, P.E. Mr. Jauregui prepared geotechnical logs of the pits which are presented in a report bound separately. Bulk samples of soils were retrieved from the sides of the various pits and were transported to our laboratory for testing.

4.2.2 Exploratory Borings

Borings were performed at 8 locations with a truck-mounted CME-55 drill rig advancing 6 5/8-inch diameter hollow stem auger. Borings were completed at three locations each near the Dysart Road and the El Mirage Road crossings, and at two locations near the Airline Canal crossing.

Standard penetration testing and sampling in accordance with ASTM D1586 or open-end drive sampling using a 3-inch diameter split barrel drive sampler were performed at selected intervals in the borings.

Drilling of the borings also was directed by Mr. Jauregui. Geotechnical logs of the auger borings are also presented in a report bound separately along with site plans showing the boring and test pit locations.

4.2.3 Laboratory Testing

Index tests (moisture content, dry density, Atterberg limits, grain-size distribution and hydrometer) were performed on selected drive samples and bulk samples recovered from the borings and test pits. Moisture content and dry density values are present on the boring logs. Grain-size distribution and Atterberg limit test results are presented in the Technical Appendices.

Direct shear tests were performed on samples recovered from borings at the two possible bridge locations (Boring Nos. D-1, E-1, E-2 and E-3) for evaluation of the engineering behavior of the soils at those locations. Results of these tests are presented in the technical appendices bound separately.

4.3 PROJECT SETTING & GEOTECHNICAL PROFILE

4.3.1 Project Setting

The proposed alignment of the Colter Channel traverses the floodplain and terraces of the Agua Fria River. In Section 15 where the channel begins, the terrain is relatively undisturbed low desert with a relatively heavy growth of creosote and other desert brushes and a few mesquite trees. Between Dysart Road and El Mirage Road, the channel will cross land which is currently in cultivation or which apparently was cultivated in the past. An irrigated field presently exists within the half mile east of

Airline Canal. For about a half a mile west of El Mirage Road, the channel will traverse farm land. The final few hundred feet of the channel crosses the recent floodplain of the Agua Fria River. Some gravel mining operations within the river is occurring near the outfall.

4.3.2 Geotechnical Profile

Throughout the proposed alignment of the channel, fluvial and alluvial soils are present to depths of 10 feet and greater. The soils were deposited by running water either in the channel of the ancestral Agua Fria River or on alluvial fans reaching over the river's floodplain.

For purposes of discussion of subsurface conditions, the project site is divided into segments and structure locations as follows:

Channel Beginning to Dysart Road

Soils within this segment mainly consist of stratified fine grained alluvium. Silty clay and clayey silt predominant, with a lessor amount of clayey fine sand and silty sand also being present. The plasticity of the clay fraction is mostly in the low to medium range. Nearly all of the soils are cemented to some degree with calcium carbonate. In the upper 2 to 4 feet, the cementation is generally weak. Weak to moderately weak cementation is present at greater depths. Strong cementation of a mostly fine grained soil is attributed as the cause of refusal of the backhoe at location of TP-1 near the beginning of the channel.

Dysart Road Crossing

From the surface to depths of about 20 feet, clayey sand and silty sand with only a small percentage of gravel is present. The clays exhibit low to medium plasticity and are weakly to moderately cemented with calcium carbonate. From 20 to about 58 feet, clayey or silty sand and gravel mixtures are present. While the percentage of gravel and cobble sized fragments is large, the clay/silt and cement binder provides cohesion. At a depth of 58 feet in Boring No. D-2, a very highly plastic clay stratum was encountered.

Dysart Road to El Mirage Road

Soils to a depth of 12 feet are predominantly sandy, but possess sufficient clay and silt to behave as cohesive soils. A small amount of gravel is present. Generally the percentage of gravel increases toward the east. At most locations the soils encountered were cemented to some degree with carbonate, typically in the range of weak or weak to moderate.

Airline Canal Crossing

At the location where the Airline Canal will cross the Colter Channel, the subsoils consist of stratified silty sand, clayey sand and sandy clay in the upper 8 to 12 feet. At greater depths, silty sand, with some to considerable gravel, is present. The clayey soils exhibit highly variable plasticity, ranging from very low to high. Nearly all of the soils are weakly to moderately cemented with calcium carbonate.

El Mirage Road Crossing

From the surface to a depth of 8 to 12 feet, a silty sand and gravel mixture is present. This stratum possesses little if any plasticity, but is weakly cemented with calcium carbonate. Below the surficial stratum, a lens or pocket of silty clay, which is medium to highly plastic, was encountered. This stratum is about 10 to 15 feet thick. Below a depth of about 30 feet, a weakly cemented, well graded sand and gravel stratum is present to depths of 40 to 60 feet (Boring No. E-2).

El Mirage Road to Agua Fria River

Nearly all of the soils encountered to a depth of 12 feet are granular, being well graded clean sands, silty sands and sand/ gravel mixtures. A few cobbles are also present in isolated strata. These soils are geologically recent channel and floodplain deposits of the Agua Fria River. Cementation for the most part is not present and locally severe caving of the sides of the backhoe test pits occurred.

4.3.3 Soil Moisture & Groundwater Conditions

No free groundwater was encountered in any of the borings. Moisture contents were found to be generally low throughout, which is typical in a desert setting.

4.4 DISCUSSION & RECOMMENDATIONS

4.4.1 Excavation & Conditions

Mass excavations for the channel can be made with conventional earth-moving equipment. In some locations, particularly west of Dysart Road, the cementation of the alluvial soils may result in difficult excavation. The use of heavy ripping teeth or of a hoe ram may be necessary in zones where strong cementation is encountered. The need for controlled blasting is not anticipated. For the segment east of El Mirage Road, excavation in the granular soils will be relatively easy, however caving and ravelling will occur if steep cuts are made. The contractor should take the necessary steps to provide safety with this particular type of soil condition.

4.4.2 Slope Stability & Erosion Protection

Permanent cut slopes in the sides of the channel should be no steeper than 1 1/2:1 (horizontal to vertical). In the relatively uncemented soils east of the El Mirage Road, permanent slopes should not exceed 2:1 without some type of erosion protection.

Throughout most reaches of the channel, the moderate to strong cementation of the predominantly fine grained soils will have the effect of greatly limiting the amount of erosion which will occur during the intermittent flows in the channel. In those reaches where cementation is very weak or absent, some erosion protection may be required.

4.4.3 Foundation Design for Box Culverts

At the site of the Airline Canal, a box culvert will be used to carry the Airline Canal under the Colter Channel. It is anticipated that the bottom of the box will be 5 to 8 feet below general surrounding grade.

Excavation should be made to the planned elevation of the base of the culvert floor. The exposed surface should be observed by a site representative of the geotechnical firm. If locally soft or wet zones of soil are encountered, overexcavation and replacement with structural fill would be directed. If firm cemented soils, typical of these encountered in nearby borings (A-1 and A-2) are encountered, no overexcavation will be required.

If fill is needed beneath the floor of the box culvert, it should be placed in lifts no thicker than 8 inches and compacted to a density which is at least 95 percent of maximum dry density as determined by ASTM D698. The moisture content during compaction should be maintained within the limits of 1 percent below to 3 percent above optimum moisture content.

It is recommended that a minimum of 4 inches of aggregate base course be placed beneath the floor of any box culvert to provide a smooth working surface and to aid in the curing of concrete.

With the treatment described in this section, an allowable soil bearing pressure of 2,000 pounds per square foot (psf) should be assigned to the foundation soils for dead plus live loads.

At the Dysart Road and El Mirage Road crossings, it is anticipated that if box culverts are used to carry the Colter Channel beneath the roadways, the floor of the box will be about 4 to 6 feet below roadway grade. At these depths, the box floor should be designed on the basis of an allowable soil bearing pressure of 2,000 psf for dead plus live loads at both locations.

4.4.4 Design Criteria for Box Culvert Walls

In designing for earth pressure against box culvert walls, it is assumed the structure will be rigid and absolutely restrained from lateral movement. Accordingly, the walls will be subject to a hydrostatic load diagram equal to that of a fluid imposing 50 pounds per square foot per foot of depth.

Relatively free draining granular backfill should be utilized behind the north and south sides of the culvert(s) above the channel elevation. This material should consist of relatively clean sand and gravel having no more than 12 percent passing the no. 200 sieve. The materials should be nonplastic when tested in accordance with ASTM D4318. Compaction of the fill should be to at least 95 percent of maximum dry density as determined by ASTM D698.

4.5 Drilled Pier Foundations for Bridges

4.5.1 Downward Capacities

If a conventional bridge structure is chosen for a drainage crossing, straight drilled, cast-in-place concrete piers may be used for support of bridge foundations at both the Dysart Road and El Mirage Road crossings. Piers should extend at least 10 feet below the elevation of the bottom of the channel and 10 feet below the pier cap or grade beam, whichever results in the greater depth. Safe downward capacities for 18-, 24- and 30-inch diameter piers are presented below:

Dysart Road Crossing

Diameter (feet)	Depth (feet)	Safe Downward Capacity (kips)
1.5	10.0	57
	15.0	80
2.0	10.0	81
	15.0	112
2.5	10.0	108

El Mirage Road Crossing

Diameter (feet)	Depth (feet)	Safe Downward Capacity (kips)
1.5	10.0	65
	15.0	100
2.0	10.0	94
	15.0	141
2.5	10.0	120

The capacities apply to full dead plus live loads. A one-third increase is recommended when considering wind or seismic forces. A minimum shaft diameter of 18 inches is recommended for drilled pier foundations.

4.5.2 Estimated Settlements

It is estimated that the settlement of cast-in-place concrete pier foundations designed and constructed in accordance with criteria presented herein will not exceed 1/2 inch. In most instances, settlements will be less than 1/4 inch. Settlements will occur immediately after construction and the first few applications of live loads.

4.5.3 Resistance to Lateral Loads

For the design of isolated drilled pier foundations against lateral forces, the passive resistance should be considered as being equal to the forces exerted by an equivalent fluid having a unit weight of 900 pounds per cubic foot. A factor of safety of 2.5 is recommended in applying the ultimate bearing pressure to design.

Piers may be considered isolated when they are placed at least 3 diameters center to center perpendicular to the line of thrust, and 6 diameters center to center parallel to the line of thrust. Group reduction factors for more closely spaced pile groups can be provided upon request.

4.5.4 Geotechnical Conditions for Construction

It appears that drilled pier excavations can be advanced to the depths recommended with very little, if any, caving. A small amount of concrete overrun may occur where clean sands or silty sands are encountered. In our judgment, the pier excavations can be advanced with conventional auger drill rigs.

4.5.5 Cleaning of Pier Excavations

After each shaft has been advanced to the planned depth, the bottom of the excavation should be cleaned of slough and loose material in a manner acceptable to the geotechnical engineer. The cleaning should ultimately result in the bottom of the excavation having an average of no more than 4 inches of disturbed material prior to placement of concrete.

Various techniques may be used at the contractor's option to accomplish the cleaning. Manual cleaning with hand labor or by vacuum cleaning are acceptable. Careful machine cleaning with rig-mounted tools also is acceptable but the equipment should be approved by the geotechnical firm.

4.5.6 Placement of Concrete

Concrete should be placed through a hopper or other device approved by the geotechnical engineer so that it is channeled in such a manner to free fall and clear the walls of the excavation and reinforcing steel until it strikes the bottom.

Adequate compaction will be achieved by free fall of the concrete up to the top 5 feet. The top 5 feet of concrete should be vibrated in order to achieve proper compaction. The concrete should be designed, from a strength standpoint, so that the slump during placement is in the range of 5 to 7 inches.

4.5.7 Construction Quality Assurance

Continuous observation of the construction of drilled pier foundations should be carried out by a representative of the geotechnical engineer. The representative should verify proper diameter of the shaft, depth and cleaning, and should also verify the nature of materials encountered in the pier excavations. Concrete placement should be continuously observed to ensure that it meets requirements. A quality assurance report should be submitted on each pier stating all details have been observed and confirming that the pier meets construction requirements.

4.6 Spread-Type Footings for Bridges

Spread-type footings are feasible for the support of the bridges. However, spread-type footings are more susceptible to settlements should the supporting soils experience substantial moisture increases. This is particularly the case at the location at the El Mirage Bridge. Concrete lining in the bottom of the channel would assist in mitigating moisture infiltration and preventing scour. It is recommended that a preliminary safe soil bearing pressure of 4,000 psf be used to design spread-type footings. The footings should extend to at least elevation 1040 feet at Dysart Road and 1017 feet at El Mirage Road. A review of the above bearing pressures are recommended when the exact loads and type of bridge have been determined in order to estimate potential settlements.

4.7 Earth Fissure Inspection

A reconnaissance of the project area was made by David E. Peterson, P.G. and Keith H. Dahlen, P.E., both of SHB-Agra, Inc., on October 8, 1992. Recent aerial photography (Landiscor, Inc., negatives L-12 and M-12, dated October 3, 1990) was utilized to guide the field reconnaissance. The photos were examined for the presence of linear features which could indicate the existence of fissures. A known earth fissure located 2 miles north of the site (Shumann, 1974; SHB, 1982) was examined. This fissure was clearly active, displaying lineal collapse features, surface erosion and zones of piping.

Several features not previously identified as fissures were identified from the air photos and examined in the field. The investigation encompassed a 5-square mile area located mostly along and to the north of the proposed channel alignment. No features were identified during the site reconnaissance that would indicate the presence of fissuring near the proposed alignment of the Colter Channel.

Historical fissuring has occurred in several areas along the west flank of a large underground salt dome, known as the Luke Salt Body, which underlies the project site (Eaton, 1972). Both ground subsidence and fissuring in the area are the result of groundwater level declines to the west of the salt dome and east of the White Tank Mountains. Several maps depicting the location of earth fissures have been developed for the project area (Emcon, 1989; SHB, 1990, 1988, 1982; Laney and others, 1978; U.S. Army Corp of Engineers, 1973).

Depths to groundwater in the site vicinity were estimated to be on the order of 10 to 20 feet before extensive irrigation-based agriculture was established in the western Salt River Valley in the early 20th century (Smith and others, 1982). The groundwater decline between 1928 and 1968 was about 130 feet near the project site, however, the groundwater decline over much of the area between the salt body and the White Tank Mountains exceeded 300 feet. The groundwater level near the project site has risen about 20 feet since 1968 (Reeter and Remick, 1986).

Based on SHB's site reconnaissance and given the apparent geologic and hydrogeologic conditions in the site area, there appears to be little chance of earth fissuring occurring along or near the proposed channel alignment. The potential for fissures to occur within the project site appears to be limited to the area between Litchfield Road and Dysart Road, based on the existence of known fissures located north of Glendale Avenue which, if extended, would trend through this area.

5.0 HYDROLOGY

The Colter Channel hydrology is based on results from the White Tanks - Agua Fria River Area Drainage Master Study (ADMS) (Reference 5) as refined by the District. Hydrologic modeling for the ADMS was performed using the Corps of Engineers' HEC-1 program. Additional drainage into the channel caused by a "relaxation of on-site retention" requirements from sub-basins immediately adjacent to the north side of the channel was developed by the District for the channel design.

5.1 Agua Fria River Hydrology

The following available references on the frequency-discharge relationship on Agua Fria River below the New River confluence was reviewed to arrive at the 100-year peak design flows:

1. U.S. Army Corps of Engineers, *Hydrology for Evaluation of Flood Reduction by New Waddell Dam, Agua Fria River below New Waddell Dam to the New River confluence*, Preliminary, September, 1988.

2. Flood Control District of Maricopa County, *Flood Insurance Study, New River below Skunk Creek, Maricopa County, Arizona*, December 30, 1986 and the hydrology for *"New River & Agua Fria River"* by the U.S. Army Corps of Engineers.

Agua Fria River flows above the New River confluence appear in columns 2 and 3 of Table 1, without and with the New Waddell Dam, respectively. These flows were taken from the Corps of Engineers Study (Reference 1). Flows on New River above the Agua Fria River confluence were obtained from the New River Flood Insurance Study (Reference 2) and appear in column 4 of Table 1. This source, however, did not provide flows for the 2-, 5-, 25-, and 200-year events. These missing flows were estimated based on interpolation and extrapolation using a probability paper plot as shown on Figure 2. The updated New River data appears in column 5 of Table 1 on the following page.

Estimates of Agua Fria River flows below the New River confluence were made based on the assumption of coincidental flow peaks on both the Agua Fria River and New River. Columns 6 and 7 of Table 1 list the sum of Agua Fria River and New River flows without and with the New Waddell Dam, respectively. An additional Corps of Engineers Study of flows below the Agua Fria/New River confluence provided data on flows without the New Waddell Dam and without the assumption of coincidental flow (column 8, Table 1).

Since the assumption of coincidental flow is rather conservative and, since other data is available for the non-coincidental flow condition, flows from the latter source were used for Agua Fria flows at the Colter Channel outfall.

Design Flows:

The 100-year peak flows used in this Recommendation Report are as follows:

CONCENTRATION POINT	HEC-2 ID CHANNEL STATION	DESIGN PLAN CHANNEL STATION	PEAK FLOW	
			EXISTING	FUTURE
Western Origin	13790	14+10	67 cfs	70 cfs
242B	13175	20+25	120 cfs	125 cfs
242C	12400	28+00	270 cfs	340[1] cfs
242D	11970	32+30	490 cfs	540 cfs
242E	11700	35+00	490 cfs	620 cfs
242F	10000	52+00	840 cfs	1060 cfs
243A	7050	81+50	950 cfs	1080 cfs
243F	10800	44+00	710[3] cfs	900[3] cfs
243	4552	106+48	1040 cfs	1210 cfs
245	2000	132+00	1040[2] cfs	1210[2] cfs
Agua Fria Outfall	0	152+00	1040[2] cfs	1210[2] cfs

1 Interpolated between CP-242B and CP-242D for Future.

3 Interpolated between CP-242F and CP-242E

2 Modeled based on the diverted flow only equal to 1,210 cfs (future condition) because outfall channel is within Agua Fria floodplain. Actual flow from WLB hydrology, including the additional 100 cfs as mentioned above, is 2,170 cfs (existing condition) and 2,400 cfs (future condition).

Concentration Point locations and the channel alignment are shown on Figure 3 for the "Existing Condition" and on Figures 4 and 5 for the "Future Condition".

5.2 Colter Channel Hydrology

Hydrologic analysis of the drainage area of Colter Channel considered the existing condition and four scenarios of future development; however, for design purposes, only the following two scenarios were reviewed.

Existing Condition:

For the existing condition, the hydrologic characteristics for the contributing watershed were derived from the White Tanks ADMS. Figure 3 shows the subbasin delineation. The hydrologic analysis assumed that there are no developments in the area apart from those in existence as of July, 1992.

Future Condition:

For the future condition, consideration is given to relaxing the retention policy for those subbasins *immediately* adjacent to the Colter Channel alignment, thus allowing stormwater runoff from these adjacent areas to discharge directly to the channel without on-site retention. Future condition subbasin delineations are depicted on Figures 4 and 5. The future condition runoff was estimated using HEC-1 and the published plans of development for Litchfield Ridge, New Village Homes, and Wigwam Creek as indicated in preliminary plats available as of July, 1992.

The commercial development in subbasin 243 is expected to produce a peak stormwater flow 100 cfs greater than the HEC-1 prediction for that subbasin. The 100 cfs is an estimate based on the rational equation, which is permitted for use in parcels of 160 acres or less *(Drainage Design Manual for Maricopa County.)* Since developers of this parcel (subbasin 243) are likely to use the rational equation, an additional 100 cfs is added to the estimated peak flow at CP-243. This additional 100 cfs carries through the rest of the downstream reaches of the channel to the outfall in the Agua Fria River.

Channel Design:

a. Channel design is based on the 100-year flows as provided by the District based on the ADMS as discussed above. Additional flows from increased runoff due to a "relaxation of on-site retention" requirements for sub-basins adjacent to the north side of the channel have also been considered.

b. Design has been based on the "post-New Waddell Dam" Agua Fria River flows.

5.3 Agua Fria River/Colter Channel Confluence Hydrology

Since the proposed Colter Channel discharges into the Agua Fria River, the effect of coincidental flooding in the Agua Fria floodplain as a result of various frequency storms was considered. Specifically, the 2-, 5-, 10-, and 25-year events with the New Waddell Dam in place, and the 10-, 25-, and 100-year events without the New Waddell Dam. A HEC-2 model was developed for the reach of the Agua Fria River from Camelback Road upstream, a distance of approximately 10,000 feet. The flows used in this model were derived as described previously in Section 5.1, and the cross-sectional data were taken from the Agua Fria River Flood Insurance Study by Jerry R. Jones & Associates, Inc., (Ref. 6).

The results of the HEC-2 models, shown on Figure 6, indicate that flows in the Agua Fria River greater than the 10-year event breakout of the main channel and flood the west overbank area are as far west as El Mirage Road. This means that much of the lower reach (about 2,500 feet) of the proposed Colter Channel will be inundated by the Agua Fria during flows of a magnitude greater than or equal to the 10-year event.

5.4 Existing FIS Floodplain Delineations

The basis for the Agua Fria River floodplain analysis was the Agua Fria River Flood Insurance Study by Jerry R. Jones & Associates for the Flood Control District of Maricopa County, April 1988. This study provided the 100-year floodplain and floodway delineations as well as the base map and HEC-2 cross-sectional data for analysis of floodplains for additional flood frequency events on the Agua Fria River.

The flows in the HEC-2 model used in the Jerry R. Jones study were modified to reflect the 10-year Agua Fria flow with the New Waddell Dam and the 25-year flow without the New Waddell Dam. The resulting floodplain was delineated within the west overbank to determine the starting water surface elevation for the proposed Colter Channel.

6.0 CHANNEL DESIGN

6.1 Channel Alignment And Profile

The channel corridor was developed by the District based on work performed both in-house and by the District funded study which was performed by WLB Group Inc. as part of the White Tanks ADMS.

This concept study identifies the specific alignment with the corridor that is workable for the final design, based on the requirements of the channel cross-section and additional features such as side swales, side weirs, maintenance roads and Agua Fria River outfall. As a result, based on the future condition hydrology, the following right-of-way changes need to be further addressed:

Channel Plan Sections	Right-of-Way Requirements
Beginning of project to Hyde property line (Station 9+59 to 14+00)	It is possible to eliminate this portion of the Channel and still collect flows from the same watershed.
Hyde property line to Dale Creek (Station 14+00 to 28+00)	Decrease right-of-way width from 150 to 100 feet. Channel centerline coincides with right-of-way centerline.
Dale Creek Wash (Station 28+00 to Station 34+00) right-of-way centerline.	The 150-foot right-of-way along the channel alignment is sufficient for the Dale Creek confluence. Channel centerline coincides with
Station 34+00 to 42+00	Channel centerline coincides with a line 10 feet south of the right-of-way centerline. No change to right-of-way.
Station 42+00 to 52+00	Channel centerline coincides with a line 10 feet south of the right-of-way centerline. No change to right-of-way.
Station 52+00 to 58+00	Right-of-way widens from 200 feet to 240 feet to accommodate channel access ramps from north and south maintenance roads. Channel centerline coincides with right-of-way centerline.

Channel Plan Sections	Right-of-Way Requirements
Dysart Road to Airline Canal (Station 58+00 to 83+20)	Channel centerline coincides with a line 10 feet south of the right-of-way centerline. No change to right-of-way. This right-of-way will accommodate channel access ramps from north and south maintenance roads at Airline Canal.
Station 83+20 to 107+00	Right-of-way can be reduced from 350 feet to 270 feet (if it can parallel the meandering centerline of channel) and accommodate meandering channel per SunCor requirements. Channel centerline meanders within right-of-way.
El Mirage Road (Station 107+00 to 120+00)	Increase right-of-way and temporary construction easement south of channel centerline from 100 feet to 150 feet (200 feet to 250 feet total) to accommodate proposed channel section and new ABC Sand & Rock access road. Channel centerline coincides with a line 50 feet south of the right-of-way centerline.
Station 120+00 to 135+00	Increase right-of-way and temporary construction easement from 200 feet to 310 feet to accommodate proposed channel section and new ABC Sand & Rock access road. Channel centerline tapers from 50 feet south of right-of-way centerline at Station 120+00 to 20 feet south at Station 135+00.
Station 135+00 to 140+50	Increase right-of-way from 200 feet to 290 feet. Channel centerline varies from 20 feet south of channel centerline at Station 135+00 to coincide with right-of-way at Station 140+50.
Station 140+50 to 142+50	Increase right-of-way from 200 feet to 310 feet to accommodate access road to high voltage power line corridor. Channel centerline coincides with right-of-way centerline.
Station 142+50 to 151+85.31	Increase right-of-way from 200 feet to 290 feet to accommodate proposed channel section. Channel centerline coincides with right-of-way centerline.

Channel Plan Sections	Right-of-Way Requirements
Channel Outfall (Station 151+85.13)	From Station 151+85.13, extend right-of-way 200 feet east to Station 153+85.13, to a width of 600 feet; 100 feet north of channel centerline and 500 feet south of channel centerline.

The channel profile was developed based on new topographic mapping performed as part of this project. Slopes and flowline elevations were used such that the channel would be incised into the existing ground, eliminating the need for an embankment to confine the flows (other than the maintenance road) on the south side of the channel. Sheets 1, 2, and 3 depict recommended plan and profile of Colter Channel for the future condition. A typical channel section is shown on Figure 7.

Because additional right-of-way is required, it is recommended that archaeological, hazardous waste, and plant material count investigations be performed.

6.2 Reach Characteristics

Channel Section Alternatives:
The channel consists of an incised, unlined earthen channel with 6:1 side slopes to minimize bank erosion and to provide for easy maintenance access. Bottom widths vary along the alignment to account for variable flows. Because of existing topographic conditions east of El Mirage Road, the channel extends out into the Agua Fria River floodplain.

Existing - and Future Condition Difference:
The results of the White Tanks ADMS indicated that the future condition flows are somewhat greater than the existing condition flows (refer to the flow summary table on Figure 5). As a result, channel bottom widths are reduced between 2 and 30 feet in the existing condition compared to the future condition for a given channel depth. Furthermore, corresponding right-of-way width requirements also decrease in the existing condition.

The future condition was used in the conceptual design and in all phases of the hydraulic analysis of the proposed Colter Channel.

Threshold Channel Alternative
A threshold channel section represents the boundary of an erodible channel at which no erosion occurs with a minimum water area for a given discharge. In designing a trapezoidal channel as in the previous section of this report, the tractive force is made equal to the permissible value over only a part of the perimeter of the section, where shear stresses are close to the maximum. For a trapezoidal channel, much of the channel perimeter has a shear stress that is less than the permissible value. A threshold channel is therefore the more efficient channel section compared to the trapezoidal channel.

In this preliminary design, a threshold channel section was derived for each reach of Colter Channel based on the change in soil conditions and discharge along the channel alignment. The procedure used for estimating the threshold channel section was developed by Diplas and Vigilar (1992) (Ref. 10) and publications detailing the methodology are provided in an appendix to this report (referred to from now on as the DV method). CRSS developed a spreadsheet template for carrying out the computations. The DV method is an enhancement of the stable hydraulic section method given in Chow (see Chow section 7-15, pg. 176, Ref. 12). The DV method accounts for the flux of downstream momentum due to turbulence, referred to as turbulent diffusion. This generally results in a channel section that is wider and has more area compared to the method given in Chow.

The primary advantage of the threshold channel compared to a trapezoidal design is that it requires a smaller cross-sectional area and therefore less excavation. Because of the inherent efficiency of the channel, maintenance should be less since the channel section will not be inclined to readjust to a more natural cross-section.

The primary disadvantage of the threshold channel is the difficultly of construction. The section shape has continually varying side slopes and a curved invert. Construction of the channel invert might require relatively small excavation equipment or creation of a special template. Maintenance operations will need to consider the shape of the channel invert during cleaning and mowing.

To improve the constructability and maintenance of the threshold channel, we developed two alternatives that simplify the channel section. The first alternative is a simplified seven-point section. This section provides a V-shaped channel invert, and a compound bank slope (see figure 8). The section provides a close approximation of the wetted area and perimeter of the hypothetical threshold section. The second alternative is a further simplification using a five-point channel section. This alternative is a modified-trapezoidal section, since it has a single channel bank slope but a V-shaped channel-invert. For both simplified sections the channel-invert is typically wide enough to accommodate large construction equipment or similar size maintenance vehicles.

Control of Side Inflow

Side inflows from sheetflow, washes, and from other points of concentrated flow are incorporated into the main channel flow by means of side swales and weirs. These inlet points will be stabilized as required using riprap, concrete, or other material per Figures 9 and 10.

Side inflows may also include irrigation tailwater runoff from irrigated fields immediately adjacent to the channel which whose boundary will be adjusted by construction of the channel.

In general, handling of side inflows is accomplished by analyzing the magnitude of side inflows along the proposed Colter Channel alignment. In areas of minimal side inflow, no special feature is provided. In cases of moderate side inflow, V-shaped unlined side swales are provided to collect flows of a magnitude up to the 5-year flow. With the cross slope on the adjacent maintenance road as depicted on Figure 7, an additional 0.5 feet of freeboard is provided in the side swale, increasing its capacity without freeboard to that of approximately the 25-year flow. During side inflow events of greater magnitude than the 25-year event, flow will spill over the maintenance road into the main Colter Channel.

For areas of concentrated side inflow, such as areas where the proposed Colter Channel intersects an existing natural wash, a side weir is provided, as shown on Figures 9 and 10. These V-shaped side weirs, that also act as a dip section for the maintenance road crossings, are aligned perpendicular to the main channel. They were analyzed assuming that there is some flow in the main Colter Channel at the same time that flow passes over the side weir. Because of this coincidental flow, the potential for erosion of the south channel bank will be minimal. In addition, the bottom width of the proposed Colter Channel provides enough distance between the side weir and the south channel bank to dissipate energy and further reduce the potential for erosion. In the final design, some adjustments are anticipated to account for a site-specific condition on some side weirs.

Between Stations 28+50 and 33+00, two major washes contribute a large concentrated flow to the proposed Colter Channel. These washes, referred to as Dale Creek and tributary, carry a total 100-year flow of 440 cfs into the main Colter Channel. The flow in the main channel at this point is only 125 cfs; therefore, the side flow at this point is very significant -- almost four times as much as the main channel flow. Furthermore, the exact location of the side inflow is somewhat uncertain due to the 160-foot distance between Dale Creek and its tributary. Jointly, these two major washes create a very wide floodplain of approximately 500 feet.

For collection of side inflows, this is a complex situation because the approach angle of Dale Creek and tributary to the Colter Channel is nearly 90 degrees. This, combined with the magnitude of the side inflow and the long reach over which the side inflow takes place, requires that an interceptor side ditch be used instead of a single side weir. Because of the large width of the Dale Creek/tributary floodplain, a concrete lining is needed to eliminate erosion to the north collector channel bank. A confluence angle of 20 degrees is used to introduce the large interceptor channel flow into the main channel. Since the side channel serves as a collector channel, no freeboard is provided.

The side channel is conceptually designed to be fully incised, therefore, no significant backwater will be produced and no adverse flooding of adjacent property to the north will occur. Flow in the side channel is subcritical with a Froude number less than 0.85. The concrete side channel terminates as a maintenance road dip section at the 20 degree confluence. The main channel at the confluence is lined with riprap to reduce the velocity of flow from the side channel, thus reducing erosion potential in that reach.

Several lining alternatives have preliminarily been investigated to determine the most cost-effective method of protecting the side bank from erosion caused by flows from the side weirs. Criteria used in the selection process included strength and durability of the material, cost and feasibility of construction, slope stability, aesthetics, and maintenance expenses. The alternatives explored include:

1. Reinforced Concrete
2. Gabions
3. Loose Riprap
4. Reinforced Gunite
5. Soil Cement
6. Grouted Riprap.

Reinforced Concrete

4-inch thick concrete would be placed over reinforcing steel adequate to prevent cracking. At the top of this lining, a 3-foot turn-down would be included for stability and protection from undermining. Weep holes throughout the length of the lining may be needed to reduce hydrostatic pressure caused by saturation of the material behind the lining. Maintenance of the lining would require periodic inspection and repair of any spalling or cracking.

Gabions

Gabions, or wire-meshed enclosed riprap, would provide flexibility to conform to scour that could threaten the stability of the bank. This alternative calls for placement of the mattresses on 6:1 slope. An advantage of gabions is a more natural-looking appearance compared to grouted riprap or concrete structures. Gabions also utilize the large river stones that are readily available in the area.

Loose Riprap

This alternative calls for the use of a minimum 1.5-foot thick lining using a 10-inch maximum stone on a 6:1 slope. To minimize loss of material below the lining, filter fabric would be used. Riprap has a natural appearance, however, loose riprap requires a stone size that may not readily be available in the area.

Reinforced Gunite

This alternative consists of low slump concrete jetted over a welded wire reinforcement. Design features are the same as for reinforced concrete. Maintenance would also be similar.

Soil Cement

This material was considered for its demonstrated ability to adequately protect the surface in other projects of a similar nature, including those designed by the Corps of Engineers. The soil cement alternative calls for placement of two 6-inch lifts, with a total of 12-inch thick soil cement, compacted with a vibratory smooth roller. The material would then be trimmed on the channel side to a relatively smooth surface. With its properties, this alternative is expected to be the least expensive in maintenance. Aesthetically, this alternative would draw the least attention to itself, as the color and gradation would closely match the surrounding soil conditions.

Grouted Riprap
This alternative calls for the use of a minimum 1.0-foot thick lining, 8-inch minimum stone, grouted in place with shotcrete. This alternative may require additional reinforcement or special treatment of the base material, as it is especially susceptible to cracking.

6.3 Hydraulic Analysis

Design Parameters:

- Design flows - 100-year storm based on White Tanks ADMS (Ref. 5)
- Channel stability - allowable velocity approach; and threshold approach (Ref. 3)
- Minimum radius - $r_c/T = 3$ (Ref. 3, Section 5.8)
- Superelevation - insignificant (Ref. 3, Section 5.9)
- Freeboard - minimum 1' (Ref. 3, Section 5.10)
- Drop structures - based on FHWA HEC-14 (Ref. 4)
- Lining material and turndowns (Ref. 3 Section 5.5)
- Backwater analysis and box culvert losses - by the use of HEC-2 (Ref. 7)

Although the 100-year event was used for the hydraulic design of the proposed Colter Channel, it is unlikely that a coincidental 100-year event will also occur on the Agua Fria River. Therefore, Agua Fria flows of varying frequency, including the 10- and 25-year events, were used to determine the starting water surface elevation for the proposed Colter Channel.

These starting water surface elevations were entered in a HEC-2 model of the proposed channel. Corresponding to the Agua Fria 10-year and 25-year flows, profiles with the post-development Colter Channel 100-year flow event were used. In addition, corresponding to the Agua Fria 10-year flow, a profile with the Colter Channel 10-year flow was used. The results of these profiles showed that in all cases, the Agua Fria water surface elevation controls the Colter Channel starting water surface elevation rather than normal depth in the Colter Channel.

The table on the following page summarizes various conditions for the starting water surface elevations.

SUMMARY OF STARTING WATER SURFACE ELEVATIONS

FLOW CONDITION	CHANNEL STATION	STARTING WATER SURFACE		CONTROLLING WATER SURFACE ELEVATION
		AGUA FRIA	COLTER CHANNEL[1]	
1. 100-year in Colter Channel, 10-year in Agua Fria River	152+00	1022.2	1020.70	1022.2
2. 10-year in Colter Channel, 10-year in Agua Fria River	152+00	1022.2	1020.50	1022.2
3. 100-year in Colter Channel, 25-year in Agua Fria River	122+00	1025.13	1023.33	1025.13

[1] Normal Depth

The HEC-2 model uses the special culvert routine for the culverts at El Mirage Road, Airline Canal, and at Dysart Road. Mannings *"n"* values of 0.035 for earth surfaces, and 0.012 for concrete surfaces (culverts and drop structures) were used in the model. In general, cross-sections are spaced every 500 feet in uniform reaches of the channel, and 50 feet upstream and downstream of transitions of slope or cross-section geometry. At culverts, cross-sections at both the upstream and downstream faces were used, as well as at 50 feet upstream and downstream from the culvert faces.

The *"n"* value of 0.035 was used to model the channel in a state of moderate vegetative growth, which is expected to be the case as the channel ages. For comparison purposes, the channel was also modeled using an *"n"* value of 0.022 to represent the new bare soil condition during the 5- and 10-year storms.

A maximum velocity of 4.5 fps was used for the earthen channel, per the Scope of Work guidelines.

In the actual conceptual design, however, lower velocities were used based on the results of the soil borings performed by SHB. These results are summarized in the table on the following page:

TABULATION OF TESTS RESULTS AND PERMISSIBLE VELOCITIES

CHA STATION	HOLE NO.	VISUAL CLASSIFICATION	PERMISSIBLE VELOCITY (fps)
145+00	TP-25	Silty Sand, Sand	2.7
151+00	TP-26	Silty Sand	2.7
140+00	TP-24	Silty Sand, Sand & Gravel	3.5
136+00	TP-23	Silty Sand, Sand & Gravel	3.5
131+00	TP-22	Silty Sand, Sand	2.7
126+00	TP-21	Silty Sand	2.7
121+00	TP-20	Silty Sand, Sandy & Gravel	3.5
117+00	TP-19	Sand, Silty Sand	2.5
112+00	TP-18	Silty Sand, Sandy Silt	2.7
102+00	TP-17	Silty Sand, Clayey Sand	3.5
98+00	TP-16	Clayey Sand, Clayey Sand & Gravel	3.5
89+00	TP-15	Clayey Sand	3.5
84+00	TP-14	Sandy Clay	4.0
79+00	TP-13	Clayey Sand, Sandy Silt	3.5
74+50	TP-12	Clayey Sand & Gravel, Clayey Sand	3.5
69+50	TP-11	Sandy Clay, Clayey Sand	4.0

CHA STATION	HOLE NO.	VISUAL CLASSIFICATION	PERMISSIBLE VELOCITY (fps)
64+50	TP-10	Clayey Sand, Sandy Silt	3.5
60+00	TP-9	Silty Sand & Gravel, Sandy Silt, Silty Sand	2.7
49+00	TP-8	Clayey Sand	3.5
43+00	TP-7	Sandy Clay, Clayey Sand	4.0
38+50	TP-6	Silty Clay, Sandy Clay	4.5
32+50	TP-5	Sandy Silt, Silty Clay	2.8
31+00	TP-4	Clayey Silt, Silty Clay, Clayey Silt	4.5
27+00	TP-3	Silty Clay	2.8
20+50	TP-2	Sandy Silt	2.8
15+50	TP-1	Sandy Silt, Sandy Clay	4.0

The permissible velocities were obtained using the guidelines in the District's Hydraulics Manual; these velocities ranged from 2.7 to 4.5 feet per second.

A check of the velocities from HEC-2 models versus the allowable velocities was performed using the output for the 100-year flow with an "*n*" value of 0.035, and for the 10-year flow with an "*n*" value of 0.022. The model results indicated that the velocities under both conditions are very similar, and that they fall well below the maximum of 4.5 feet per second.

Freeboard and radius of curvature requirements conform to requirements stated in the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 3). Freeboard is not provided in the channel east of El Mirage Road due to its location within the Agua Fria River floodplain. For the remainder of the channel reach, a freeboard of 1 foot is provided.

6.4 Sediment Yield Analysis

There are several potential sources of sediment from the Colter Channel. In general order of importance, these sediment sources include the contributing watershed area, existing stream channels, and the bed and banks of the new Colter Channel. By design the Colter Channel will be designed as a stable channel, meaning that scour of the channel should be small over the life of the facility. The Dale Creek channel is the largest existing stream channel that is tributary to the Colter Channel. To prevent erosion at this junction, the confluence area will be stabilized. Dale Creek and other smaller stream channels in the Colter watershed are well vegetated and do not show indications of erosion.

The major source of sediment to the Colter Channel is the contributing watershed area. Soils over the watershed area typically consist of medium sand with a large fraction of silt and some clay. For the Colter watershed the erodability of the soil increases with an increasing silt fraction in the soil. Along the Colter alignment the silt fraction increases to the west and soils in the watershed tend to siltier in the upland areas and less near the Agua Fria River floodplain.

Computations of watershed sediment yield were made using the Modified Universal Soil Loss Equation (Ref. 11, Williams, 1975). This equation substitutes runoff energy for rainfall energy and is more suitable to arid regions where runoff producing rainstorms are few. The computations are made for a series of individual runoff events (2-, 5-, 10-, 25-, 50-, and 100-year floods). This provides an estimate of the expected sediment yield (which is equivalent to the average annual sediment yield) and the specific sediment load for design events. For the total watershed area of 2,630 acres, the expected sediment yield is about 330 tons/year. This is equivalent to 185 cubic yards of sediment per year. The concentration of sediment would average about 3,200 ppm; this concentration value is typical of watersheds with some farm land. As urbanization replaces agricultural lands in the watershed, the sediment yield will decrease.

During the 100-year storm about 1,800 tons of sediment will be yielded from the Colter watershed (equivalent to about 1,000 cubic yards of sediment) at a concentration of about 4,600 ppm. This is about 5-1/2 times the annual sediment yield from the Colter Channel.

The dominant flood for producing sediment from the Colter watershed will be about the 5-year storm. This storm will produce slightly in excess of the expected sediment yield during the event and will occur frequently.

Discharge of sediment to the Agua Fria River from the Colter Channel will be small compared to the larger sediment load transported. All the sediment discharged to Agua Fria River will be derived from existing erosion that is characteristic to soils and land use in the watershed. The streams for the Colter watershed area drain to the Agua Fria River. Construction of the Colter Channel will improve the efficiency of the drainage system and, as a result, the transport of sediment from watershed. Over the long term (life of the project) the net yield of sediment to the Agua Fria River should be about the same.

In terms of water quality requirements (per Water Quality Certification, Arizona Department of Environmental Quality), the proposed Colter Channel will transport sediment from natural background watershed erosion. This is not a new source of sediment to the Agua Fria River. There is not expected to be any increase in water quality parameters in the Agua Fria River including turbidity, and settleable solids concentration.

In conclusion the following aspects of sedimentation in the Colter Channel are summarized:

The Colter Channel will transport sediment that naturally occurs in the contributing watershed. Future urbanization will reduce the sediment yield to the channelOther sources of sediment loading to the Colter Channel are relatively small. None of the storm events produce an excessive sediment load. Discharge to the Agua Fria River of this sediment load will be essentially the same with or without the Colter Channel project. Because of the relatively small sediment yield, there is no need for a sedimentation basin to prevent silting of the Colter Channel or the outlet to the Agua Fria River. Likewise, since the sediment load is derived from natural erosion, there is no need for a sedimentation basin to maintain water quality.

6.5 Hydraulic Structures

Box culvert crossings were used in the modeling of the channel at Dysart Road, Airline Canal, and El Mirage Road. The culverts were used for hydraulic modeling purposes only; the recommended design and cost estimate consists of either box culverts or flat concrete slabs. Drop structures were used at the El Mirage Road, at Station 99+00 and Airline Canal crossings.

The need for above-grade berms to confine flows within the channel cross-section was minimized by using a collector side swale along the north side of the channel.

Above-grade berms are not used along the south side of the channel and east of El Mirage Road. Therefore, there are no impacts to the fringe area of the Agua Fria River floodplain to be determined and taken into consideration.

Dysart Road Crossing:
A 4-barrel, 12' x 3' - 110 lineal foot concrete box culvert has been proposed for the Dysart Road crossing.

Airline Canal Crossing:
A 3-barrel, 10' x 3' - 45 lineal foot concrete box culvert crossing for the Airline Canal irrigation ditch and maintenance road has been proposed. This culvert crossing provides the same maintenance road width as in the existing condition. Standard Arizona Department of Transportation box culvert designs have been used.

As an alternative, the box width of 60 feet was also evaluated to accommodate a 60-foot wide collector road in the future per input from SunCor. This width accommodates the existing Airline Canal, an irrigation ditch, and a maintenance road.

El Mirage Crossing:
A 4-barrel, 10' x 3' - 100 lineal foot concrete box culvert has been proposed for the El Mirage Road crossing.

Drop Structures:
Three straight drop structures are recommended for the proposed Colter Channel due to topographic constraints. The first drop structure (see Figure 11), immediately west of El Mirage Road is achieved by means of a drop inlet immediately upstream of the box culvert. The second drop structure is located 1,500 feet east of the Airline Canal

at Station 99+00 and is a conventional drop structure. It accommodates a similar fall in the existing ground at that location. The third drop is similar to the one at El Mirage Road as shown on Figure 12.

For cost comparison purposes, a vertical, (see Figure 13) as well as a sloping drop (see Figure 14), were evaluated for the structure location at Station 99+00. For durability, strength and cost reasons, a straight (vertical) drop is recommended for further consideration. The sloping drop structure, as depicted on Figure 14, will consist of grouted riprap lining material. However, since this structure could cost significantly more ($32,000 as compared with $23,000 for the straight drop), it was eliminated from further consideration.

6.6 Agua Fria River Confluence

The Colter Channel outfall to the Agua Fria River is on a very flat gradient of 0.00089 ft./ft. primarily because the channel transverses the relatively shallow west overbank of the Agua Fria River floodplain.

Evaluation of this reach is critical due to the complexities associated with the Agua Fria River floodplain, potential tailwater conditions at the channel mouth, the extremely flat gradient, and potential of backwater and breakout by raised berms to contain the channel flows. Several channel options were considered including a fully unlined cross-section:

1. For the 2,500 lineal foot reach immediately upstream of the outfall point, evaluations were made using a composite cross-section. To enhance velocity and to reduce right-of-way width, a 12-foot concrete gutter section was considered within the unlined dirt channel bottom. Because of maintenance concerns and potential damage to the concrete section, this concept was eliminated from further consideration.

2. For the same reach, a fully-lined concrete section was also evaluated. This section would offer enhanced velocity, better sediment transport, minimal erosion due to flood flows from Agua Fria River, and easy maintenance. However, this option was eliminated because of extremely expensive improvement costs, together with unfavorable aesthetic considerations.

3. As an option to extremely flat channel slopes, an idea of storage basins within the BLM parcel was conceptually explored. The purpose of these storage basins was to provide:

a. A better hydraulic gradient for more frequent flow diverted by Colter Channel
b. The ability to confine maintenance to the basin area
c. A significant reduction in the frequency of maintenance.

This concept was also rejected because:

1. It will require an additional 27 acres of right-of-way from BLM
2. It will require an additional 240,000 cubic yards of earthwork
3. It will require a sump pump to drain the basin
4. It will require a diversion structure to mitigate inundation from frequent flows from the Agua Fria River.

Since the outlet velocity is very low and there is a potential of some water in the Agua Fria River channel, channel stabilization measures and an outlet structure have not been proposed to introduce channel flows into the Agua Fria River floodway. No freeboard is provided in the outfall reach of the proposed Colter Channel due to its location in the Agua Fria River floodplain.

Per discussions with the District, the channel east of El Mirage Road has been conceptually designed to carry only those flows diverted into the channel upstream of El Mirage Road. Flows from subbasin 245 east of El Mirage Road presently drain the Agua Fria River floodplain toward the south across the proposed channel alignment. Therefore, instead of designing the channel to carry the full 2,400 cfs at CP-245, the channel is designed to convey only the 1,210 cfs collected upstream of El Mirage Road.

By selecting this design alternative, areas south of the proposed channel and east of El Mirage Road experience the same 100-year flows with the proposed channel in place as in the existing condition. Therefore, no flowage easements are required beyond the permanent channel right-of-way. Refer to Section 5.0 of this report for further discussion of channel flows east of El Mirage Road.

6.7 Access Control

Public access barriers, such as gates and barbed-wire fences, have been proposed at the channel outlet and at the El Mirage Road crossing to prevent unauthorized access into the channel. These access barriers will discourage public access, especially *"off road"* bikes and vehicles.

A stabilized gravel at-grade crossing of the channel has been designed for access to the sand and gravel operation along the present access alignment off of Camelback Road. A similar crossing has been proposed to maintain access to the high voltage transmission towers.

A stabilized gravel road has also been proposed along the north side of the project corridor from the east side of El Mirage Road to the ABC Sand & Rock operation specifically for access by the sand and gravel operator. The access road is located within an easement along the north side of the Colter alignment acquired by the District for the project. This road will facilitate access during flooding conditions within Colter Channel.

Several maintenance features have been proposed including:

1. A 14-foot stabilized maintenance access road along the north and south side of and immediately adjacent to the channel with access off each side of Dysart Road and El Mirage Road.

2. Invert access ramps off the maintenance access roads at each side of the Dysart Road, Airline Canal drop structure at Station 99+00 and El Mirage Road crossings. A typical ramp is shown on Figure 15.

3. A four-strand barbed wire and tee-post fence will be placed approximately 1 foot back from the edge of the maintenance roads. The fence will close off the channel at each crossing and a gate will provide for maintenance access.

7.0 STRUCTURE DESIGN

Structures anticipated for the Colter Channel project include:

- Roadway crossing at Dysart Road;
- Roadway crossing at El Mirage Road with a drop structure at the upstream face and an inlet for a tailwater ditch into the north side of the drop structure;
- Airline Canal and maintenance road crossing with a drop inlet at the upstream face;
- Drop structure at Station 99+00 between the Airline Canal and El Mirage Road crossings;
- Colter Channel maintenance road crossings of the Airline Canal.

7.1 Dysart and El Mirage Road Crossing

Final design of the Dysart Road and El Mirage Road crossings of Colter Channel will be accomplished by the Maricopa County Department of Transportation. This report addresses the issues relating to selection of a structure type for these crossings along with associated recommendations.

The ultimate roadway section for each crossing will determine the width of the structure required as measured along the channel centerline. The Dysart Road crossing could include up to three lanes northbound and southbound, a raised median and sidewalks for a total width of approximately 110 feet. The El Mirage roadway section is expected to be narrower and no more than 100 feet in width.

The waterway opening required at the Dysart Road crossing is 48 feet wide by 3 feet high (see Figure 16). At the El Mirage crossing the required opening is 40 feet wide by 3 feet high (see Figure 11). The small waterway needed for design flows limits the practical structure types to a few alternatives. Those considered are: a reinforced concrete box culvert; a two span flat slab bridge; and a single span precast prestressed voided slab bridge. The two bridge alternates have cast-in-place spread footings and abutment/pier walls. The bridge alternates require a reinforced concrete invert floor; the box culvert has an integral floor. The criteria used to evaluate structure types typically include cost, constructability, performance, serviceability, aesthetics, and the ability to be easily widened in the future.

Based on the geotechnical investigation, the allowable bearing capacities of the soil are such that the more heavily loaded bridge footings should be founded about 5 feet below the channel bottom, making drilled shafts an economically feasible foundation system for the bridge alternatives. The configuration of box culverts is such that loads are spread out through the floor and additional depth of foundation should not be necessary for this alternative. An allowable bearing capacity of 2400 psf has been used to size foundation elements for cost analysis.

Walls retaining roadway fills adjacent to crossing structures are typically oriented parallel to the roadway or skewed relative to the channel to improve inlet or outlet hydraulics. With the 6:1 channel slopes and an assumed 4:1 maximum roadway fill slope, the length of walls required for either configuration are approximately the same. For this report and cost estimate, the retaining wall orientation is, therefore, assumed parallel to the roadway.

The type of safety barrier to be used on top of the headwalls or at the edge of the bridge deck and on top of the retaining walls should be carefully reviewed with respect to current standards, MCDOT practice, and the design criteria for each phase of roadway development up to the ultimate section. Use of approach guardrails, guardrail end terminations, and guardrail transitions to fixed objects such as dadoes and parapet walls should be considered for the final configuration of roadway crossings.

To provide irrigation drainage of the agricultural properties to the north, a tailwater inlet is provided northwest of the El Mirage crossing. The inlet box structure is a MAG Standard Detail (Detail No. 501-5) sized for two 42-inch diameter reinforced concrete pipes. The pipes will drain into the channel through the north wall of the El Mirage Road drop structure. This configuration will eliminate the need for an outlet headwall and prevent any problems with scour at the outlet.

A cost comparison analysis for the Dysart Road crossing structure based on a per lineal foot cost of culvert (per foot width of bridge) resulted in the lowest cost for the reinforced concrete box culvert alternative at $920 per lineal foot, followed by the two-span reinforced concrete flat slab bridge at $1,232 and then the single-span prestressed voided slab bridge at $1,608. The reinforced concrete box culvert was about 25% less than the two-span reinforced concrete flat slab bridge and 43% less than the single-span prestressed voided slab bridge. The additional costs of retaining walls, drop structures, and barriers are similar for each of the structure alternatives.

The reinforced concrete box culvert alternative has the advantage in terms of constructability in that it allows future development of the roadway section independent of the structure. The deck of the flat slab bridge alternate does not require an additional wearing surface like the prestressed voided slab alternate. Each of the alternates may be built in two stages to maintain traffic during construction by building half of the structure at a time. Each of the alternatives has a satisfactory hydraulic performance. The reinforced concrete box culvert is, however, more susceptible to clogging from floating debris than the bridge alternates, but this is not expected to be a significant problem in this channel. None of the three alternatives considered have significant advantages over the others, aside from the above, and should be equally acceptable solutions with these exceptions.

Therefore, based on a criteria of lowest cost, acceptable hydraulic performance and adaptability to future roadway development, the reinforced concrete box culvert is the recommended structure alternative for the Dysart and El Mirage crossings.

7.2 Airline Canal Culvert

The required hydraulic opening for the Airline Canal crossing is 30 feet wide by 3 feet high (see Figure 12). The width of structure required to support the canal and canal maintenance roads is about 45 feet. A supply ditch along the east side of the canal and maintenance roads will also need to cross the channel. When the Airline Canal is eventually removed, the crossing structure may be used by SunCor Corporation to accommodate a roadway for access to their planned development. This changes the previously assumed structure lifespan from temporary to that of a permanent structure. For this crossing of the Colter Channel, a reinforced concrete box culvert has several significant advantages over other structure types. These are: the ability to support the canal and maintenance roads in the fill above the culvert; the ease of removing the canal crossing and adapting the structure to future uses and lower costs as determined by the structure type evaluation for the Dysart and El Mirage Road crossings. A reinforced concrete box culvert is, therefore, the recommended structure type for the Airline Canal crossing.

Retaining walls for the upstream face of the roadway fill will be in-line with the drop structure inlet and parallel with the canal. The downstream retaining walls may be parallel with the canal or skewed. Assuming that the downstream side of the roadway embankment has a 2:1 slope and the wingwalls area skewed at 45 degrees to the culvert, the length of wall would be about 13 feet; less than half of the length required for the parallel configuration.

The safety barrier on top of the box culvert headwalls and retaining walls may consist of pedestrian railings if the future developed roadway has non-mountable curbs and traffic speeds are those typical of residential areas. If a mountable curb is anticipated, the headwalls should extend above the fills as structural parapet walls a minimum of 1'-6" with railings to a total height of 3'-6".

Irrigation ditch maintenance road crossings of the Airline Canal will be supported on simple span reinforced concrete slabs. The slabs will be about 10 inches thick and will rest on footings or small drilled shafts on each side of the canal. The slabs will be supported above the existing grade a few inches so that they do not encroach into the canal freeboard. The canal and channel maintenance road fills will be graded to match the slab height at the channel maintenance road crossing the canal.

To provide a temporary crossing for the irrigation supply ditch which runs along the east side of the canal and maintenance roads, two alternates have been considered. The first alternate is routing the ditch into a 24-inch diameter reinforced concrete pipe buried in the maintenance road fill above the box culvert crossing. The second alternate is to span the channel with a 24-inch diameter steel pipe with one or two center piers. The pipe inlets and outlets will have concrete headwalls located outside the channel and maintenance road section which will be similar for either alternate. To route the buried concrete pipe through the box culvert, fill will require an offset in alignment near each end. The offsets may make the pipe more susceptible to clogging and will make cleaning more difficult. The steel pipe crossing of the channel will require one or two piers in the channel which will have some scour around their columns. Another disadvantage of the steel pipe crossing is that it presents an attractive nuisance to children, however, a fence may be placed at each end of the pipe to discourage these activities. The steel pipe alternate will be easier to remove when the supply ditch is no longer needed and will have some salvage value. The estimated cost of the buried reinforced concrete pipe alternate is $8,050 and for the supported steel pipe alternate $7,500. The cost for future removal or salvage value are not included in these figures. The steel pipe supply ditch crossing of the channel is, therefore, recommended based on comparable cost and potentially easier maintenance.

The Airline Canal crossing consists of a 3-barrel, 10' x 3' - 60 lineal foot concrete box culvert. The recommended design of this crossing is based on discussions with SunCor and conforms with the Scope of Work. The 60-foot length accommodates either a future 60-foot-wide collector road or the existing canal, irrigation ditch, and maintenance road.

The recommended structure is located such that there is no required alignment change for the Airline Canal or the maintenance road. In the future condition, the 60-foot box will serve as a channel crossing of a residential collector street; at that time, the Airline Canal and the irrigation ditch will no longer be in operation. At SunCor's request and with their cost participation, a 36-inch conduit is recommended under the box culvert along the alignment of the Airline Canal. This conduit can function as a future inverted siphon to accommodate Airline Canal flows as required.

Whenever the proposed channel maintenance road crosses the existing irrigation ditch or Airline Canal, a culvert crossing will be provided; as an option to culverts, flat concrete slabs may be used.

7.3 Drop Structures

Drop structures or inlets will be located upstream of the Airline Canal crossing, upstream of the El Mirage Road crossing, and one will be located at Station 99+00 between the two crossings. A cast-in-place reinforced concrete vertical drop structure alternate and a sloping grouted riprap drop alternate were considered for this report. The height of the drops varies from 3 to 5 feet.

At the El Mirage Road and Airline Canal crossings the straight drop structure alternate may be integral with the crossing structure and configured to also function as an inlet to the structure opening. The El Mirage Road straight drop structure alternate would include a formed concrete inlet wall, a paved basin floor level with the downstream invert and a small sill wall near the structure opening. Design of this type of structure will take into account the hydraulic pressures and/or suction on the exposed faces of the basin walls and floor and the uplift pressures which could occur after a period of continued flow and a rapid drawdown. Cutoff walls will be provided below the inlet wall to prevent piping below the structure and to reduce the chance that uplift forces will occur. The drop structure located at Station 99+00 between the canal and El Mirage crossings will be different in configuration with the inlet/cutoff wall extending up the channel side slopes (see Figure 13).

The sloping drop inlet alternate has an inlet floor sloping to a horizontal basin floor and an outlet floor sloping up to the downstream invert (see Figure 14). This type of drop structure will probably not be integral with the crossing structures at the Airline Canal and El Mirage Road. Several alternatives can be considered for armoring the slopes and basin floor. These include riprap with a heavy geotextile filter blanket; gabion mats with a heavy geotextile filter blanket or reinforced paving on the basin slopes and gabions or riprap for the floor of the basin to allow drainage; and grouted riprap slopes and floor. Considerations for the riprap or gabion alternates include the soil stability of the saturated basin slopes, erosion and maintenance of the structure. Paved basin slopes will need toe downs or cutoff walls at the upstream and downstream slope edges to prevent undercutting and piping. Grouted riprap has the disadvantages of not being flexible and self-healing like riprap or gabions and also does not have the strength of reinforced concrete. This makes grouted riprap susceptible to piping, undercutting and to subsequent deterioration once failure begins.

A cost analysis comparing the straight and sloping drop alternates indicates that the sloping drop alternate has a 40% higher cost than the straight drop alternate. The straight drop type of drop structure is recommended because of a lower initial cost and future maintenance costs.

8.0 ENVIRONMENTAL COMPLIANCE

8.1 Water Quality Certification

The proposed Colter Channel project must fulfill certain water quality requirements of the Arizona Department of Environmental Quality (ADEQ) in order to obtain Water Quality Certification under Section 401. No difficulty is expected in obtaining this certification for the following reasons:

1. Since the project does not involve the placement of fill material within the channel, there will be no possible hazard associated with fill material.

2. The proposed project will not impact groundwater quality due to the relatively short duration of flood flows and because no new source of stormwater runoff is introduced into the Agua Fria River watershed. In other words, only flows originating in the Agua Fria River watershed are diverted to the Agua Fria River.

3. The conceptual design of the proposed Colter Channel is such that flow velocities are sufficiently low to minimize erosion and significant sediment transport to the Agua Fria River. Turbidity is not expected to increase since no new source of runoff is introduced to the Agua Fria River by the proposed project.

8.2 Dredge and Fill Permit

Based on conceptual work on the proposed Colter Channel, the District received the following opinion from the Corps of Engineers regarding Section 404 permitting for dredge and fill materials:

The Corps of Engineers has no permit authority under Section 404 of the Clean Water Act in the area(s) outside of the ordinary high water mark or outside wetlands designated in the following table. However, any activity that discharges dredged or fill material into the designated jurisdictional area(s) requires a Section 404 permit. This jurisdictional determination will remain in effect for three years from the date of this letter unless an unusual flood event occurs. After this three-year period, or after an unusual flood event alters stream conditions, the Corps of Engineers reserves the authority to retain the original jurisdictional limits or to establish new jurisdictional limits as conditions warrant.

Since then, refinements to the proposed channel alignment and cross-section have resulted in a general reduction in area of disturbance compared to previous estimates. The following table summarizes areas of disturbance and areas of fill impacted by the proposed channel. Since the Colter Channel is fully incised, fill operations are minimal at the wetland areas designated in the table.

To provide a positive outfall into the Agua Fria River, however, additional excavation is anticipated. Accordingly, about 2.755 acres of area will be disturbed, which was previously not accounted for. This disturbance area generally consists of sandy riverbed with absolutely no vegetation or any environmental features. The disturbance will entail simple earthwork excavation to cut the channel bed by an average of 1.5 foot.

STATION	AREA OF DISTURBANCE		AREA OF FILL	
	FT. X FT	ACRES	FT. X FT.	ACRES
10+00	5 X 100	0.011	0 X 0	0
20+25	10 X 70	0.016	0 X 0	0
	10 X 130	0.030	0 X 0	0
	10 X 130	0.030	0 X 0	0
105+40	6 X 280	0.039	6 X 280	0.039
151+85.13	200 X 600	2.755	0 X 0	0

The areas of disturbance in the above table are based on the limits of the "waters of the United States" as defined by the Corps of Engineers and on the right-of-way widths as summarized in Section 6.1.

8.3 Hazardous Materials Identification

Based on the findings developed in the *Preliminary Site Assessment, Colter Channel*, by Western Technologies, Inc., the following measures are recommended:

- Sample and test the contents of the two, 5-gallon containers and the one, 55-gallon drum near Stake No. 126-53 to identify the contents. Perform limited soil sampling to evaluate the surface stain in the vicinity of the two, 5-gallon containers.

- Remove solid waste to a landfill prior to excavation activities.

- Abandon the inoperable groundwater well according to ADWR guidelines.

- Screen soils in areas of past or current agricultural use to evaluate potentially regulated pesticides with regard to hazardous waste determinations.

9.0 COST OPINION

This section provides a construction cost opinion for the Colter Channel drainage improvements based on two possible runoff conditions (see discussion of Colter Channel Hydrology, Section 5.2).

To simplify evaluation, the future conditions analysis was evaluated in detail initially. Then the channel section, bridge and drop structures and right-of-way needs were revised to account for downsizing of the channel system due to a flow reduction in the existing condition design.

Tables 3-F and 3-E provide a summary of probable costs of the Colter Channel project for future and existing condition design, respectively. (Detailed cost breakdown is included in the technical appendices).

Based on these tables, the differences in costs of improvements and right-of-way requirements are summarized below:

	IMPROVEMENT COSTS	RIGHT-OF-WAY NEEDS
Future Condition	$2,191,500	81.7 Acres
Existing Condition	$1,989,000	75.1 Acres
Difference	**$ 202,500**	**6.6 Acres**

Major Cost Elements (Future Condition Design):

1. **Earthwork:** The major cost item for this project is earthwork. Since all earthwork is excavation and the dirt has to be disposed of away from the channel right-of-way, an offsite location (or locations) will be needed to waste the material. The earthwork cost was developed based on one or more of the following assumptions:

   a) Waste dirt will be provided to the property owners affected by the channel construction.

b) Waste dirt will be provided to the property owners adjacent to channel construction.

c) Waste dirt will be disposed of on BLM Land to fill the entire parcel to the elevation of base flood plus one foot or higher.

d) Waste dirt will be disposed on one of several parcels located within the Agua Fria River floodplain west overbank.

e) Waste dirt will be disposed of on a floodplain parcel that is acquired for that purpose.

2. **Side Spillways:** For side spillways, six different alternatives were investigated as presented in Section 6.2 of this report. For durability reasons, a concrete lining was selected (as depicted on Figures 9 and 10) for further consideration. It is estimated that the cost associated with all spillways will be $21,000.

3. **Dale Creek Confluence:** To handle a significantly large flow entering the channel, a concrete-lined collector channel is proposed at the Dale Creek confluence. It is estimated to cost $57,000 for all the elements associated with the confluence.

4. **Dysart Road Box:** For the Dysart Road crossing, three alternatives were evaluated as presented in Section 7.1. It was concluded that the box culvert will be the most cost-effective alternative at this location. Therefore, it is recommended for further consideration. It is noted that the crossing as well as utilities will be the responsibility of MCDOT.

5. **Airline Canal and Drop Inlet:** Three alternative costs were derived for the Airline Canal and drop inlet.

    a) To maintain two maintenance roads and canal with a separate flume to convey irrigation supply flows an estimated length of 45 feet is needed at a cost of $67,860.

    b) Increase the length of the structure from 45 to 50 feet to accommodate the irrigation supply ditch on the box at an incremental cost of $3,600.

As an alternative, a steel flume was also considered. Due to its higher estimated cost of $8,050 it was rejected from further consideration.

c) Increase the length of the structure from 45 to 60 feet to accommodate all immediate and future needs by SunCor. The structure will accommodate a future collector street for SunCor. Total estimated cost is $78,535.

A 36-inch RGRCP sleeve is recommended underneath and along the existing Airline Canal alignment. SunCor, at their cost, has requested this sleeve for future use.

6. **El Mirage Road Box Culvert and Drop Inlet:** This structure is very similar to the structure at Dysart Road with the exception of a drop inlet. As discussed earlier with Dysart Road, a box culvert is recommended for cost-effective reasons. This will be a MCDOT structure at an estimated cost of $130,500.

7. **Drop Structure:** A straight drop structure was found more cost-effective than the sloping drop structure. Therefore, a straight drop is recommended for further consideration at an estimated cost of $20,500.

8. **ABC for Access Roads:** For the access roads servicing the ABC sand and rock operation and the high voltage powerline, ABC is proposed at an estimated cost of $17,580.

9. **Riprap:** All riprap quantities are accounted for with individual elements, e.g., side spillway, Dale Creek confluence, etc.

10. **Fencing and Gates:** The entire project will be fenced by a 3-strand barbed wire fence with gates off all major streets. This item is estimated to cost $72,750.

11. **Utility Relocation (Dysart):** All utilities within Dysart Road will be relocated by MCDOT. The relocation includes two telephone lines, 6-inch petroleum line, and an overhead electric line at an estimated cost of $14,500.

12. **Utility Relocation (Other):** Other utilities that need to be relocated by the District include a 6-inch Tierra Buena waterline, an east-west powerline east of El Mirage Road, and an overhead powerline at El Mirage Road. This relocation is estimated to cost $12,000.

13. **Irrigation Relocation:** There are several irrigation ditches which will need to be relocated. It is estimated that it will cost $34,500 to relocate these ditches.

14. **Land Acquisition:** Based on the preliminary design, it is estimated that 81.7 acres will be needed to accommodate the Colter Channel project. Section 6.1 in this report gives details as to the right-of-way needs for the future condition.

Major Elements (Existing Condition Design):

Major elements for existing condition design are identical to the ones presented above. As can be seen from Table 3-E, however, there are reductions in costs due to the relocation in design flows for the following elements:

1. Earthwork
4. Dysart Road Box
5. Airline Canal Box and Drop Inlet
6. El Mirage Road Box and Drop Inlet
7. Drop Structure
14. Land Acquisition.

10.0 RECOMMENDATIONS

Based on the concept preliminary design, the following is recommended.

1. The Colter Channel improvements are approximately ten percent (10%) more expensive for the condition based on the future hydrology with relaxed retention requirements as opposed to the existing hydrology for the contributing watershed parcels. There will be significant savings to the adjacent development in the form of more land, less improvement cost for the detention basins and drainage system. For this reason, the future condition design is recommended. The District can pre-determine some cost-share equation for the parcel owners who benefit from the relaxed retention requirements.

2. An earthen channel with a modified-trapezoidal section as shown in Figure 8 is recommended for design. The modified-trapezoidal section incorporated a sloping channel invert in accordance with findings from the threshold channel analysis. The use of a compound bank slope that is a feature of the threshold channel will not be used.

3. The recommended right-of-way corridor and channel alignment are detailed on the recommended plan (Sheets 1, 2, and 3). The recommended channel profile will incorporate several drops to reduce channel gradient and minimize excavation.

4. A collection of side swales in conjunction with side weirs as depicted on Figures 9 and 10 are recommended as the best means of reducing side inflow erosion.

5. A sediment basin is not required for the Colter Channel. The sediment load for the channel will be derived from natural erosion, and the load is expected to decrease with future urban development. Sediment discharge to the Agua Fria River will be essentially unchanged with the construction of the Colter Channel.

6. Box culverts are recommended because of their lower overall costs, for major road crossings at Dysart and El Mirage and for the Airline Canal crossing.

7. Some adjustments to the right-of-way requirement are needed. Generally, the right-of-way can be reduced along the westerly end within the Hyde and Corpstein properties. However, additional right-of-way is necessary within the Agua Fria River overbank area.

8. Because of the large width of the Dale Creek/tributary floodplain, a concrete lining is recommended to eliminate erosion to the north collector channel bank. A confluence angle of 20 degrees is recommended to introduce the large interceptor channel flow into the main channel.

11.0 REFERENCES

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11. Jimmy R. Williams, *Sediment - Yield Prediction With Universal Equation Using Run-Off Energy Factor*, ARS-5-40, June 1975.

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TABLE 1
SUMMARY OF PEAK FLOWS
AGUA FRIA & NEW RIVER

STORM (YRS.)	DA = 1929 SQ. MILES (CP. 1039.4) (REF. 1) AGUA FRIA RIVER ABOVE NEW RIVER WITHOUT NEW WADDELL DAM	WITH NEW WADDELL DAM	NEW RIVER ABOVE AGUA FRIA RIVER CONF. (REF. 2)	NEW RIVER ABOVE AGUA FRIA RIVER	AGUA FRIA RIVER BELOW NEW RIVER CONFLUENCE (ASSUMED COINCIDENTAL FLOW) WITHOUT NEW WADDELL DAM	WITH NEW WADDELL DAM	AGUA FRIA RIVER BELOW NEW RIVER CONFLUENCE (NON-COINCIDENTAL FLOW) WITHOUT NEW WADDELL DAM
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
500	177,000	48,000	70,000	70,000	247,000	118,000	183,000
200	120,000	38,000	-	50,000	170,000	88,000	---
100	90,000	30,000	39,000	39,000	129,000	69,000	94,000
50	66,000	23,000	29,000	29,000	95,000	52,000	69,000
25	45,000	16,000	-	19,300	64,300	35,300	51,000
10	18,000	8,700	12,500	12,500	30,500	21,200	23,000
5	4,600	4,600	-	7,600	12,200	12,200	---
2	1,400	1,400		3,100	4,500	4,500	---

EXPLANATION

Column	Description
2,3	Taken from Reference 1 as noted in letter.
4	Taken from Reference 2 as noted in letter.
5	Column 4, updated data. Missing data for 200-year, 25-year, 5-year, 2-year, filled in based on interpolated values from Figure 1.
6	Columns 2 & 5 are added together assuming coincidental flow, values are very conservative when compared with values from the Corps of Engineers' estimate (non-coincidental flow) in Column 8.
7	Columns 3 & 5 are added together; again, using coincidental flow. Recommended using these values for this project since there is no other data available.
8	Taken from the Corps' Study. Recommended using these values.

TABLE 2
SUMMARY OF PROBABLE COSTS

COLTER CHANNEL PROJECT
W/P NO 92915.00
FCD NO 92-02
COLTCOST.WQ1

FUTURE Vs EXISTING DESIGN
COST COMPARISIONS

1	FUTURE CONDITION DESIGN	2191520
2	EXISTING CONDITION DESIGN	1988944
	COST DIFFERENCE	***202576***

TABLE 3F
SUMMARY OF PROBABLE COSTS

COLTER CHANNEL PROJECT
W/P NO 92915.00
FCD NO 92-02
COLTCOST.WQ1

OPTION 1
BASED ON FUTURE CONDITION FLOWS

ITEM	*DESCRIPTION*	*QUANTITY*	*UNIT*	*UNIT COST*	*AMOUNT*	*NOTE*
1	EARTH WORK	286000	CY	3	858000	
2	SIDE SPILLWAYS	21000	LS	1	21000	
3	DALE CREEK CONFLUENCE	57000	LS	1	57000	
4	DYSART ROAD BOX	154500	LS	1	154500	(a)
5	AIRLINE CANAL BOX & DROP INLET	67900	LS	1	67900	
6	EL MIRAGE RD BOX & DROP INLET	130500	LS	1	130500	(a)
7	DROP STRUCTURE	20500	LS	1	20500	
8	ABC FOR MAINTENANCE ROAD	5860	SY	3	17580	
9	RIPRAP		CY	25	0	
10	FENCING , GATES	29100	LF	2.5	72750	
11	UTILITY RELOCATION / MCDOT ROW	1	LS	14500	14500	(a)
12	UTILITY RELOCATION FCD ROW	1	LS	12000	12000	
13	IRRIGATION RELOCATION	1	LS	34500	34500	
14	LAND ACQUISITION	81.7	AC	3580	292486	
	SUB TOTAL				1753216	
	CONTINGENCIES		%	25	438304	
	TOTAL				**2191520**	

(a)	MCDOT RESPONSIBILITY	299500
(b)	ADDITIONAL ITEMS FOR SUNCOR CONCERN:	
	COST OF 60' WIDE CROSSING AT AIRLINE CANAL	78500
	COST OF 36" RGRCP FOR FUTURE SIPHON	3500

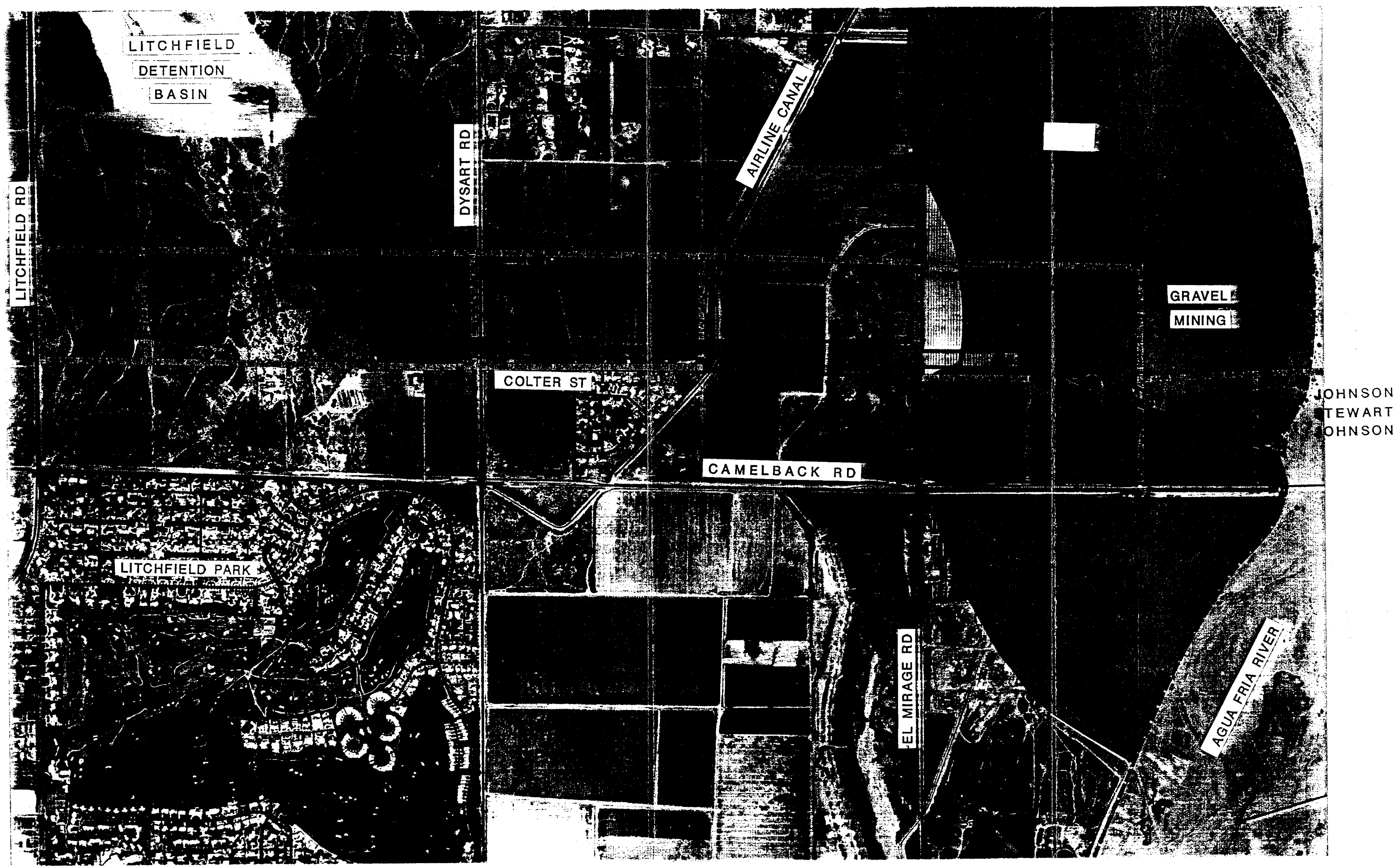
TABLE 3E
SUMMARY OF PROBABLE COSTS

COLTER CHANNEL PROJECT
W/P NO 92915.00
FCD NO 92-02
COLTCOST.WQ1

OPTION 2
BASED ON EXISTING CONDITION FLOWS

ITEM	*DESCRIPTION*	*QUANTITY*	*UNIT*	*UNIT COST*	*AMOUNT*	*NOTE*
1	EARTH WORK	260000	CY	3	780000	
2	SIDE SPILLWAYS	21000	LS	1	21000	
3	DALE CREEK CONFLUENCE	57000	LS	1	57000	
4	DYSART ROAD BOX	125000	LS	1	125000	(a)
5	AIRLINE CANAL BOX & DROP INLET	61200	LS	1	61200	
6	EL MIRAGE RD BOX & DROP INLET	113700	LS	1	113700	(a)
7	DROP STRUCTURE	19000	LS	1	19000	
8	ABC FOR MAINTENANCE ROAD	5860	SY	3	17580	
9	RIPRAP		CY	25	0	
10	FENCING , GATES	29100	LF	2.5	72750	
11	UTILITY RELOCATION / MCDOT ROW	1	LS	14500	14500	(a)
12	UTILITY RELOCATION FCD ROW	1	LS	12000	12000	
13	IRRIGATION RELOCATION	1	LS	34500	34500	
14	LAND ACQUISITION	75.1	AC	3501	262925	
	SUB TOTAL				1591155.1	
	CONTENGENCIES		%	25	397789	
	TOTAL				**1988944**	

(a)	MCDOT RESPONSIBILITY	253200
(b)	ADDITIONAL ITEMS FOR SUNCOR CONCERN:	
	COST OF 60' WIDE CROSSING AT AIRLINE CANAL	70500
	COST OF 36" RGRCP FOR FUTURE SIPHON	3500



CRSS CIVIL ENGINEERS, INC.
IN ASSOCIATION WITH
WOOD/PATEL ASSOC.
ALPHA ENGINEERING GROUP

LEGEND

COLTER CHANNEL ALIGNMENT

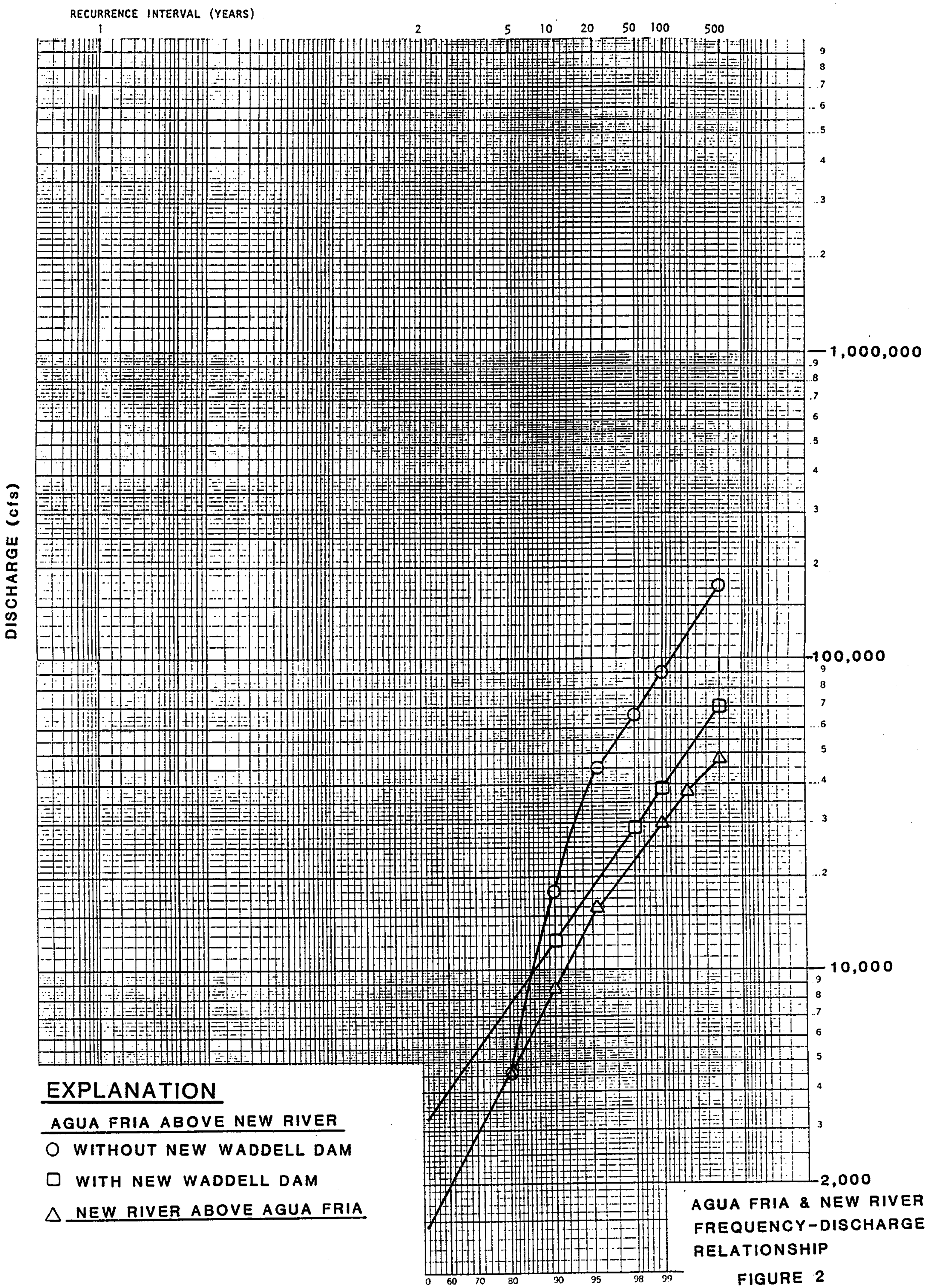
100 YEAR FLOOD LIMITS

FLOODWAY LIMITS

COLTER CHANNEL

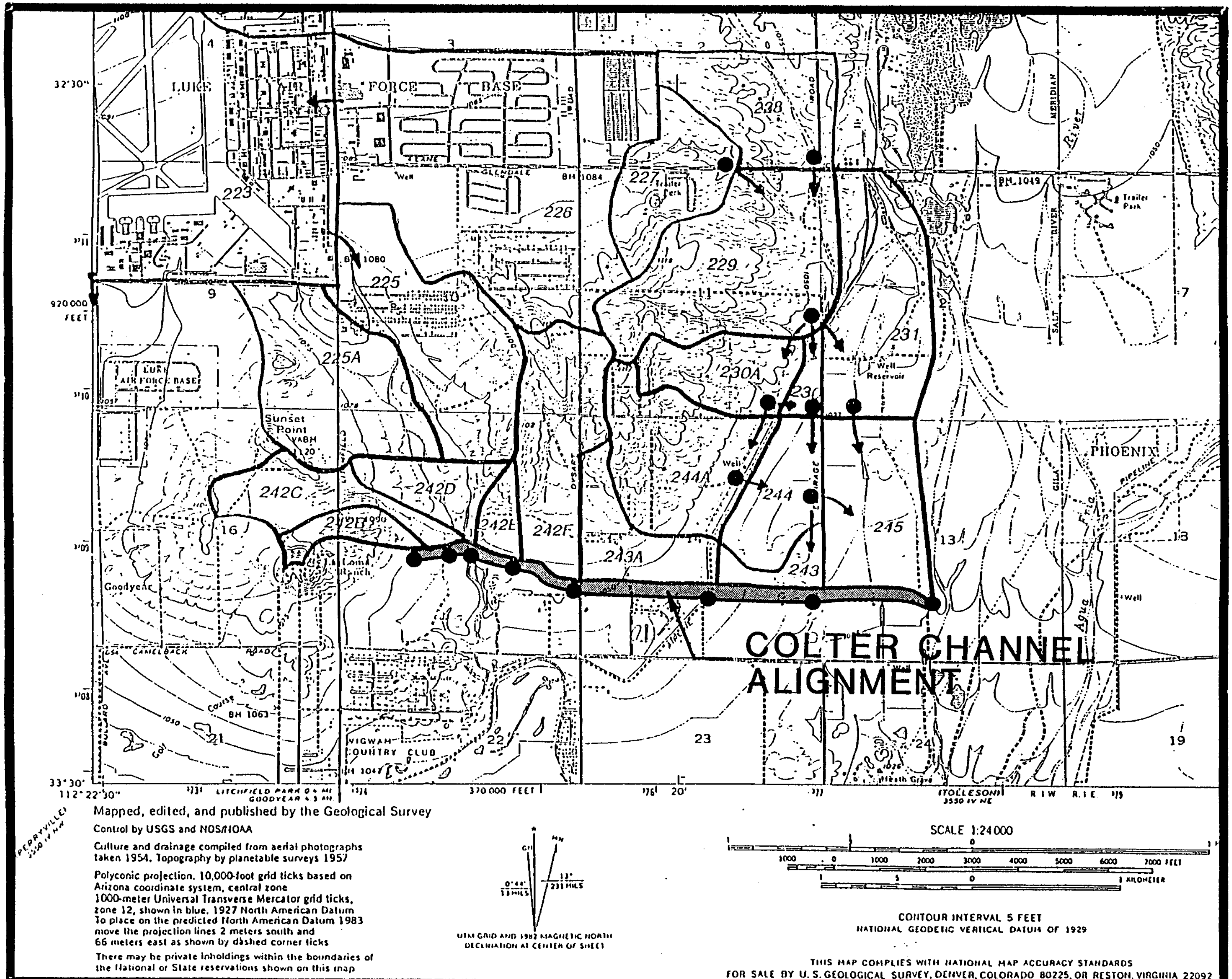
DRAINAGE IMPROVEMENTS

FIGURE 1



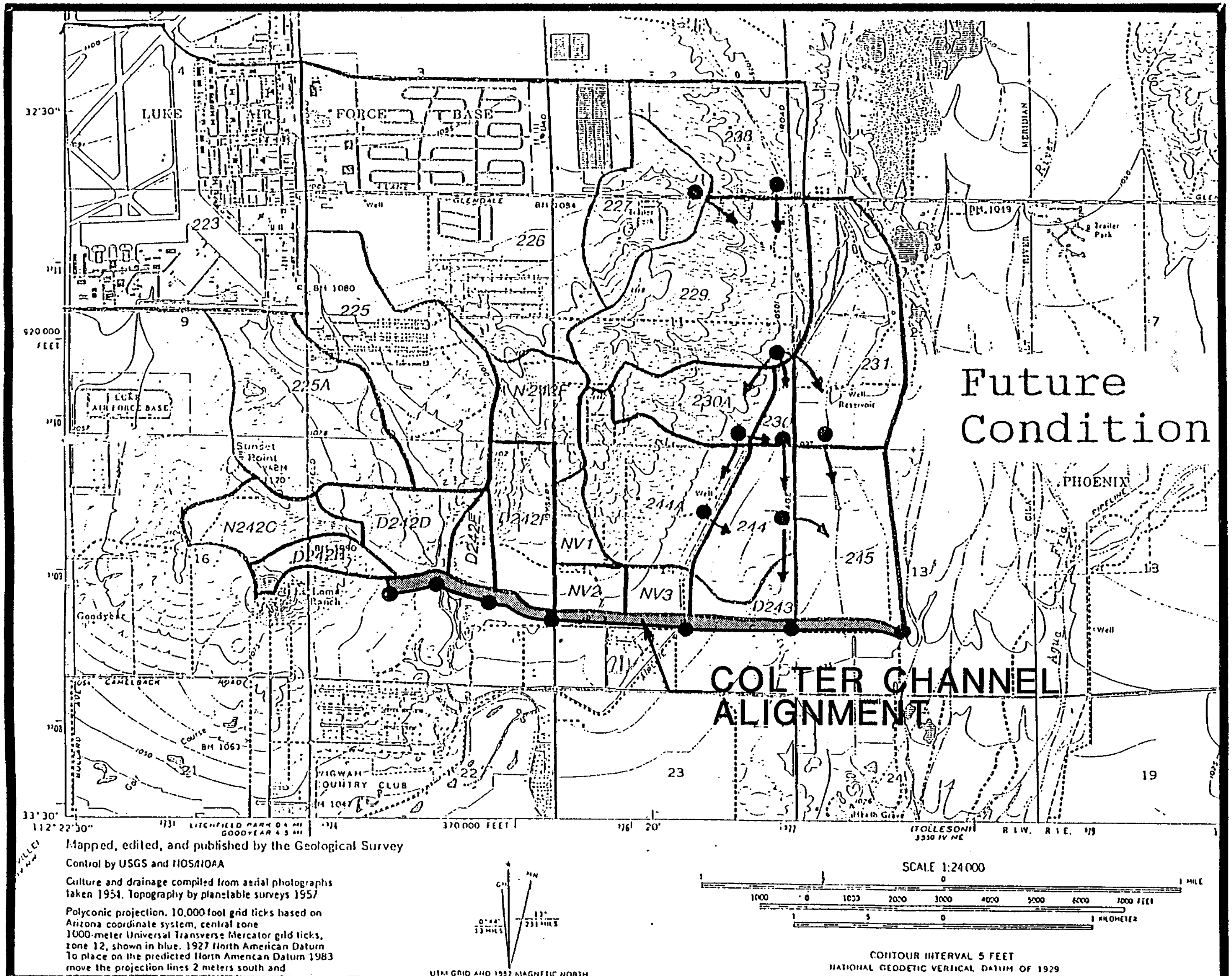
AGUA FRIA & NEW RIVER FREQUENCY-DISCHARGE RELATIONSHIP

FIGURE 2



EXISTING CONDITION DRAINAGE MAP

FIGURE 3



FUTURE CONDITION DRAINAGE MAP

FIGURE 4

LEGEND

225	Drainage Basin Designation
●	Concentration Points on Channel
○	Concentration Points in Contributory Watershed
⊙	Additional Location For Concentration Points
———	Flow Diversion in Watershed
➡	Flow in Channel
———	Drainage Basin Boundary
— — —	Drainage Subbasin Boundary
———	Channel Alignment
▥▥▥	Side Swale
···	Side Weir
➤	Source Inflow

NOTES:

- TOPOGRAPHIC MAPPING FROM WHITE TANKS ADMS.
- HYDROLOGIC DATA INCLUDING DRAINAGE AREA BOUNDARIES FROM FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.

SUMMARY OF FLOWS

CONCENTRATION POINT	HEC-2 ID CHANNEL STATION	DESIGN PLAN CHANNEL STATION	PEAK FLOW	
			EXISTING	FUTURE
Western Origin	13790	14+10	67 cfs	70 cfs
242B	13175	20+25	120 cfs	125 cfs
242C	12400	28+00	270 cfs	340 cfs
242D	11970	32+30	490 cfs	540 cfs
242E	11700	35+00	490 cfs	620 cfs
242F	10800	44+00	710[3] cfs	900[3] cfs
242F	10000	52+00	840 cfs	1060 cfs
243A	7050	81+50	950 cfs	1080 cfs
243	4552	106+48	1040 cfs	1210 cfs
245	2000	132+00	1040[2] cfs	1210[2] cfs
Agua Fria Outfall	0	152+00	1040[2] cfs	1210[2] cfs

[1]Interpolated between CP-242B and CP-242D for Future.

[2]Modeled as 1210 cfs (future) because outfall channel is within Agua Fria floodplain. Actual flow from WLB hydrology, including the additional 100 cfs as mentioned above, is 2170 cfs (existing) and 2400 cfs (future).

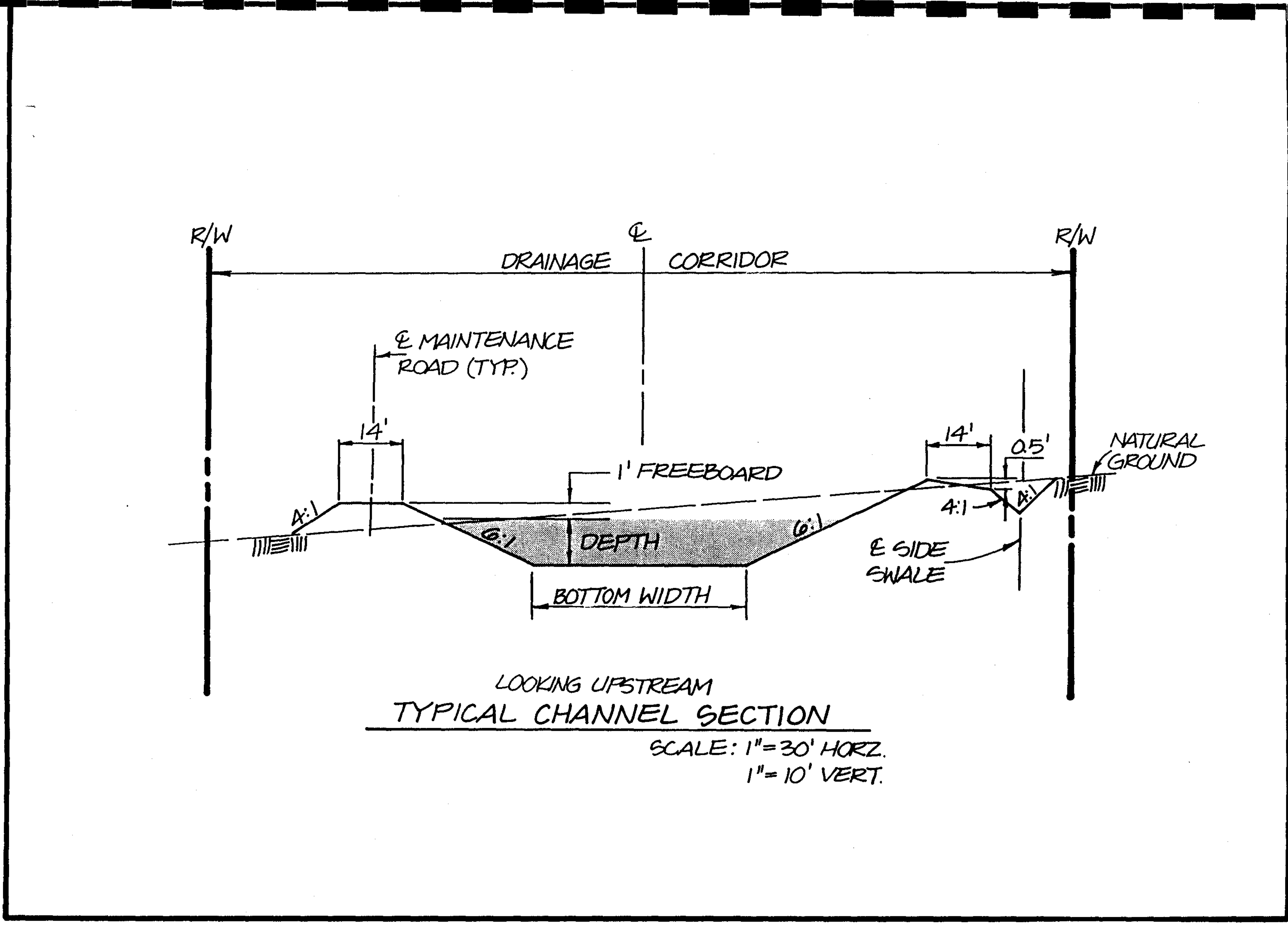
[3]Interpolated between CP-242F and CP-242E

DRAINAGE MAP

FUTURE CONDITION HYDROLOGY

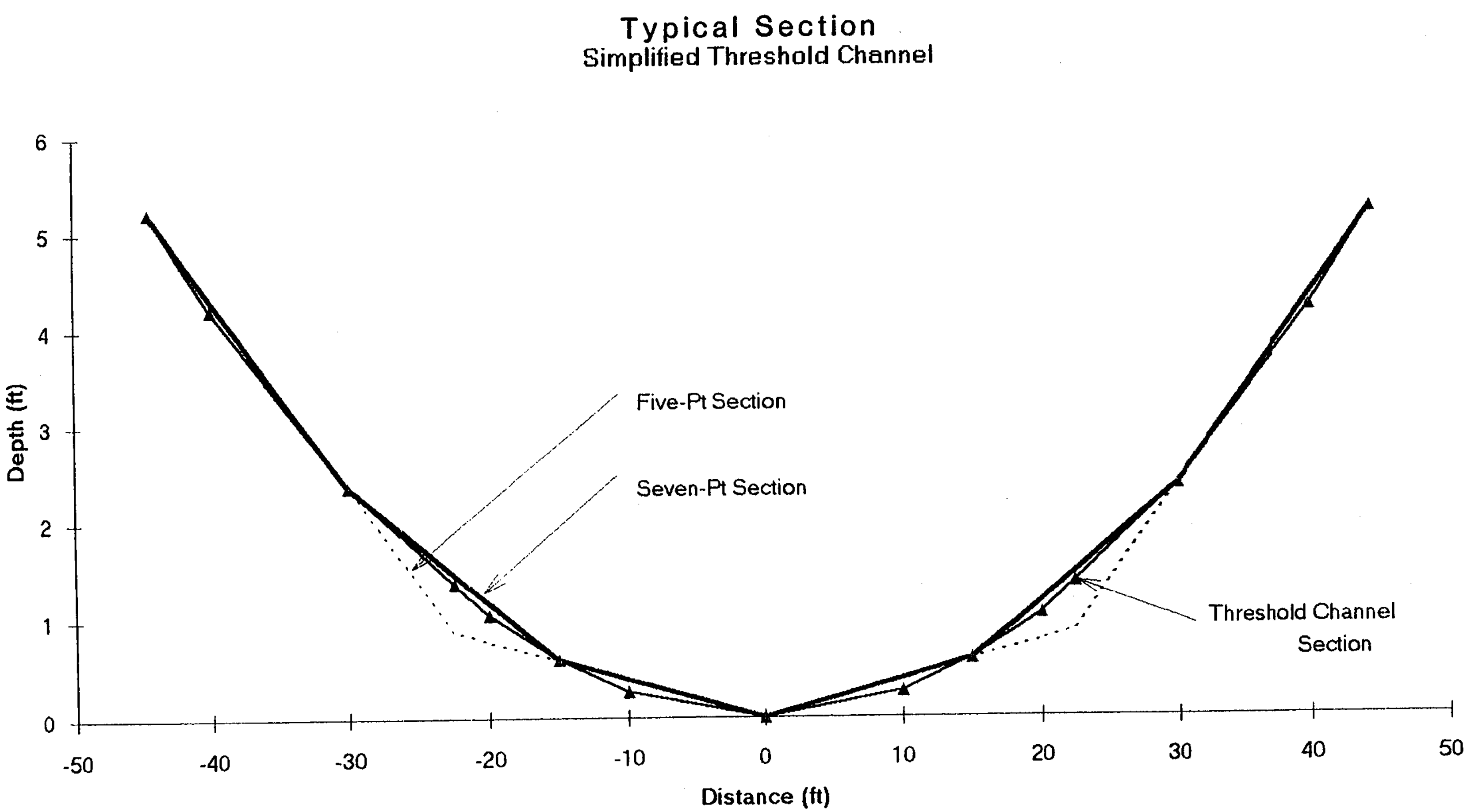
COLTER CHANNEL PROJECT– FCD NO. 92-02

WOOD/PATEL ASSOCIATES Civil Engineers Hydrologists Land Surveyors (602) 957-3149	SCALE 1" = 400'	FIGURE 5
	DATE NOV. 1992	JOB NO. 92915
	DESIGN	CHECK
	DRAWN	FILE



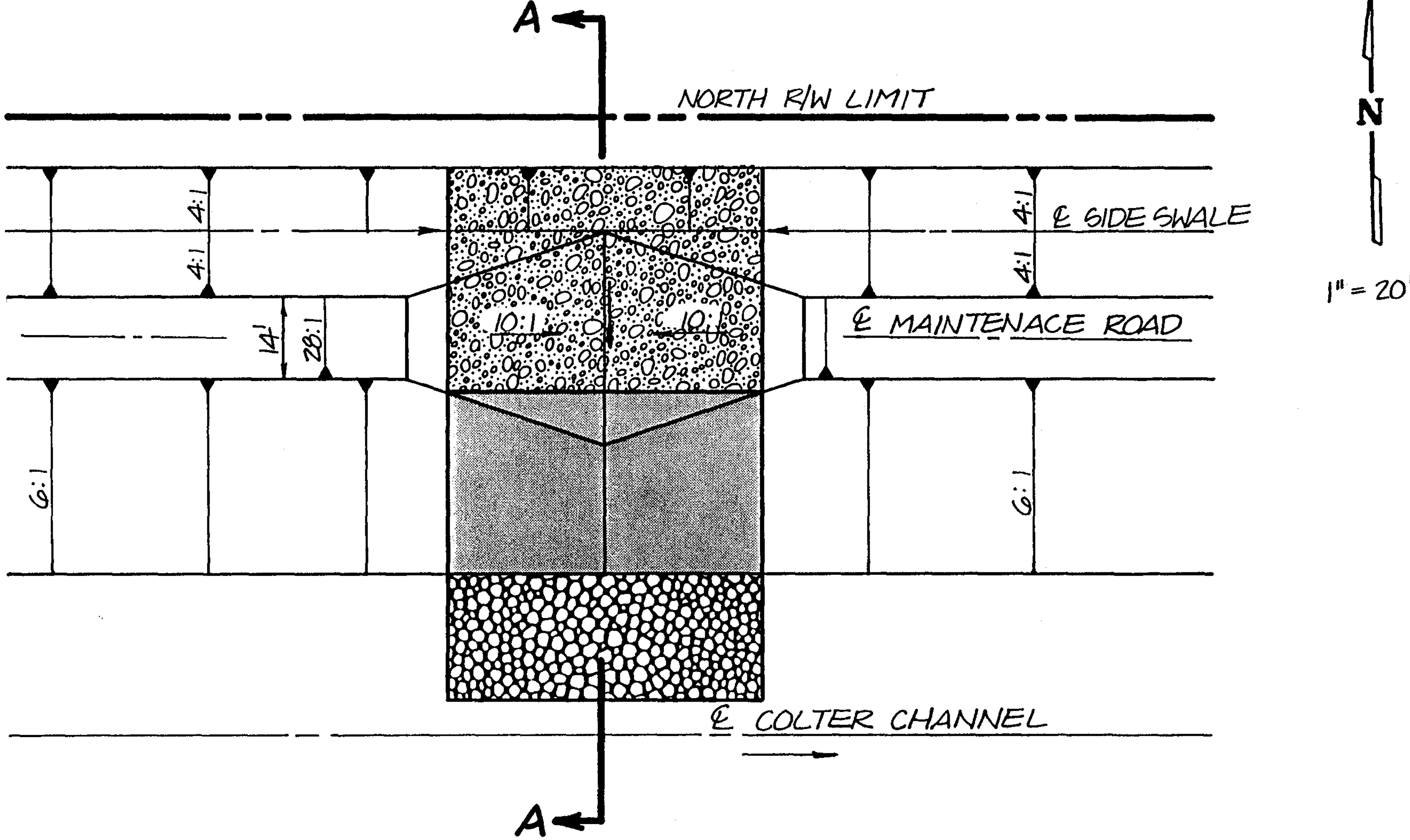
R/W
℄
R/W
DRAINAGE CORRIDOR
℄ MAINTENANCE ROAD (TYP.)
14'
14'
0.5'
NATURAL GROUND
1' FREEBOARD
4:1
4:1
4:1
6:1
6:1
DEPTH
℄ SIDE SWALE
BOTTOM WIDTH
LOOKING UPSTREAM
TYPICAL CHANNEL SECTION
SCALE: 1"=30' HORZ.
1"= 10' VERT.

FIGURE 7



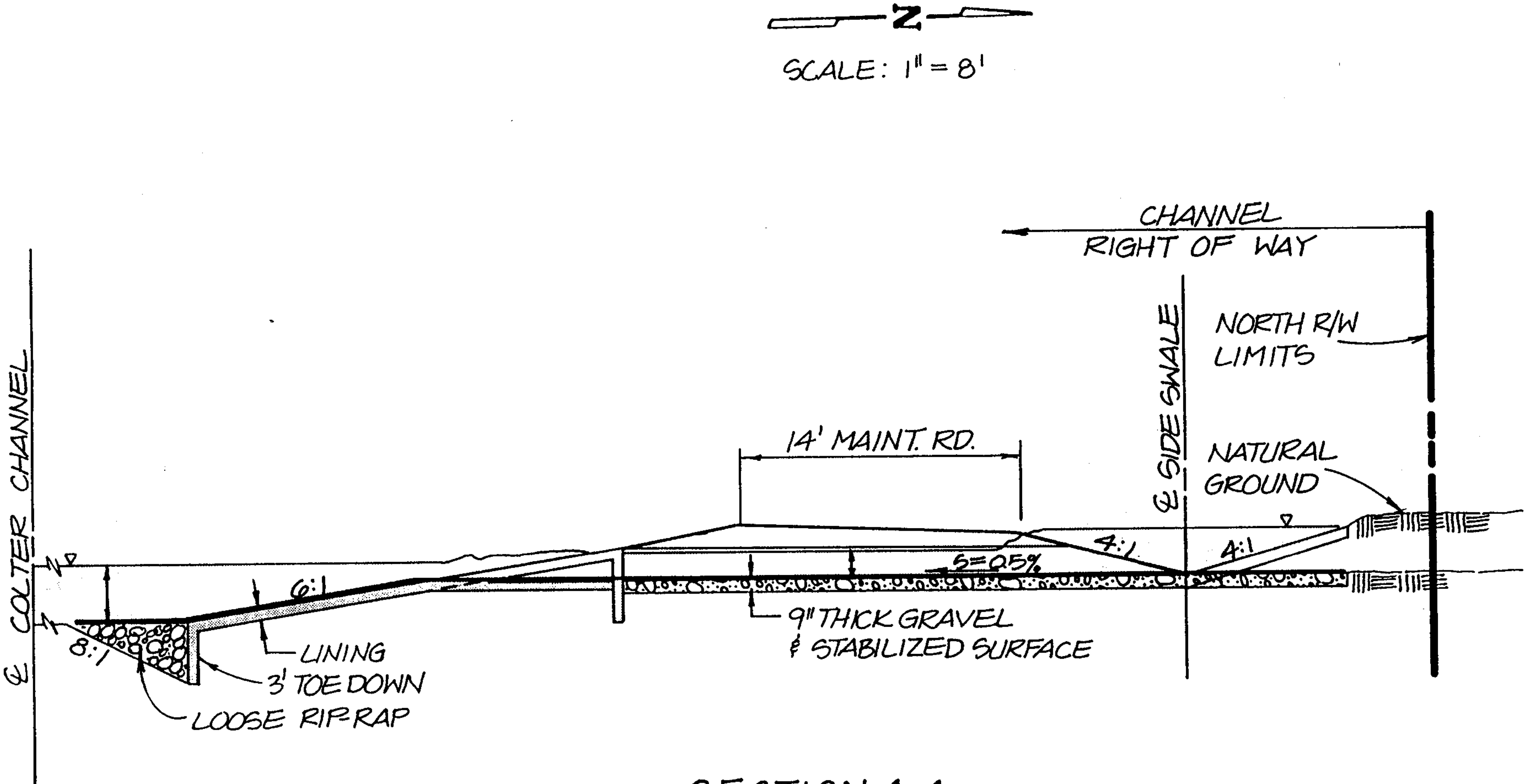
Threshold Channel Typical Section

FIGURE 8



SIDE WEIR, PLAN VIEW

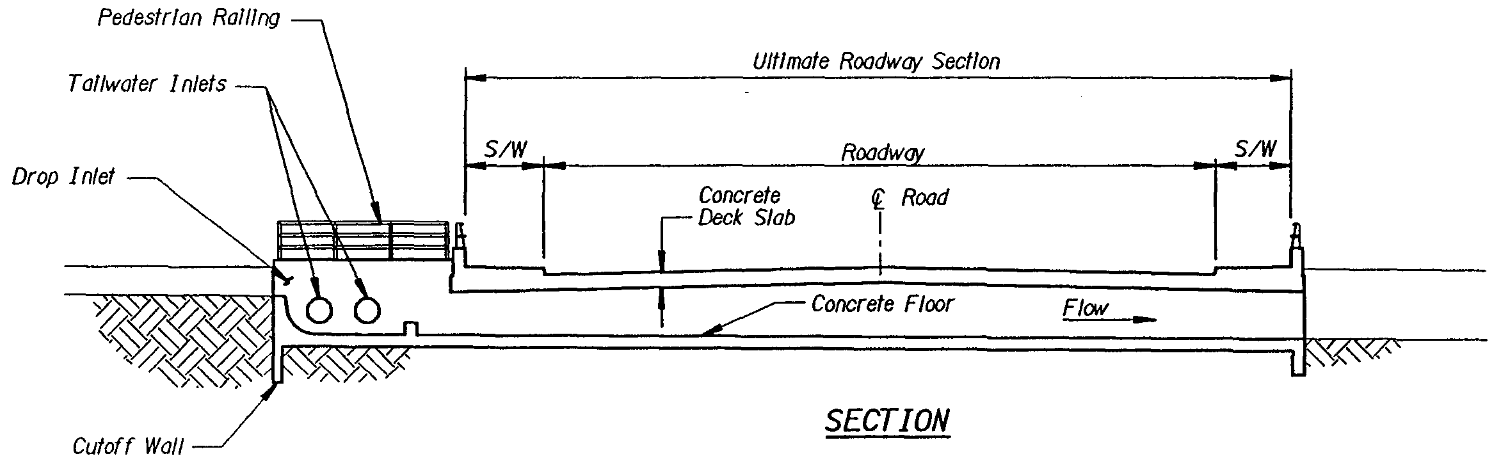
FIGURE 9



SECTION A-A

PROFILE THROUGH SIDE WEIR

FIGURE 10



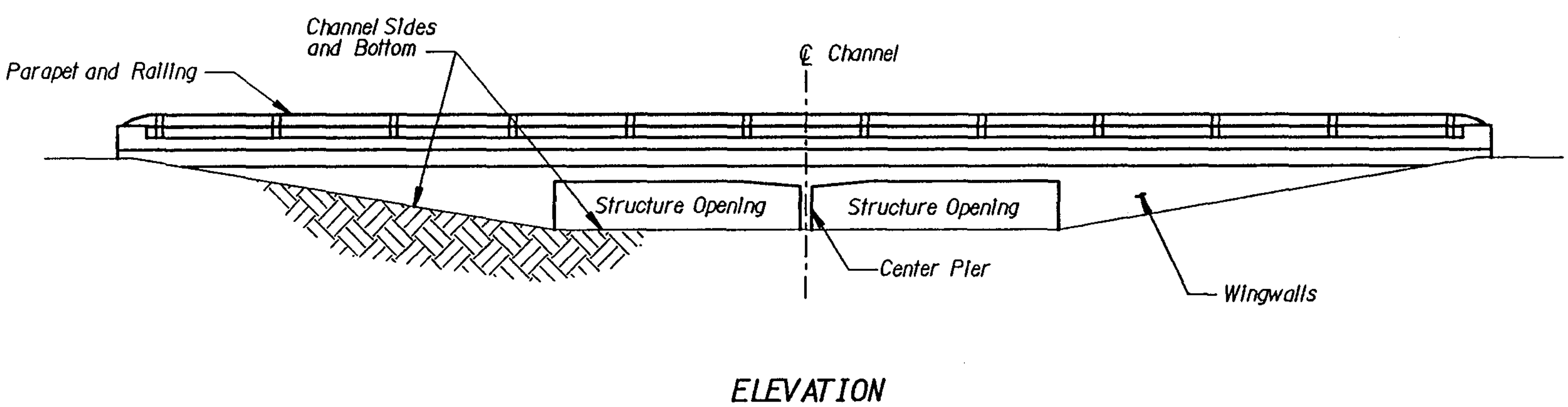
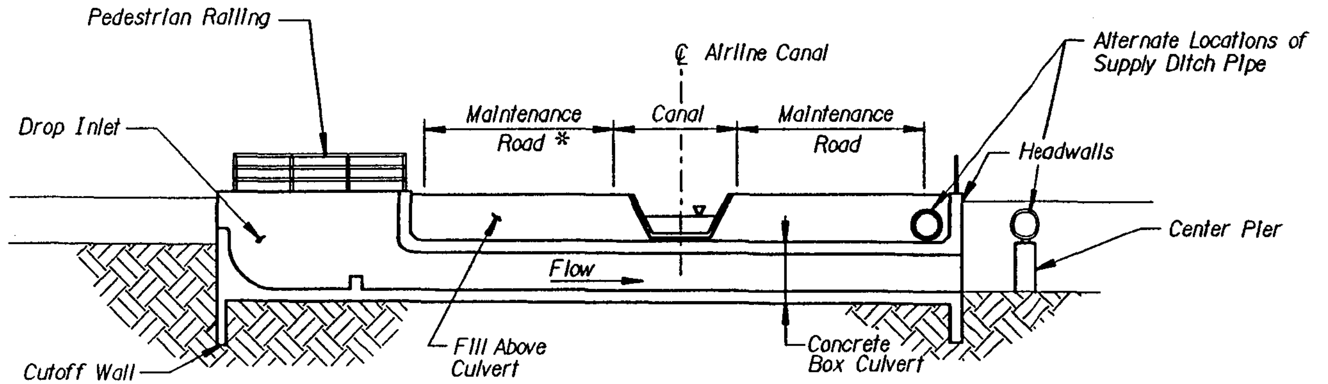
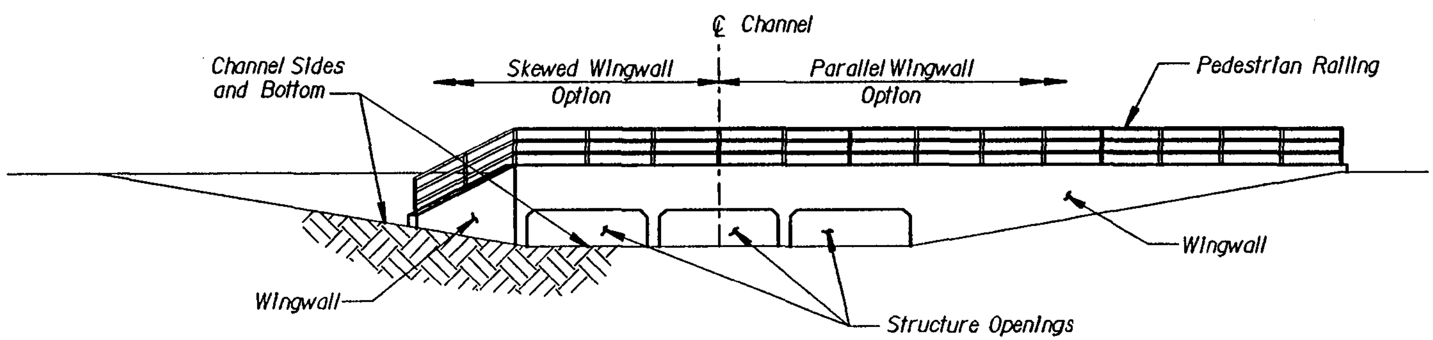


FIGURE 11

EL MIRAGE ROAD CROSSING
FLAT SLAB ALTERNATE



SECTION

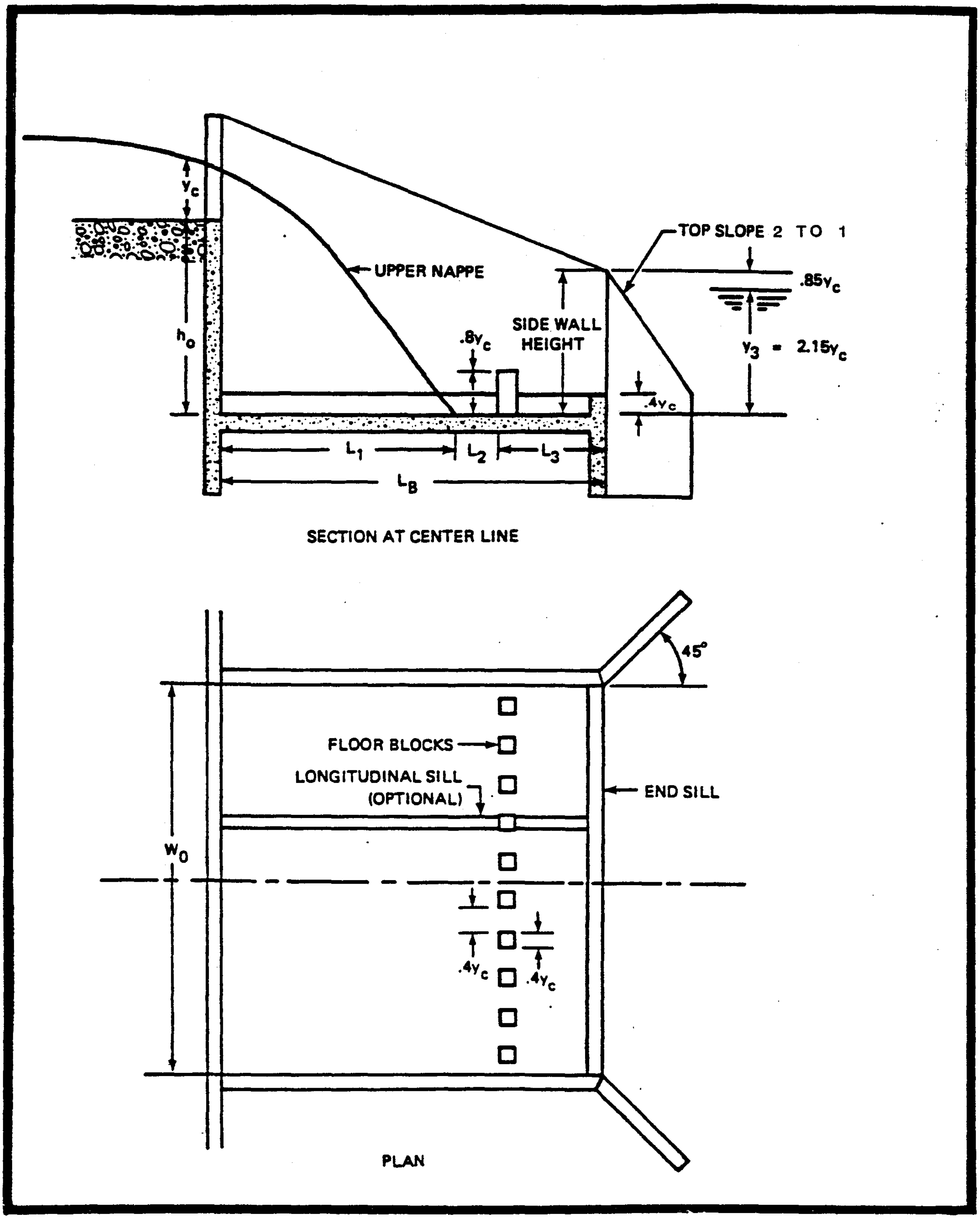


ELEVATION

* THIS PORTION IS NOT REQUIRED BY SUNCOR AND WILL BE RELOCATED DOWNSTREAM ON SUNCOR PROPERTY.

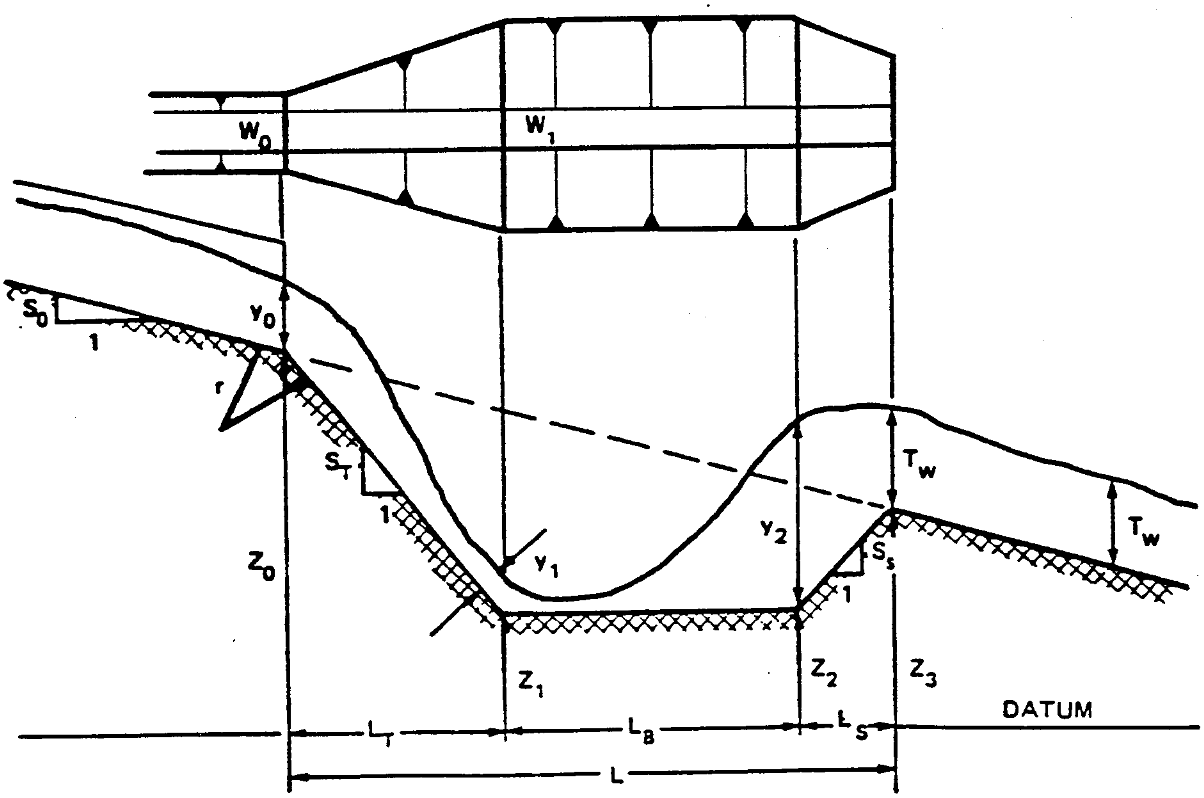
FIGURE 12

AIRLINE CANAL CROSSING
REINFORCED CONCRETE BOX CULVERT



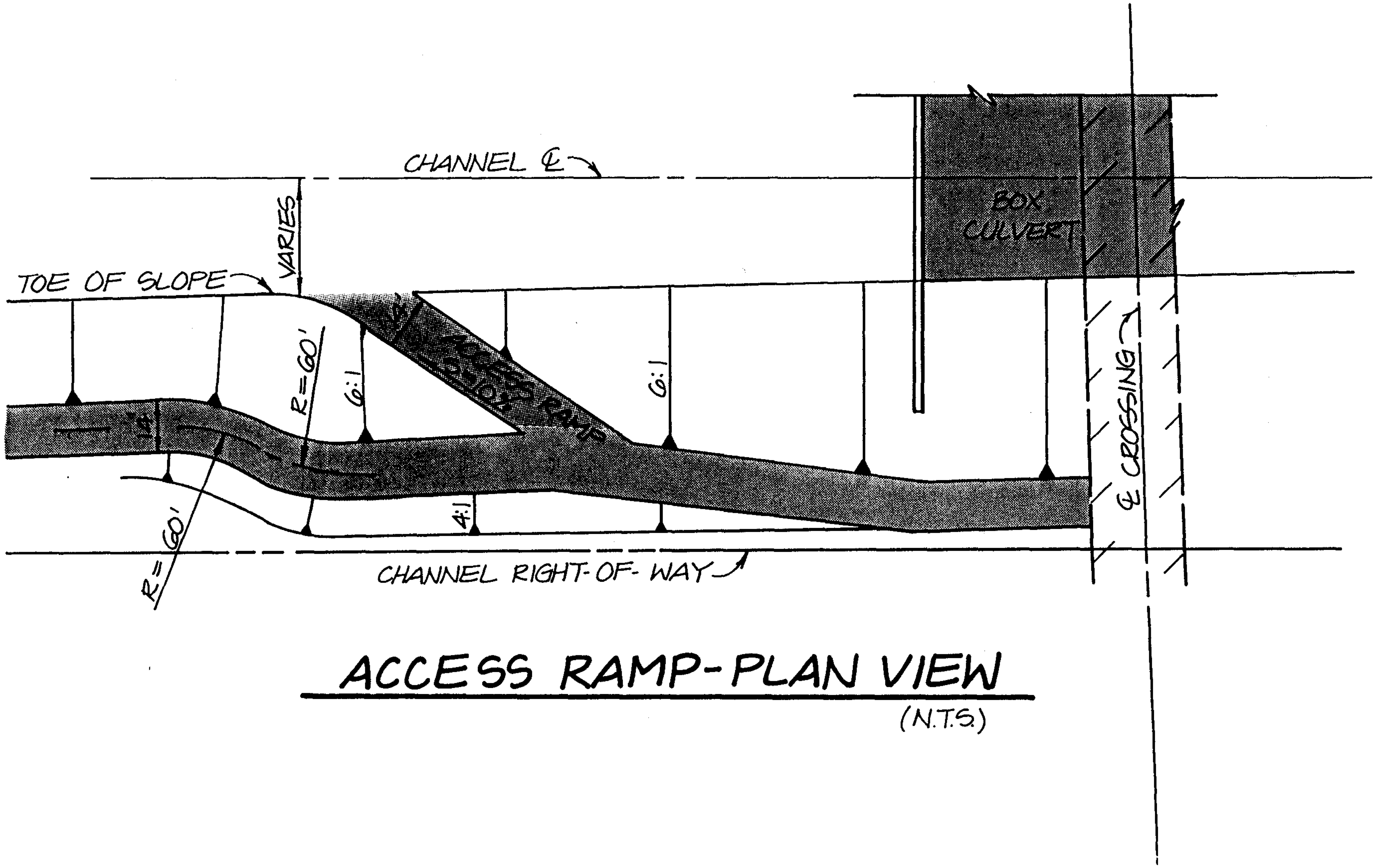
STRAIGHT DROP STRUCTURE

FIGURE 13



SLOPING DROP STRUCTURE

FIGURE 14



ACCESS RAMP-PLAN VIEW

(N.T.S.)

FIGURE 15

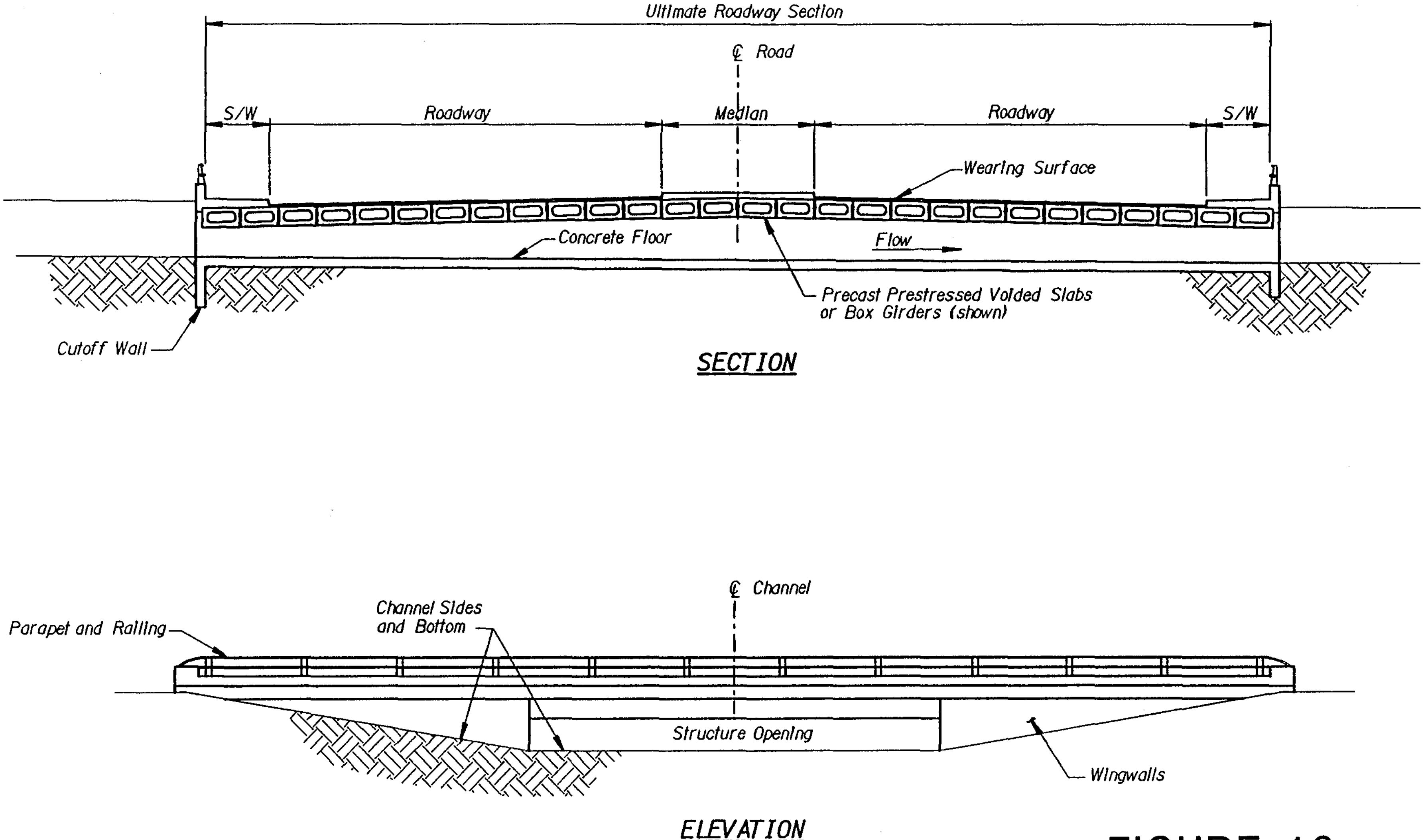
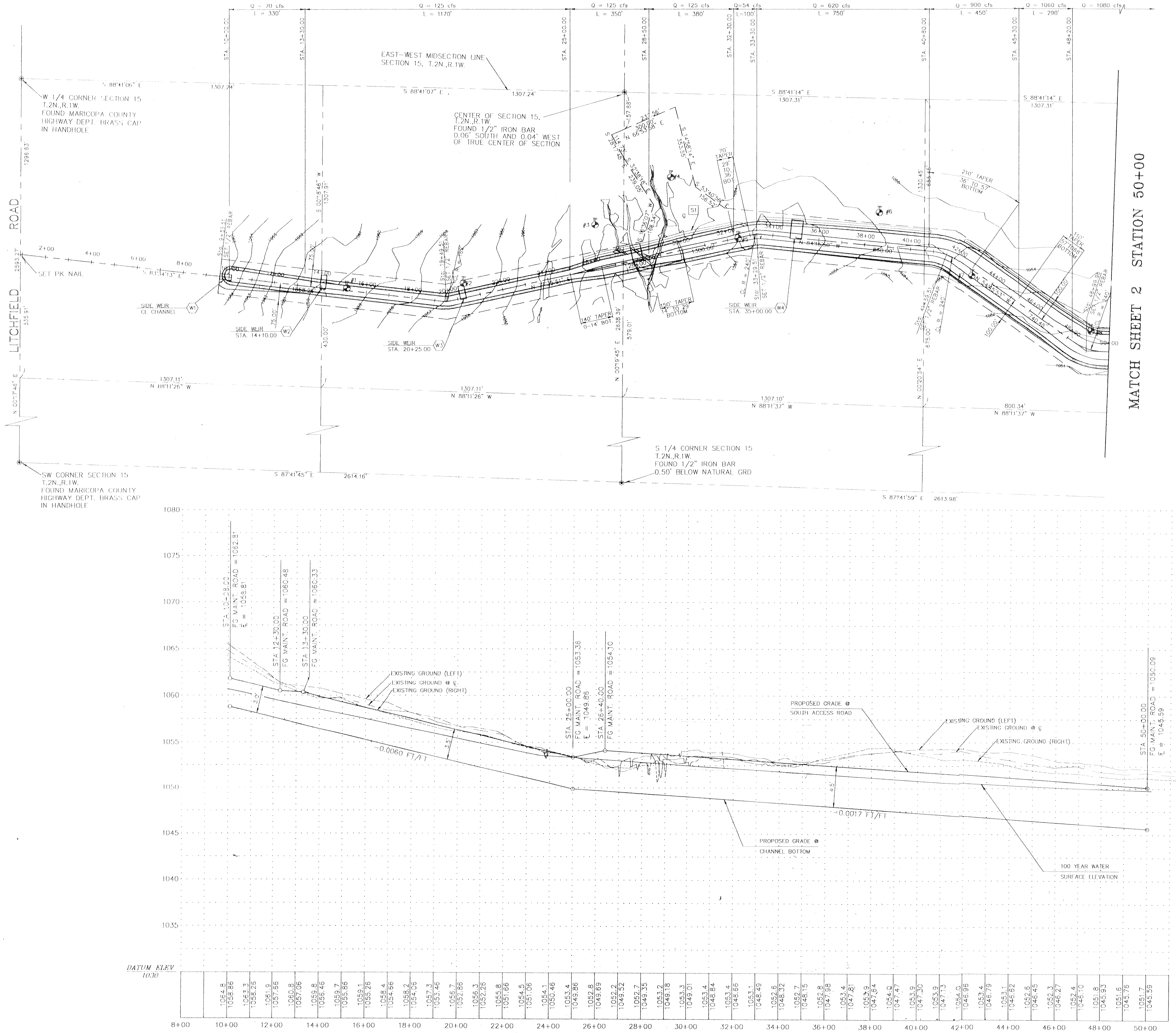


FIGURE 16

DYSART ROAD CROSSING
VOIDED SLAB ALTERNATE

N
400 0 400 800
1" = 400'
scale
feet
AGUA FRIA RIVER
NEW RIVER
ZONE AE
CAMELBACK ROAD
EL MIRAGE ROAD
PROPOSED COLTER CHANNEL
MARICOPA COUNTY UNINCORPORATED AREAS
CITY OF GLENDALE CORPORATE AREAS
CITY OF PHOENIX CORPORATE AREAS
TOWN OF GOODYEAR CORPORATE AREAS
LEGEND
WITH NEW WADDELL DAM
10- YEAR FLOOD LIMITS
25-Year Flood Limits
WITHOUT NEW WADDELL DAM
West Bank Ridgeline,
25-Year Flood Limits
50-Year Flood Limits
100-Year Flood Limits (a)
Floodway Limits (a)
Thalweg(Sta.100+00) # = River Mile (a)
FP=100 YR. WSEL
FW=FLOODWAY WSEL
Cross Section ♦ = End of Coding (a)
Zone Boundary (a)
Corporate Limits (a)
Base Flood Elevs. (a)
NOTES:
• MAP BASED ON 1" = 400' TOPOGRAPHIC MAPPING PREPARED BY COOPER AERIAL SURVEY COMPANY FROM PHOTOGRAPHS TAKEN IN MAY, 1987. CONTRACT NO. C.A.S. 870526
• ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.
• (a)BASEMAP DATA INCLUDING 100-YEAR FLOODPLAIN FOR EXISTING CONDITION (WITHOUT NEW WADDELL DAM) TAKEN FROM FLOOD INSURANCE STUDY WORK MAP, FLOOD CONTROL DISTRICT OF MARICOPA COUNTY BY JERRY R. JONES & ASSOCIATES, INC. (APRIL, 1988)
FLOODPLAIN DELINEATIONS
WEST OVERBANK, AGUA FRIA RIVER
VARIOUS FREQUENCY STORMS
COLTER CHANNEL PROJECT, FCD 92-02
WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
(602) 957-3149
SCALE 1"=400'
FIGURE 6
DATE NOV. 1992
JOB NO. 92915.00
DESIGN
DRAWN
CHECK
FILE



EXISTING UTILITIES

(U1) UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.

(U2) UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.

(U3) 6" HIGH PRESSURE PETROLEUM LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.

(U4) OVERHEAD ELECTRIC POWER POLE IN DYSART ROAD TO BE RELOCATED OUTSIDE OF PROPOSED CONSTRUCTION.

(U5) 6" TIERRA BUENA WATER LINE TO BE RELOCATED BELOW PROPOSED CHANNEL CROSSING.

(U6) OVERHEAD ELECTRIC LINES IN EL MIRAGE ROAD (NO POLE RELOCATION REQUIRED).

(U7) OVERHEAD ELECTRIC POWER POLES (2 EACH) WITHIN CHANNEL ALIGNMENT TO BE RELOCATED OUTSIDE OF CHANNEL LIMITS.

(U8) HIGH VOLTAGE OVERHEAD ELECTRIC LINES IN AREA (NO RELOCATIONS REQUIRED).

PROPOSED SIDE WEIRS

W1 STA 9+59.51, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.

W2 STA 14+10, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.

W3 STA 20+25, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.

W4 STA 35+00, SIDE WEIR FOR SIDE CHANNEL.

W5 STA 52+00, SIDE WEIR FOR SIDE CHANNEL.

W6 STA 56+00, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.

W7 STA 81+50, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.

PROPOSED STRUCTURES

S1 CONFLUENCE STRUCTURE FOR DALE CREEK & ADJACENT WASH.

S2 4 - 12' x 3' - 110 L.F. BOX CULVERT AT DYSART ROAD.

S3 3 - 10' x 3' - 60 L.F. BOX CULVERT WITH DROP INLET AT AIRLINE CANAL.

S4 DROP STRUCTURE AT STATION 98 + 80.

S5 2 - 42" x 70 L.F. PIPE WITH HEADWALL AT EL MIRAGE ROAD.

S6 4 - 10' x 3' - 100 L.F. BOX CULVERT WITH DROP INLET AT EL MIRAGE ROAD.

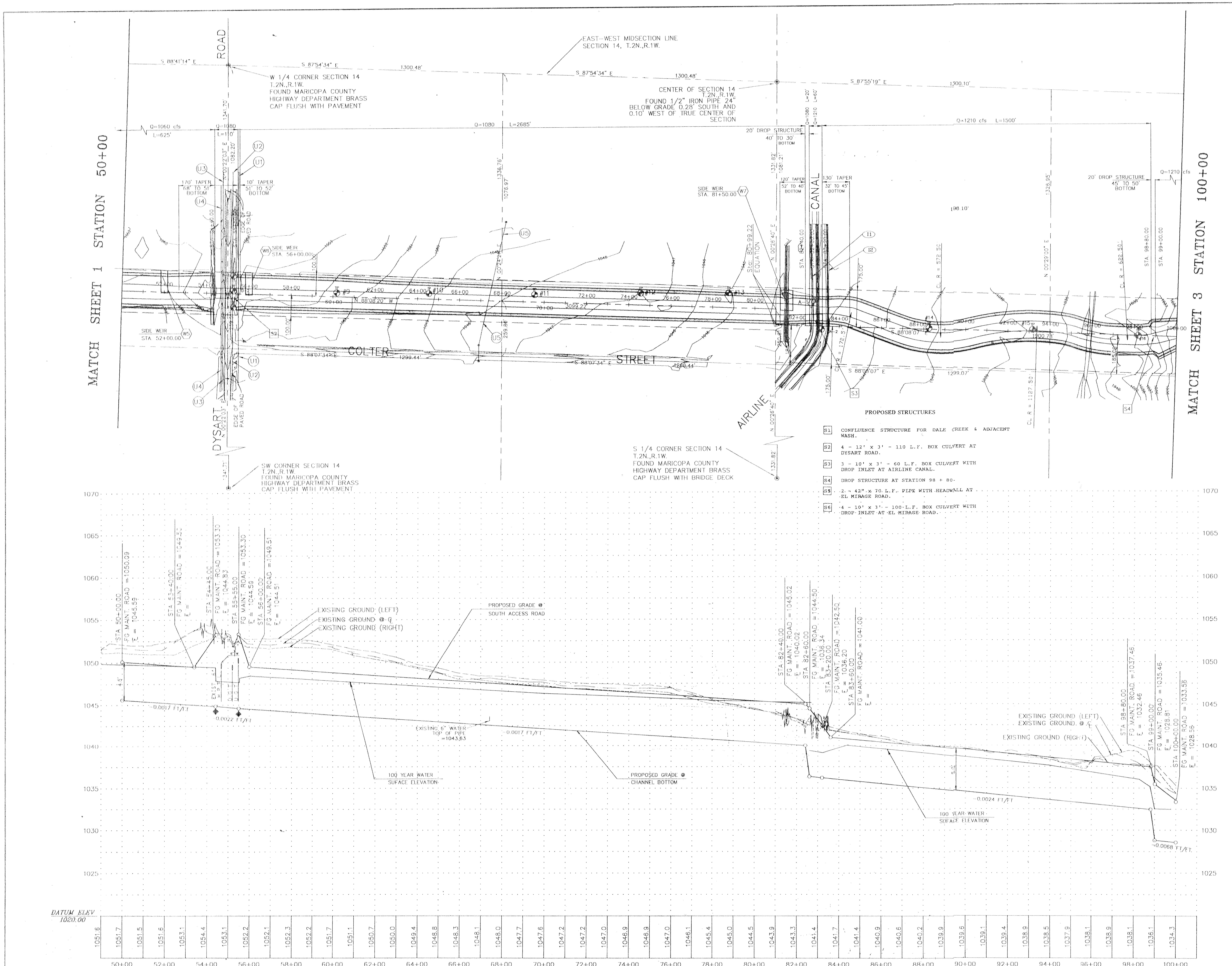
NOV 30 1992

HORZ: 1" = 200'
VERT: 1" = 5'

WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
(602) 957-3149

COLTER CHANNEL PROJECT
RECOMMENDED PLAN ALONG COLTER STREET ALIGNMENT
LITCHFIELD RD TO AGUA FRIA RIVER

DATE	SCALE	SHEET
OCT 1992	1"=200'	1 OF 3
JOB NO.	DESIGN AP	CHECK AP
92915	DRAWN JR	FILE 91151



PROPOSED STRUCTURES

- S1 CONFLUENCE STRUCTURE FOR DALE CREEK & ADJACENT WASH.
- S2 4 - 12' x 3' - 110 L.F. BOX CULVERT AT DYSART ROAD.
- S3 3 - 10' x 3' - 60 L.F. BOX CULVERT WITH DROP INLET AT AIRLINE CANAL.
- S4 DROP STRUCTURE AT STATION 98 + 80.
- S5 2 - 42" x 70 L.F. PIPE WITH HEADWALL AT EL MIRAGE ROAD.
- S6 4 - 10' x 3' - 100 L.F. BOX CULVERT WITH DROP INLET AT EL MIRAGE ROAD.

1 inch = 200 ft.

EXISTING UTILITIES

- U1 UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- U2 UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- U3 6" HIGH PRESSURE PETROLEUM LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- U4 OVERHEAD ELECTRIC POWER POLE IN DYSART ROAD TO BE RELOCATED OUTSIDE OF PROPOSED CONSTRUCTION.
- U5 6" TIERRA BUENA WATER LINE TO BE RELOCATED BELOW PROPOSED CHANNEL CROSSING.
- U6 OVERHEAD ELECTRIC LINES IN EL MIRAGE ROAD (NO POLE RELOCATION REQUIRED).
- U7 OVERHEAD ELECTRIC POWER POLES (2 EACH) WITHIN CHANNEL ALIGNMENT TO BE RELOCATED OUTSIDE OF CHANNEL LIMITS.
- U8 HIGH VOLTAGE OVERHEAD ELECTRIC LINES IN AREA (NO RELOCATIONS REQUIRED).

PROPOSED SIDE WEIRS

- W1 STA 9+59.51, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- W2 STA 14+10, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- W3 STA 20+25, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- W4 STA 35+00, SIDE WEIR FOR SIDE CHANNEL.
- W5 STA 52+00, SIDE WEIR FOR SIDE CHANNEL.
- W6 STA 56+00, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.
- W7 STA 81+50, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.

EXISTING IRRIGATION DITCHES

- I1 AIRLINE CANAL TO BE RECONSTRUCTED OVER NEW CULVERT CROSSING.
- I2 IRRIGATION SUPPLY LINE AT AIRLINE CANAL TO BE RECONSTRUCTED OVER NEW CULVERT OR CARRIED IN FLUME OVER CHANNEL CROSSING.
- I3 IRRIGATION SUPPLY LINE AT EL MIRAGE ROAD TO BE RECONSTRUCTED OVER NEW CULVERT.
- I4 CONSTRUCT TAILWATER DITCH (WITHIN TEMPORARY CONSTRUCTION EASEMENT) ADJACENT TO 30' ACCESS ROAD TO A.B.C. SAND & ROCK.
- I5 CONSTRUCT FLUME FROM TAILWATER DITCH INTO EXISTING TAILWATER/SUPPLY DITCH ON SOUTH SIDE OF CHANNEL.
- I6 CONSTRUCT TAILWATER/SUPPLY DITCH (WITHIN TEMPORARY CONSTRUCTION EASEMENT) ADJACENT TO THE SOUTH MAINTENANCE ROAD TO THE EXISTING WASH WEST OF A.B.C. SAND & ROCK ACCESS ROAD.

NOV 30 1992

HORZ: 1" = 200'
VERT: 1" = 5'

WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
(602) 957-3149

COLTER CHANNEL PROJECT
RECOMMENDED PLAN ALONG COLTER STREET ALIGNMENT
LITCHFIELD RD TO AGUA FRIA RIVER

DATE	SCALE	SHEET
OCT 1992	1"=200'	2 OF 3
JOB NO.	DESIGN AP	CHECK AP
92915	DRAWN JR	FILE 911S2

EXISTING IRRIGATION DITCHES

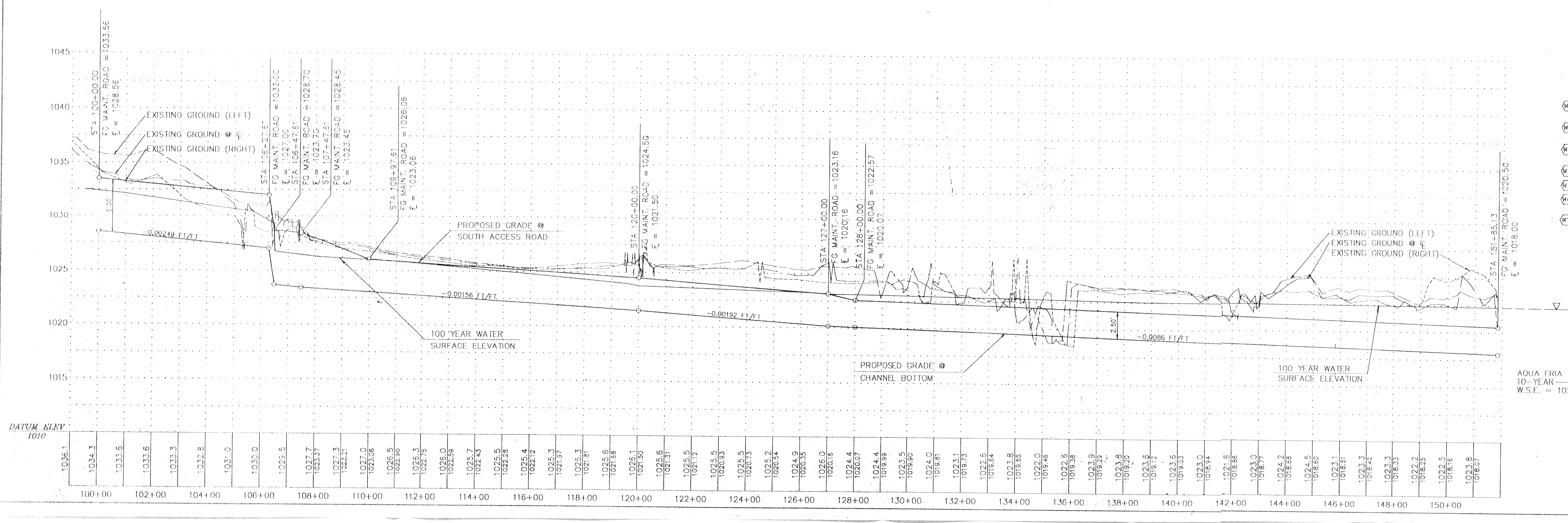
- (I1) AIRLINE CANAL TO BE RECONSTRUCTED OVER NEW CULVERT CROSSING.
- (I2) IRRIGATION SUPPLY LINE AT AIRLINE CANAL TO BE RECONSTRUCTED OVER NEW CULVERT OR CARRIED IN FLUME OVER CHANNEL CROSSING.
- (I3) IRRIGATION SUPPLY LINE AT EL MIRAGE ROAD TO BE RECONSTRUCTED OVER NEW CULVERT.
- (I4) CONSTRUCT TAILWATER DITCH (WITHIN TEMPORARY CONSTRUCTION EASEMENT) ADJACENT TO 30' ACCESS ROAD TO A.B.C. SAND & ROCK.
- (I5) CONSTRUCT FLUME FROM TAILWATER DITCH INTO EXISTING TAILWATER/SUPPLY DITCH ON SOUTH SIDE OF CHANNEL.
- (I6) CONSTRUCT TAILWATER/SUPPLY DITCH (WITHIN TEMPORARY CONSTRUCTION EASEMENT) ADJACENT TO THE SOUTH MAINTENANCE ROAD TO THE EXISTING WASH WEST OF A.B.C. SAND & ROCK ACCESS ROAD.

EXISTING UTILITIES

- (U1) UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- (U2) UNDERGROUND TELEPHONE LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- (U3) 6" HIGH PRESSURE PETROLEUM LINE IN DYSART ROAD TO BE RELOCATED BELOW PROPOSED CULVERT CROSSING.
- (U4) OVERHEAD ELECTRIC POWER POLE IN DYSART ROAD TO BE RELOCATED OUTSIDE OF PROPOSED CONSTRUCTION.
- (U5) 6" TIERRA BUENA WATER LINE TO BE RELOCATED BELOW PROPOSED CHANNEL CROSSING.
- (U6) OVERHEAD ELECTRIC LINES IN EL MIRAGE ROAD (NO POLE RELOCATION REQUIRED).
- (U7) OVERHEAD ELECTRIC POWER POLES (2 EACH) WITHIN CHANNEL ALIGNMENT TO BE RELOCATED OUTSIDE OF CHANNEL LIMITS.
- (U8) HIGH VOLTAGE OVERHEAD ELECTRIC LINES IN AREA (NO RELOCATIONS REQUIRED).

PROPOSED STRUCTURES

- [S1] CONFLUENCE STRUCTURE FOR DALE CREEK & ADJACENT WASH.
- [S2] 4 - 12' x 3' - 110 L.F. BOX CULVERT AT DYSART ROAD.
- [S3] 3 - 10' x 3' - 60 L.F. BOX CULVERT WITH DROP INLET AT AIRLINE CANAL.
- [S4] DROP STRUCTURE AT STATION 98 + 80.
- [S5] 2 - 42" x 70 L.F. PIPE WITH HEADWALL AT EL MIRAGE ROAD.
- [S6] 4 - 10' x 3' - 100 L.F. BOX CULVERT WITH DROP INLET AT EL MIRAGE ROAD.



PROPOSED SIDE WEIRS

- (W1) STA 9+59.51, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- (W2) STA 14+10, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- (W3) STA 20+25, SIDE WEIR FOR CONCENTRATED OFFSITE FLOW.
- (W4) STA 35+00, SIDE WEIR FOR SIDE CHANNEL.
- (W5) STA 52+00, SIDE WEIR FOR SIDE CHANNEL.
- (W6) STA 56+00, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.
- (W7) STA 81+50, SIDE WEIR FOR SIDE CHANNEL & CONCENTRATED OFFSITE FLOW.

NOV 30 1992

HORZ: 1" = 200'
VERT: 1" = 5'

WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
(602) 957-3149

COLTER CHANNEL PROJECT
RECOMMENDED PLAN ALONG COLTER STREET ALIGNMENT
LITCHFIELD RD TO AGUA FRIA RIVER

DATE	SCALE	SHEET
OCT 1992	1"=200'	3 OF 3
JOB NO.	DESIGN AP	CHECK AP
92915	DRAWN JR	FILE 91153