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Final Report of Alternatives Analysis
McMicken Dam Fissure Risk Zone Remediation Project
Contract FCD 2002C011, Work Assignment No. 1

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Final Report of Alternatives Analysis
McMicken Dam Fissure Risk Zone Remediation Project
Contract FCD 2002C011, Work Assignment No. 1

Submitted to:

Flood Control District of Maricopa County
Phoenix, Arizona

Registered Professional Engineer (Civil)
CERTIFICATE NO.
13872
LAWRENCE A.
HANSEN
Date Signed 11/5/03
ARIZONA, U.S.A.

Submitted by:

AMEC Earth & Environmental, Inc.
Phoenix, Arizona

5 November 2003

AMEC Job No. 2-117-001066

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Bobbie Ohler, P.E.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

Dear Ms. Ohler:

Re: Final Report of Alternatives Analysis
McMicken Dam Fissure Risk Zone Remediation Project
Contract FCD 2002C011, Work Assignment No. 1

Transmitted herewith are eight copies of the final report presenting the summary of the alternatives analysis completed for the McMicken Dam fissure risk zone remediation project. The memorandum discusses the various steps included in the alternatives analysis and presents 15 percent design plans and a cost estimate for the selected preferred alternative and for the other final alternatives considered.

Should you have any questions, please do not hesitate in contacting the undersigned.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
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LAWRENCE A.
HANSEN
Date Signed 11/5/03
ARIZONA U.S.A.

Lawrence A. Hansen, PhD., P.E.
Senior Vice President

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c: Addressee (8)

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Date Signed 11/5/03
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1.0 INTRODUCTION

This memorandum prepared by AMEC Earth & Environmental, Inc. (AMEC) presents a summary of the alternatives analysis process completed to select a preferred alternative for the rehabilitation of the south end of McMicken Dam. This memorandum was prepared as the final document for the alternative analysis being completed for the Flood Control District of Maricopa County, herein referred to as the District. The various tasks that are summarized herein were conducted for the District in accordance with the McMicken Dam Fissure Risk Zone Remediation (FRZR) Project, Work Assignment 1 of Contract FCD 2002C011 between AMEC and the District. The purpose of the McMicken Dam FRZR Project is to mitigate the risk associated with the earth fissures that have been identified near the south end of the dam, and which may intersect the dam and its foundation. The intent of the alternatives analysis process is to select a preferred alternative for mitigation of the fissure risk zone, thereby enhancing the safety of dam. This final report for the project presents a preliminary design (15 percent plans) for the preferred alternative.

2.0 ALTERNATIVES ANALYSIS OVERVIEW

The overall purpose of the alternatives analysis was to identify and evaluate alternatives that will remediate the potential flooding that could occur, if one or more earth fissures compromised the function of McMicken Dam. The general process was to identify potential dam and foundation modifications, and alternatives to replace the function of the part of the dam located within the earth fissure risk zone, then evaluate these alternatives using criteria developed specifically for the alternatives analysis. The analysis was completed with successive levels of complexity, leading to the selection of a preferred alternative. The steps in the process included:

- Development of a list of alternatives and a list of criteria for evaluation of the alternatives.

- Development of conceptual plans for the listed alternatives, completion of preliminary cost estimates, and performance of preliminary failure modes and consequence analysis of the alternatives.

- Initial screening of the list of alternatives to reduce the number of alternatives to about eight for further evaluation.

- Intermediate screening of the alternatives selected from the initial screening, based on more detailed designs (15 percent design level) and cost estimates, and identification of significant issues and design constraints that would make one alternative more or less favorable than another. The intermediate screening was to reduce the number of alternatives to about three.

- Completion of a quantitative, structured risk analysis of the alternatives selected from the intermediate screening.

- Completion of a structured value engineering, or preferred alternative analysis, of the alternatives selected from the intermediate screening.

- Additional studies, including numerical analyses to estimate the level of horizontal strain within the fissure hazard zone, which can be related to the possible presence of earth fissures, and analyses of the impact of breaching the existing McMicken Dam at locations south of Station 107+00.

- Selection of a preferred alternative.

The above steps were not completed as discreet tasks, but were overlapped in the alternatives analysis process. Screening of the alternatives was completed in meetings attended by representatives of the District, AMEC and Stantec Consulting, Inc. (Stantec). Generally, AMEC and Stantec provided preliminary designs, cost estimates, evaluation matrices and draft reports for use during the screening, risk analysis, and value engineering meetings. A representative of the Arizona Department of Water Resources (ADWR) also was involved in the screening process, except for the selection of the preferred alternative.

3.0 INITIAL ALTERNATIVES AND EVALUATION CRITERIA LISTS

Draft lists of alternatives and evaluation criteria were submitted to the District on 2 December 2002, and a meeting was held on 5 December 2002 to discuss and revise the lists. Draft evaluation criteria included function criteria, performance criteria, risk, cost, environmental considerations, land use, aesthetics, capability of being accommodated in future plans, and regulatory requirements/acceptance. Based on the discussions, these were revised to include performance criteria (which included the function criteria of the draft list), failure consequences (a subset of the draft risk criterion), time and schedule (a new criterion), cost, environmental considerations, land use, opportunities for additional benefits (another new criterion), aesthetics, and capability of being accommodated in future plans. Minor revisions also were made to the sub-criteria included for each of these major criteria. A weighting system for the criteria also was discussed, and a preliminary weighting system was adopted.

Environmental considerations primarily focused on potential impacts to archeological sites, and impacts to vegetation and habitat upstream and downstream of McMicken Dam. Areas of disturbance included areas within and outside of the waters of the US. Potential areas within the US Army Corps of Engineers' (USCOE) 404 jurisdiction included the existing McMicken Dam low flow channel and the numerous washes located upstream of the dam. Consequently, the alternatives analysis focused on minimizing environmental impacts within the waters of the US in accordance with the USCOE's 404 (b) 1 guidelines.

The draft list of alternatives included system alternatives and system component alternatives. The system components are those design features that would be common to many of the systems. For example, a new homogeneous embankment could utilize a geosynthetic to protect against flow through embankment cracks, or the new embankment could be designed as a zoned earthen structure to provide the same protection. The system alternatives generally include structures that require a more spatial consideration and have varying potential direct impacts on the environment, land use and other factors, independent of the components used in the systems. The purpose in separately identifying components is that the process allowed comparative evaluation of the components primarily on the basis of cost, impact on time and schedule, and other specific criteria.

The list of system alternatives included five general categories, including no action, monitor only, rehabilitation of the existing structure, abandonment of the existing structure and segmenting the existing structure. Rehabilitation alternatives (Category 3) included construction of a new earthen, roller compacted concrete (RCC) or soil cement (SC) embankment upstream or downstream of the existing structure, or widening the existing structure such that it fulfilled the criteria of protecting it against shrinkage/settlement cracking and earth fissures. Rehabilitation alternatives also included construction of an upstream blanket and hydraulic barriers, and crack filling in conjunction with construction of upstream hydraulic barriers. The abandonment alternatives (Category 4) generally provided for the abandonment of the existing structure, recognizing the comparatively small size of the watershed located upstream of the section of the existing dam that would be abandoned. These alternatives included construction of an upstream dam and spur dike outside of the moderate and high hazard fissure zones, construction of the same systems within the moderate and high hazard fissure zones, and construction of an upstream diversion and spur dike outside of the moderate and high hazard fissure zones. The spur dikes (or dam extensions) are required to prevent backflows from a major storm event occurring within the northern part of the watershed, and the dam or diversion would be designed to direct flow to the northern part of the existing dam. The dam segmentation alternatives (Category 5) included construction of a spur dike (or dam extension) only to segment that part of the dam within the moderate and high hazard fissure zones, with significantly less flow required to be impounded by the segmented southern part of the dam.

In discussing these alternatives, the District established that for initial screening of the alternatives, rehabilitation, abandonment or segmentation of the existing dam only within the high hazard fissure zone was to be considered. Further, based on a parallel study being conducted for the District by URS Corporation, any of the systems requiring new structures or dam extensions within the identified moderate or hazard fissure zones were to include system components to protect against embankment or foundation piping that could result from settlement/shrinkage cracking or earth fissuring. These components included removal of the Holocene soils, construction of upstream and downstream barriers extending into the Pleistocene soils, and construction of a hydraulic barrier on the upstream face of the dam. For consistency in cost comparisons, the same system components were incorporated into the

preliminary designs for the structures, with the actual components to be used to be determined during the design phase of the project. These components included cutoffs extending into the Pleistocene soils constructed using a flowable backfill and geomembrane/geotextile barriers on the upstream faces of the new structures and the cutoffs. Further evaluation or analysis of system components was deferred to the design phase of the project, and not considered in the alternatives analysis.

The list of systems adopted for the alternatives analysis included the no action and monitoring only alternatives. The rehabilitation alternatives (Category 3) included construction of a new earthen, RCC or SC embankment upstream, downstream or at the present location of the existing structure. The alternatives of widening the existing structure were considered to be essentially the same as new upstream or downstream construction. The alternative of stabilizing the Holocene soils by grouting or other treatments was included in the list of rehabilitation alternatives. The abandonment alternatives (Category 4) remained essentially unchanged, and included an upstream dam and dam extension located either outside of or within the fissure hazard zone, and an upstream diversion and dam extension located either outside of or within the fissure hazard zone. The dam segmentation alternatives (Category 5) included construction of a dam extension. The segmentation alternatives included with and without rehabilitation of the existing McMicken Dam, removal of the existing dam and providing for basin containment, and segregating the dam into multiple segments without rehabilitating the existing structure. The list adopted for initial screening included 23 alternatives.

4.0 INITIAL SCREENING OF ALTERNATIVES

AMEC and Stantec completed the initial screening of the adopted alternatives, and a draft memorandum presenting the results of the initial screening was issued on 20 December 2002, with the final report being submitted on 4 June 2003 (AMEC, 2003b)[1]. The report included the list of evaluation criteria, and the lists of system and system component alternatives adopted. A systems evaluation matrix was presented, based on a numerical rating system that was adopted. Each of the alternatives was assigned a numerical rating of 1 through 5. A numerical rating of 3 indicated that the alternative generally was neutral with respect to that evaluation criterion. A numerical rating of 5 indicated the alternative was very favorable, and a numerical rating of 1 indicated the alternative was very unfavorable. A weighting factor was adopted for each evaluation criterion, with the factor varying from 100 for the categories of performance criteria and failure consequences to 10 for aesthetics.

Although the numerical evaluation process was not complex, difficulty was encountered in developing comparable ratings for each of the evaluation criteria groups and in systematically rating each of the alternatives. As discussed in the draft report, the difficulties associated with the rating system, as applied, appeared to have skewed the alternatives analysis. For example,

[1] References are listed at the end of this report.

the alternatives of no action and monitoring only had very similar scores that exceeded the scores for some of the rehabilitation and abandonment alternatives. Obviously, neither of these alternatives provides protection against an earth fissure, and would not be considered further. The evaluation matrix generally indicated that some very positive rehabilitation alternatives (RCC or SC structures) rank slightly higher than some abandonment and segmentation alternatives, and alternatives involving grouting or other treatments ranked lower.

The report also presented the results of hydrologic analyses of the watersheds located upstream of the moderate and high hazard fissure zones. The analyses indicated the watersheds contributing to the fissure risk zone are very small in relation to that for the entire dam, but the peak flows are relatively high. Thus, an upstream diversion to contain the Probable Maximum Flood (PMF) would need to be very large. However, the analyses determined that peak discharges and runoff volumes for 100- to 500-year events are approximately 16 to 23 percent of the PMF, and could more readily be diverted. It was also determined that the runoff from a 100-year precipitation event occurring within the watershed upstream of the dam south of Station 75+00, approximately the northern boundary of the high hazard fissure zone, could be contained in the existing low flow channel. In general, the hydrologic analyses indicated the abandonment and segmentation alternatives were viable, provided protection of only the high hazard fissure zone was required.

The draft initial screening memorandum was reviewed and the initial screening was completed during a project meeting on 7 January 2003. As a result of discussions during the meeting, the no action and monitor only alternatives were removed from further consideration and deleted from the evaluation matrix. Further, a few alternatives were removed from further consideration, including rehabilitation at the same location as the existing structure, since these alternatives would require complete removal of the existing structure, and would have a much higher capital cost. The abandonment with dam extension alternatives were consolidated into just two alternatives, upstream dam and upstream diversion, since construction outside of the identified fissure zone would not be economically feasible because of the length of the structures. The segmentation alternatives were renamed isolation alternatives, but otherwise remained the same.

Some of the evaluation criteria also were modified to reflect the additional data that had been collected and as result of reconsideration of the criteria. A separate capital cost criterion with a weighting factor of 60 was established, reflecting the relative importance of capital costs as compared to other costs, and the remaining cost criteria were assigned a weighting factor of 40. The number of sub-criteria included under the environmental considerations criterion was significantly reduced, since it was determined that all of the alternatives had essentially the same or very similar impacts. The remaining sub-criteria were impacts on cultural resources and on waters of the US. A potential enhancements sub-criterion was added to the opportunities for additional benefits evaluation criterion. The remaining evaluation criteria were unchanged.

Based on the initial screening, ten alternatives were selected for further analysis. In order of their ranking, these included:

- Abandonment Alternative 4B (ranking of 1), diversion structure located upstream of the existing dam, with further analyses to consider both the 500-year and PMF events.

- Isolation Alternative 5C (ranking of 2), dam extension and segmentation with modification of the existing dam and possible basin containment, with further analyses to consider both the 500-year and PMF events.

- Rehabilitation Alternatives 3B and 3A (rankings 3 and 4, respectively), new embankment dam located either upstream or downstream of the existing dam, with further analysis to consider either the upstream or the downstream location but not both.

- Rehabilitation Alternatives 3E and 3D (rankings of 6 and 8, respectively), RCC structure located either upstream or downstream of the existing dam, with further analysis to consider either the upstream or the downstream location but not both.

- Rehabilitation Alternatives 3H and 3G (rankings of 6 and 8, respectively), SC structure located either upstream or downstream of the existing dam, with further analysis to consider either the upstream or the downstream location but not both.

- Isolation Alternative 5B (ranking of 10), dam extension and segmentation with limited rehabilitation of the existing dam, with further analyses to consider both the 500-year and PMF events, and the option of basin containment and downstream channels.

- Abandonment Alternative 4A (ranking of 11), dam extension or new dam located upstream of the existing dam.

It is noted that Alternative 5A, dam extension with multiple segments and rehabilitation of the existing dam, with a ranking of 5 was not selected for further analysis. This is because this alternative incorporates minor variations of Alternatives 5B and 5C, and analysis of these alternatives for both the 500-year and PMF events provides essentially the same benefits.

The results of the initial screening were presented in a memorandum dated 4 June 2003 (AMEC, 2003b). This final memorandum expanded on the draft memorandum by adding a section on environmental considerations and consequences for each alternative. The final memorandum also expanded on the screening process and how the rankings for the different alternatives were determined.

5.0 SECONDARY SCREENING OF ALTERNATIVES

More detailed plans and cost estimates for the alternatives, or variations thereof, selected as part of the initial screening were developed, and a draft secondary screening memorandum was issued on 28 January 2003, with the final report being submitted on 9 May 2003 (AMEC, 2003a). The focus of the alternatives, as established during the initial screening, was the protection of the high hazard fissure zone, extending from Station 56+00 to Station 75+00. The three rehabilitation alternatives included a new upstream embankment dam (Alternative 3A), and new RCC and SC structures located downstream of the existing dam (Alternatives 3E and 3H, respectively). Details of the design configurations and system components assumed for protection against embankment settlement/shrinkage cracking (hydraulic barrier on the upstream face of the dam) and earth fissures (removal of the Holocene soils and construction of two cutoffs with hydraulic barriers extending into the Pleistocene soils) are presented in the report.

Based on further analysis, two variations of Alternative 4A were considered, including a new 3,210-foot long upstream dam connecting to the existing structure at Stations 52+00 and 79+00 (Alternative 4A2). The section of the structure within the high hazard fissure zone was assumed to have the same system components as the rehabilitation alternatives, but the section within the low hazard fissure zone was assumed to not require the system components to protect against an earth fissure. Alternative 4A1 included a 1300-foot long dam extension connected to a 4,600-foot long upstream embankment, with system components the same as Alternative 4A2. Several refinements to this alternative were identified that involved borrow locations and direction of runoff from storm events.

Based on further analysis two variations of Alternative 4B were considered, both of which included construction of a 1,500-foot long dam extension and a diversion channel. Alternative 4B1 would divert the full PMF and Alternative 4B2 would divert the 500-year event, with variations on the capture and disposition of PMF runoff in excess of the 500-year event discussed. The diversion channels were assumed to be concrete lined, as was the spillway required for Alternative 4B2. The full length of the dam extension, including that located within the low hazard fissure zone, was assumed to have the same system components as the rehabilitation alternatives for protection against embankment settlement/shrinkage cracking and earth fissures.

Isolation Alternative 5B essentially isolates the part of the existing dam within the high hazard fissure zone by construction of a 1,500-foot long dam extension to the north and a 1,000-foot long new embankment section to the south. The dam extension was assumed to provide protection against earth fissures, but the new dam segment within the low hazard fissure zone was not. The design creates a north basin within the high hazard fissure zone and a south basin within the low hazard fissure zone. Hydraulic structures providing drainage from these basins

would be required. Refinements to the design were discussed, including excavation of a basin to provide storage and re-alignment of the dam to modify the stage within the south basin.

Based on further analysis, two variations of Alternative 5C, isolation with basin containment, were considered, both of which included construction of a 1,630-foot long dam extension to the north and an 820-foot long new dam segment to the south, creating independent north and south basins. Both alternatives included a connecting diversion channel that passed captured flow to the south basin. Alternative 5C1 would divert and retain the full PMF and Alternative 5C2 would divert and retain the 500-year event, with variations on the capture and disposition of PMF runoff in excess of the 500-year event being discussed. The diversion channels were assumed to be concrete lined, and an outlet pipe for the south basin was considered in the design and cost estimate.

Preliminary cost estimates were developed for each of the alternatives discussed above. Estimates for rehabilitation, new embankment segments and dam extensions were prepared by AMEC, including unit costs for excavation, embankment placement and compaction, geomembranes, flowable backfill, etc. Estimates for drainage improvements were prepared by Stantec, including channels, spillways, gated outlet pipes, etc. Cost summaries were presented in spreadsheets, and the same unit costs, where appropriate, were assumed for the same construction elements. Costs for design and construction engineering, construction staking and as-built plans, construction water and dust control, mobilization and construction inspection, testing and quality control were assumed to total 26 percent of the construction cost. A contingency of 20 percent of the construction cost also was assumed. The total cost of the various alternatives considered varied from $1.07 to $4.92 million (M). Generally, construction involving RCC and SC structures, and concrete diversions, had the higher costs. The alternatives having the lowest costs, in order from lowest to highest, were Alternatives 3A ($1.07M), 5C1 ($1.18M), 4A2 ($1.20M), 5C2 ($1.21M) and 5B ($1.49M).

Based on the more detailed analyses, the initial screening evaluation matrix was revised. It was determined that the environmental impacts associated with the alternatives were similar, and that all of the alternatives could be constructed within the District's right-of-way. Thus, the primary distinguishing factor was determined to be the total cost of the alternatives. The secondary screening determined the ten highest ranked alternatives, in order of their ranking, were Alternatives 5C1, 5C2, 4B2, 4A2, 3B, 4B1, 5B, 5A, 4A1 and 3A. Based on the draft secondary screening, Alternatives 3A, 4A2, 5C and 3E were further considered in the structured risk assessment, and Alternatives 3A, 5C (with further variations) and 3E were further considered in the value engineering/preferred alternative analysis.

The final secondary screening memorandum was submitted on 9 May 2003 (AMEC, 2003a). The primary modifications to the draft initial screening report included further assessment of the environmental impacts, as discussed in detail in the final initial screening memorandum. The cost estimates were updated to include revised costs for geomembrane/geotextile barriers, RCC

and SC, the later based on additional research. The cost estimates were also revised to include the cost of environmental mitigation of borrow areas. For purposes of comparison, the area of impact associated with a borrow area was estimated by assuming an excavation depth of about 4 feet, and then computing the area required to obtain the required quantity of borrow. These preliminary estimates determined that the area impacted by the alternatives varied from about 20 to 30 acres. An environmental mitigation cost of $10,000 per acre was assumed. Since each of the alternatives required onsite borrow material to construct the specific dam modifications, the environmental impacts associated with the borrow area were very similar for each alternative, and did not have a significant impact in screening for the preferred alternative.

The total revised cost of the various alternatives considered varied from $1.58 to $5.10 million. Generally, construction involving RCC and SC structures, and concrete diversions, had the higher costs. The alternatives having the lowest costs, in order from lowest to highest, were Alternatives 3A ($1.58M), 5C1 ($1.60M), 5C2 ($1.64M), 5B ($1.76M) and 4A2 ($1.93M). The draft secondary screening matrix was revised, which determined the ten highest ranked alternatives to be, in their order of ranking, Alternatives 4B2, 5C1, 5C2, 4B1, 4A2, 3A, 3B, 5B, 4A1 and 5A. Alternatives 3A, 4A2, 5B and 5C1 were concluded to be the most likely candidates for construction.

6.0 RISK ANALYSIS

The structured risk assessment was completed on 4 and 5 February. Details of the assessments completed, and the assessment process, are presented in the draft risk assessment memorandum submitted on 11 June 2003, with the final report being submitted on 17 September 2003 (AMEC, 2003c). In a risk assessment, the risk is computed for various alternatives and compared to a base condition, in this case, that of not modifying the existing McMicken Dam in the high hazard fissure zone to provide protection against the presence of an earth fissure. Detailed determination of the consequences of failure, such as economic loss or the number of lives at risk, was not completed, but four general consequence categories were identified. Breaching of the dam with a full impoundment level would have a high consequence (Consequence A) in terms of both economic loss and the likelihood that loss of life would occur. Breaching of the dam with only a low impoundment level would have a low consequence (Consequence B) with lower economic loss and much less likelihood that loss of life could occur. A third consequence (Consequence C) was defined as loss of the reservoir through seepage without a breach occurring and, thus, would have an even smaller economic loss than Consequence B and no loss of life. A fourth consequence (Consequence D) was associated with specifically defined events having less water available and, thus, would have a much lower economic loss than Consequence C.

For each of the alternatives considered, the presence of an earth fissure beneath the structure that could pass water was assumed to be the first condition for an adverse response to occur. As a basis for comparison, the probability of an adverse response of the existing McMicken

Dam in the high hazard fissure zone to flood loading was considered first, since the analysis focused on mitigation of only this zone. Alternatives representative of each of the three broad categories of mitigation being considered were then assessed, including rehabilitation of the existing structure with a new embankment dam (Alternative 3A), construction of a new upstream dam extension or embankment dam (Alternative 4A2) and isolating the existing dam by constructing a dam extension and allowing a small volume of water to be impounded by the existing dam or contained within an impoundment (Alternative 5C). A fourth alternative, rehabilitation of the existing structure by constructing a new RCC dam located downstream (Alternative 3E), also was assessed. Key components of these alternatives are the same as described in previous sections.

Consequences A and B are associated with each of the alternatives considered, and with the existing McMicken Dam. Comparison of the alternatives herein, therefore, is limited to the risk of these two consequences occurring. The median risks of Consequence A or Consequence B occurring as a result of flood loading of the existing McMicken Dam in the high hazard fissure zone are 0.0041 and 0.0064, respectively. Comparing the median risk values for the alternatives, it was determined that the risk of Consequence B occurring is slightly higher than the risk of Consequence A occurring for any of the alternatives. It is likely, however, that the annual probability of the economic loss (or another undefined parameter) is higher for Consequence A than for Consequence B, since it is likely that Consequence A has a much larger impact than Consequence B.

In terms of risk reduction (comparing the median risk associated with any of the alternatives with that of the existing McMicken Dam), it was determined that for either Consequence A or Consequence B, the risk is reduced by three or more orders of magnitude for any of the alternatives. It is further apparent that if the existing McMicken Dam is left in place, Alternatives 3A and 3E provide a significantly greater reduction in risk (about two orders of magnitude) than Alternative 5C, which in turn provides a significantly greater reduction in risk (again about two orders of magnitude) than Alternative 4A2. With the existing McMicken Dam removed, the reduction in risk is lowered by one order of magnitude for Alternatives 4A2, 5C and 3E, but by about four orders of magnitude for Alternative 3A. However, the actual values of the risk associated with the alternatives, except Alternative 4A2, perhaps, with a risk of about 0.60×10^{-4} for the old dam removed, are on the order of 1.0×10^{-6} for the old dam removed. Thus, leaving the existing McMicken Dam in place provides a greater risk reduction, but the incremental risk reduction is not as significant as the risk reduction associated with any of Alternatives 5C, 3A and 3E.

Considering the large reduction in risk afforded by Alternatives 5C, 3A and 3E, in particular, and to some degree by Alternative 4A2, all are technically viable and provide a positive approach to mitigating the earth fissure hazard present at McMicken Dam. Thus, barring any other factors, it was concluded that selection of the preferred alternative be based on the comparative design and construction costs of the alternatives.

7.0 VALUE ENGINEERING/PREFERRED ALTERNATIVE ANALYSIS

The value engineering/preferred alternative analysis was completed on 25 and 26 March 2003. Details of the assessments completed, and the assessment process, are presented in the final value engineering/preferred alternative analysis report submitted on 10 April 2003 (SiteTek, 2003). The process has been documented by the District for use as an analysis tool on capital projects. It includes development of specific performance criteria and uses a matrix approach to determine the importance of each criterion relative to each other. The hierarchy of the performance criteria established (with weight listed in parentheses) were as follows: failure consequences (10), probability of dam failure (9), project schedule (5), initial and life cycle costs (3), flexibility (2), environmental impacts (1) and constructability (1). Performance ranges were then established for each of the criteria and the alternatives were evaluated using the established matrix procedure. The previous screenings and assessments were extended to include mitigation of both the high and moderate hazard fissure zones (Stations 56+00 to 105+00), in addition to the high hazard fissure risk zone (Stations 56+00 to 75+00) only. For the analysis, more detailed plans and cost estimates were developed, as presented in the report.

For mitigation of the high hazard fissure zone only, Alternatives 3A and 3E, as previously defined, were considered. Two versions of Alternative 5C were considered, both of which included a dam extension, with diversion channels located upstream of the extension, and a low flow channel within the basin created to the south. The channel is intended to direct flow to a gated outlet near the southern end of McMicken Dam. For the alternative designated 5C-R, the dam extension within the moderate hazard fissure zone was assumed to be RCC, transitioning to an earthen embankment within the low hazard fissure zone. Within the moderate hazard fissure zone both the RCC and embankment structures were assumed to have full protection, but within the low hazard fissure zone the degree of protection was reduced. For the alternative designated 5C-E, the dam extension within both fissure hazard zones was assumed be an earthen embankment, but with different levels of protection provided in the high and moderate hazard fissure zones, similar to Alternative 5C-R. The analysis determined Alternative 5C-R to be the preferred alternative, primarily because of a lower probability of dam failure and a lesser consequence if failure were to occur, but only by a slight margin over Alternatives 5C-E and 3E.

For mitigation of both the high and moderate hazard fissure zones, Alternatives 3A and 3E, as previously defined, were considered. However, no difference in the degree of protection within the two zones was assumed. Both alternatives included protection against embankment shrinkage/settlement cracking (hydraulic barrier on the upstream face of the dam) and earth fissures (removal of Holocene soils and construction of two cutoffs extending into the Pleistocene soils) in both zones. For Alternative 5C, three separate alternatives were defined. For two of these, Alternative 5C-R as defined above was assumed for the high hazard fissure zone, coupled with either an earthen embankment (Alternative 5C-R/3A) or a RCC structure (Alternative 5C-R/3E) constructed within the moderate hazard fissure zone. For the other alternative, Alternative 5C-E was assumed for the high hazard fissure zone, coupled with an

earthen embankment (Alternative 5C-E/3E) within the moderate hazard fissure zone. The analysis determined Alternative 5C-E/3A to be the preferred alternative, but only by a slight margin over the other alternatives. The somewhat higher probability of dam failure for the preferred alternative was offset by its lesser construction and life cycle costs.

8.0 ADDITIONAL STUDIES

8.1 Numerical Analyses to Further Define Hazard Zones

During the period when the previously summarized studies were being conducted, the need for additional studies became apparent. In particular, it was recognized that numerical analyses in support of the fissure hazard zone delineation could further support the basis for the delineation of the high, moderate and low hazard fissure zones. The hazard fissure zones had been determined on the basis of lineament analysis using aerial photos (conventional and low sun angle photography), field reconnaissance, refraction seismic surveys, field investigations (test pits and test trenches), interferometry and geophysical surveys (gravity and resistivity). However it was suggested by the District that synthesis of these data into numerical models of selected cross-sections parallel and perpendicular to the axis of the existing McMicken Dam could confirm the boundaries of the three fissure hazard zones.

Details of the numerical analyses completed are presented in the final report for this task submitted on 5 November 2003 (AMEC, 2003d). Four geological profiles extending along the dam or perpendicular to sub-perpendicular to the dam within the high and moderate hazard fissure zones at the south end of the dam were considered in the analyses. The locations of the profiles were selected based on the locations of identified earth fissures, available subsidence data, available geophysical information and the acquired InSAR data.

Analysis of ground subsidence and deformation was performed using 2-D numerical models of the five geologic profiles. Modeling subsidence and deformation of the alluvium in response to changes in groundwater levels in the aquifer system required addressing displacements and pore water pressure changes simultaneously. This coupling was achieved with use of two finite element based computer programs, SEEP/W and SIGMA/W. SIGMA/W computes displacements and stresses, and SEEP/W computes the changes in pore-water pressure with time. Using these two software products in a coupled manner made it possible to perform reasonable subsidence and deformation analyses for specified time periods.

Calibration of the profiles or models was completed based on historical survey data for McMicken Dam and the Beardsley Canal. The computer modeling required three basic materials for the geologic profiles, including bedrock, higher modulus higher permeability alluvium and lower modulus lower permeability alluvium, and changes in water levels. Material properties and known groundwater level changes were used to compute various ground subsidence profiles, which were then compared to measured subsidence from surveys or from

interferograms. Variations in the profiles and manipulation of the basic parameters to match measured subsidence over modeled time served to calibrate the model profiles. Once calibrated, the models were extended forward through time to estimate future subsidence and horizontal strains. For the predictions, which extended to the year 2021, the present groundwater level was either assumed to drop 100 feet over the model time, representative of possible increased pumping, or to remain unchanged.

Based on a review of previous studies, a conservative tensile horizontal strain threshold value of 0.02 percent was adopted as the threshold value for earth fissure development. It is noted that previous studies indicate this value may be higher, approaching 0.06 percent. In general, the numerical analyses confirmed the previously determined boundaries of the high hazard zone at the south end of the dam, based on horizontal strains in excess of the threshold 0.02 percent strain being developed by the time of the field investigations completed in 1981 and in late 2002. Analyses of sections within the moderate hazard zone calculated horizontal strains approaching, but not exceeding, the threshold horizontal strain, generally confirming the boundaries of this zone.

The analyses also indicate the degree of hazard will vary depending on future groundwater pumping. If groundwater levels remain stable to 2021, the hazard will remain essentially the same, with the amount of horizontal tensile strain at the locations remaining the same or increasing only slightly. In some cases, the width of the zone of tensile stress also increases slightly with time as a result of additional subsidence. However, if groundwater levels drop significantly (on the order of the 100 feet assumed by 2021), the hazard will be intensified, with additional subsidence and horizontal strain development, at some locations approaching the 0.2 percent threshold of earth fissure development. However, the areas where the tensile horizontal strain exceeds the threshold value of 0.02 percent do not widen significantly.

Review of the basis of the analyses, including the assumptions required for development of the geologic profiles and the assumed materials parameters, led to the conclusion that the technological limits of the analyses had been reached. Thus, though the modeling effort determined some inconsistencies with the locations of the high and moderate fissure hazard zones, these are not significant enough to alter their defined locations. Further, the results of the modeling effort did not require a change in the mitigation approach to McMicken Dam developed based on the location of the high and moderate fissure hazard zones.

8.2 Dam Breach Alternatives

The District also requested that a group of dam breach alternatives, designated Alternatives 6, be evaluated for comparison with the repair or replacement alternatives. These alternatives evaluated the impact of beaching the dam within the fissure hazard risk zone, and constructing a new dam segment, thereby removing the dam from the fissure hazard zone. The three alternatives included breaching the dam (Alternatives 6A) at one of three drainage divides

(Stations 77+00, 87+00 and 107+00), breaching the dam at Station 107+00 and diverting the 100-year flood flow to the north (Alternative 6B), and breaching the dam at Station 107+00 and detaining the 100-year flood flow in a new basin (Alternative 6C). All alternatives reduce the flood protection from about the PMF event to the 100-year return event. Details of the assessments completed, and the analysis procedures, are presented in the final report prepared by Stantec (2003).

Breaching the existing McMicken Dam would be accomplished by excavating the embankment down to existing ground level at one or more locations such that runoff from events exceeding the 100-year flood event could pass through the breach, enter an existing channel and continue downstream. A part of the excavated material would be used to construct a new dam segment at one of three locations for Alternatives 6A, including Station 110+00, and at Station 110+00 for Alternatives 6B and 6C. The existing low flow channel is retained for all alternatives and functions as a detention feature to reduce the impact of flood flows downstream of the breached section of the dam.

The opportunities offered by these alternatives include:

- Some existing District right-of-way may be sold or used for purposes other than flood control,
- Runoff released into the existing washes will benefit the environment and the washes may be considered as mitigation areas,
- The dam is removed from the fissure risk zone, significantly improving the safety of McMicken Dam, and
- Peak flows and runoff volumes into McMicken Dam are decreased, with the total volume for the spillway design flood reduced by about 12 percent.

The constraints presented by these alternatives include:

- Peak flows and/or runoff volumes downstream are significantly increased,
- New 100-year floodplains are created downstream,
- The total storage volume behind McMicken Dam is reduced by a maximum of about 5 percent,
- The level of flood protection downstream of the dam is reduced, and
- The schedule for implementing this alternative will be substantially longer.

The breach alternatives will have a negative effect on areas downstream of McMicken Dam, possibly including White Tanks FRS No. 3. In addition to the increased volume of flow draining into this structure from the 100-year flood event, even larger flows drain into the structure during events larger than the 100-year event. For events larger than the 100-year flood, it is likely that flows from the watershed upstream of the fissure hazard risk zone will overtop the diversion

channel, overtop the existing low flow channel or detention basin, continue easterly and overtop and possibly breach the Beardsley Canal. Once they have overtopped and breached the canal, they may continue easterly and subsequent flow may not reach White Tanks FRS No. 3. Detailed analysis of these breaches and breakouts, and estimation of the flood hydrograph and the volume of water that will reach White Tanks FRS No. 3 is required before the actual impact of larger flood events on this structure can be determined.

A diversion channel is proposed in Alternative 6B to divert the 100-year flood runoff north into the McMicken Dam reservoir. Flows in excess of the 100-year flood could overtop the channel and continue east. The diversion channel would divert only those flows from the two largest drainage basins located north of the high hazard fissure zone. Flows from basin located south of this zone would be captured by the existing low flow channel and routed through the breaches.

A detention basin would be constructed as part of Alternative 6C by enlarging the existing low flow channel and utilizing a portion of the existing dam embankment as above ground storage and freeboard. The basin would function to capture the flood flow and release it at a slow enough rate such that the peak flows in the North Inlet Channel to White Tanks FRS No. 3 are not increased.

New floodplains would be created for all breach alternatives considered and this will require acquisition of new right of way. Up to approximately 60 acres of additional land would be required for the floodplains. Approximately 35 acres of new right of way would need to be acquired from the Arizona State Land Department for Alternative 6B for the diversion channel. No additional right of way is needed for the new end of dam segment or for the detention basin.

Some existing right of way within the McMicken Dam impoundment may be disposed of for all alternatives. However, some of this land may be un-developable because of the 100-year floodplains at the location of each major wash. Other land may be of limited use due to the presence of earth fissures. No estimate was made of the amount of land that might be disposed.

Breaching the dam and allowing flood flow to return to existing washes east of the dam and to flow along the Beardsley Canal creates additional floodplains. The effect of allowing these flows to return to these watercourses was not analyzed; however, it is clear that this would need to be done if one of these alternatives were to be selected.

All of the Category 6 alternatives have relatively high implementation costs, as detailed in the report. The costs were developed in essentially the same manner as the other alternatives previously considered, and included the same base percentages for mobilization, permits, engineering and contingency. The estimated costs for Alternatives 6A (with breach location at Station 107+00 to be comparable to Alternatives 6B and 6C), 6B and 6C are $5.93, $4.91 and $10.55 million, respectively.

Based on the analyses completed, the study included the following recommendations:

- Alternative 6A: Breaching the dam without providing any diversion, detention or other mitigation was not recommended. It is assumed that the cost to convey flood flows downstream will be excessive and the effect on White Tanks FRS No. 3, while unknown, would likely require significant and costly improvements to the dam and outlet works.
- Alternative 6B or 6C may be technically feasible; however, analysis of the effects on White Tanks FRS No. 3 and on McMicken Dam must be completed to validate this assumption. The costs for these alternatives may be excessive.
- Public involvement is required for any of the alternatives. Acceptance and approval must be obtained from major stakeholders, including the Metropolitan Water District, Luke Air Force Base, the Arizona Department of Transportation and any large landowners. Regulatory acceptance will need to be obtained from the ADWR.
- The schedule for analysis, design, permitting and construction for any of the alternatives will be longer than that anticipated for any of the dam repair or replacement alternatives.
- If considered further, a quantitative risk assessment should be undertaken to document the change in risk that would be made if any of the alternatives are chosen.

8.3 Additional and/or Modified Preliminary Designs for Alternatives

Additional and/or modified preliminary designs and cost estimates for the alternatives considered in the value engineering/preferred alternative analysis were submitted for consideration during a project meeting of 17 June 2003. Specifically, an upstream SC embankment for mitigation of the high hazard zone only (Alternative 3G), or for mitigation of both the moderate and high hazard zones was presented. Revised cost estimates for previously identified Alternatives 5C-E and 5C-R also were presented, and a new cost estimate for an alternative designated Alternative 5C-SC substituting SC for RCC was presented. Revised preliminary designs and cost estimates for earthen embankment (Alternative 3A) and RCC (Alternative 3D, relocated upstream) structures within the high and moderate hazard fissure zones also were presented. These designs and cost estimates incorporated an additional design criterion, that of allowing for the future two-foot raise of the mitigated section of the new structure.

Plans for each of the final alternatives considered are presented in Figures 1 through 5, cost estimates are presented in Tables 2 through 6, and a summary of the cost estimates is presented in Table 1. Plans for the upstream diversion structures common to the dam extension alternatives are presented in Figure 6 and the cost estimate for these structures is presented in Table 7. The unburdened cost estimate in Table 7 is incorporated in Tables 3 through 5 for the dam isolation alternatives.

As shown in Table 1, the cost estimates for mitigation of the high hazard zone only varied from $1.08M to $3.33M, with the lowest cost being estimated for Alternative 5C-E and the highest costs being estimated for Alternatives 3E ($3.05M) and 3G ($3.33M). Alternatives 5C, which included a dam extension with a composite earthen embankment and RCC or SC dam extension had an intermediate cost. The cost estimates for mitigation of both the high and moderate hazard zones, which included earthen embankment (Alternative 3A), RCC (Alternative 3D, relocated upstream) or SC (Alternative 3G) structures extending the full length of the area of mitigation from Stations 56+00 to 105+00 (unlike the composite alternatives considered in the value engineering/preferred alternative analysis), were $4.61M, $8.47M and $9.53M, respectively, reflecting the higher cost of RCC and SC.

9.0 SELECTION OF PREFERRED ALTERNATIVE

9.1 Selection Process

The preferred alternative was selected during a project meeting on 11 July 2003. The cost estimates are discussed in the previous section of this report. The sequence of the selection process included three discreet decisions: whether to mitigate only the high fissure hazard zone or both the high and moderate fissure hazard zones; whether to rehabilitate the zone selected or isolate the end of the dam located south of the high or moderate fissure hazard zone; and whether to design the rehabilitated or the new dam extension structure as an embankment or a RCC/SC structure.

9.2 Decision to Mitigate Only the High Hazard Fissure Zone

As shown in Table 1, estimated construction costs to mitigate both the moderate and high hazard fissure zones are significantly higher than estimated construction costs to mitigate only the high hazard fissure zone. The numerical analysis of the fissure zone cross sections established that horizontal strains large enough to cause earth fissuring have developed within the high hazard zone. However, the analysis also indicated that horizontal strains present within the moderate hazard zone, or which could develop in that zone in the future, are or will be at the threshold of cracking related to earth fissures. It was decided that extensive monitoring and further investigation of the moderate hazard zone would be conducted, and that this work would be included in the construction contract for McMicken Dam.

9.3 Selection of the Dam Isolation Alternative

Initially, the discussion centered on the selection of a rehabilitation alternative (Alternatives 3: embankment, SC or RCC structure located immediately upstream of the existing dam) or an isolation alternative (Alternative 5C: construction of a dam extension at about Station 75+00, thus isolating the southern part of the dam). Factors identified as favoring Alternative 5C include:

- The southern section of McMicken Dam is isolated from the impact of the much larger watersheds to the north (Trilby Wash and others).
- The much smaller watershed, as identified during the risk assessment, would minimize the consequence of a failure of the southern end of McMicken Dam, since the amount of flow and the duration of flow are greatly reduced (Consequence D as compared to Consequences A or B).
- The length of dam exposed to the earth fissure would be reduced, since the dam extension would be shorter than the length of McMicken Dam presently within the high hazard zone.
- The risk is reduced since the dam extension will not be in the high hazard zone; there would be no dam within the high hazard zone.
- It would provide an opportunity to optimize the alignment, and possibly reduce the length of the dam extension, provided the only sub-basin not diverted by the dam extension is 1A, which has an area of only about 0.6 square miles.
- Isolation would result in a much smaller watershed impacting the southern part of the dam, thus providing the opportunity for constructing basins and optimizing the final design of the facility.
- The section of the dam extension within the moderate hazard zone could be constructed partially as a SC or RCC structure for about the same cost as Alternative 3A.
- There would be reduced maintenance costs.
- A trail could be dedicated along the isolated part of the existing McMicken Dam.
- A RCC or SC structure could be grouted if a crack formed at the crest, since the RCC or SC would be exposed for monitoring and maintenance.
- The alignment could be optimized based on the depth of the Holocene soils, thus reducing foundation preparation costs and embankment costs.

In addition, alternatives considered early in the alternatives analysis included permanent impacts to vegetated areas upstream and adjacent to the dam within the high hazard zone. Alternative 5C would minimize these disturbances by allowing for preservation of portions of this high value vegetation adjacent to the dam. Alternative 5C also would allow for creation of additional mitigation area for impacts within waters of the US.

Factors identified as not favoring Alternative 5C include:

- The upstream washes present an erosion hazard; a dam extension would require specific erosion protection and/or diversion structures.
- Part of the alignment of the dam extension could be in a future high hazard fissure zone, and the alignment would, in part, be transverse to the fissure zone.
- Isolation would result in the section of McMicken Dam in the high hazard fissure zone being an impoundment, though the amount of water that would be impounded would be significantly reduced.
- A new outlet would be required.

- The total probability of Consequences A and B occurring is higher for Alternative 5C than for Alternatives 3, but still within or below the acceptable range.
- Because of the new structures required, the dam isolation alternative may have more of an impact on the environment. However, this impact is offset by the requirement for less borrow material, and borrow source area, to construct the embankment. The net impact for both alternatives is very similar.

In addition, portions of the low flow channel would be permanently impacted by construction of the dam extension. Areas within the high hazard zone would be cutoff from the contributing watershed by the dam extension. Consequently, the District may have to mitigate for disturbed areas. Also, construction of the dam extension and the upstream channels will have minor impacts on the larger upstream washes. Disturbances within these larger washes or proposed waters of the US will require some mitigation for areas cutoff or disturbed.

It was also discussed that Alternatives 3 would be generic to any of the District's flood retarding structures. Alternative 5C is unique to McMicken Dam because of the location of the earth fissure hazard zone at its southern end, and the hydrological conditions (small watershed) at its southern end. However, the system components that would be used in constructing the dam extension are generic to mitigation of the District's structures.

There also was discussion of alternatives that provide lesser flood protection (Alternatives 6: construct a new dam segment and breach the dam to provide only 100-year flood protection). In general, it was decided that these alternatives were more costly, required additional, perhaps extensive study, and added permitting and other considerations that would significantly and adversely impact the overall schedule for completion of the project.

Alternative 5C satisfies the requirements of 404 (b) 1 in that it has the least environmental damaging impacts since it minimizes impacts to the high value vegetation upstream of the dam, yields minimal impact to upstream washes by redirecting flow rather than cutting off flow completely, creates additional mitigation area in the impoundment, and is the most practicable in terms of cost and ADWR regulatory requirements.

Alternative 5C was selected as the preferred alternative, with the recognition that final design would consider alternative alignments, and modification and/or enhancement of elements of the planned construction, including a basin or basins. However, if the investigation of the moderate hazard fissure zone reveals the presence of earth fissures, the decision would be reviewed and Alternative 3A may be constructed. Final design also will consider incorporating the trail system planned for the region by Maricopa County.

9.4 Selection of RCC/SC or Embankment Structure

The discussion then focused on the design of the dam extension as an RCC/SC or embankment structure. First, it was recognized that soil cement, rather than RCC would likely be utilized. Results of laboratory testing that had been completed were discussed, particularly compression testing of soil cement mixtures. The test results indicated that 7-day strengths of 250 psi could be achieved with as little as 3 or 4 percent cement. Considering the function of the dam extension, strengths of 750 or 1000 psi, which is standard for bank protection, would likely not be required.

Factors identified as favoring the use of SC include:

- An SC structure has less risk of breach than an embankment structure,
- An SC design has less associated risk of regulatory questioning. A regulatory waiver would be required if the embankment dam included a geomembrane as a single line of defense, but otherwise there likely would not be significant regulatory questioning of an embankment dam alternative,
- An SC structure would require significantly less maintenance, and could more readily be repaired if a crack or cracks developed in the structure,
- An SC structure would be easier to monitor, since any cracks would be discernable,
- Material for use in a SC structure is available within the impoundment, or possibly could be obtained from the existing McMicken Dam, and
- The risk perception associated with an embankment structure is higher than for a SC structure.

Factors identified as favoring an embankment dam extension include:

- The cost of an embankment structure is significantly less,
- The risk (probability of failure) associated with an embankment structure is acceptable,
- An earthen embankment would be easier to construct in a desert environment, however, the District has significant experience with constructing SC/RCC and cement stabilized aggregate structures,
- It will be necessary to cover a SC structure with an embankment (minimal compaction) to minimize aesthetic and safety issues, and
- The breach of a SC structure would result in a sudden outflow.

It generally was concluded that the use of SC is preferred, particularly in the moderate fissure hazard zone. Thus, final design of the dam extension will include the use of SC in the moderate hazard zone, and possibly in the low hazard zone.

REFERENCES

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AMEC Earth & Environmental, Inc., 2003b, Alternatives Analysis Memorandum, Alternatives Development and Initial Screening, McMicken Dam Fissure Risk Zone Remediation Project, Contract FCD 2002C011, Work Assignment No. 1, June 4.

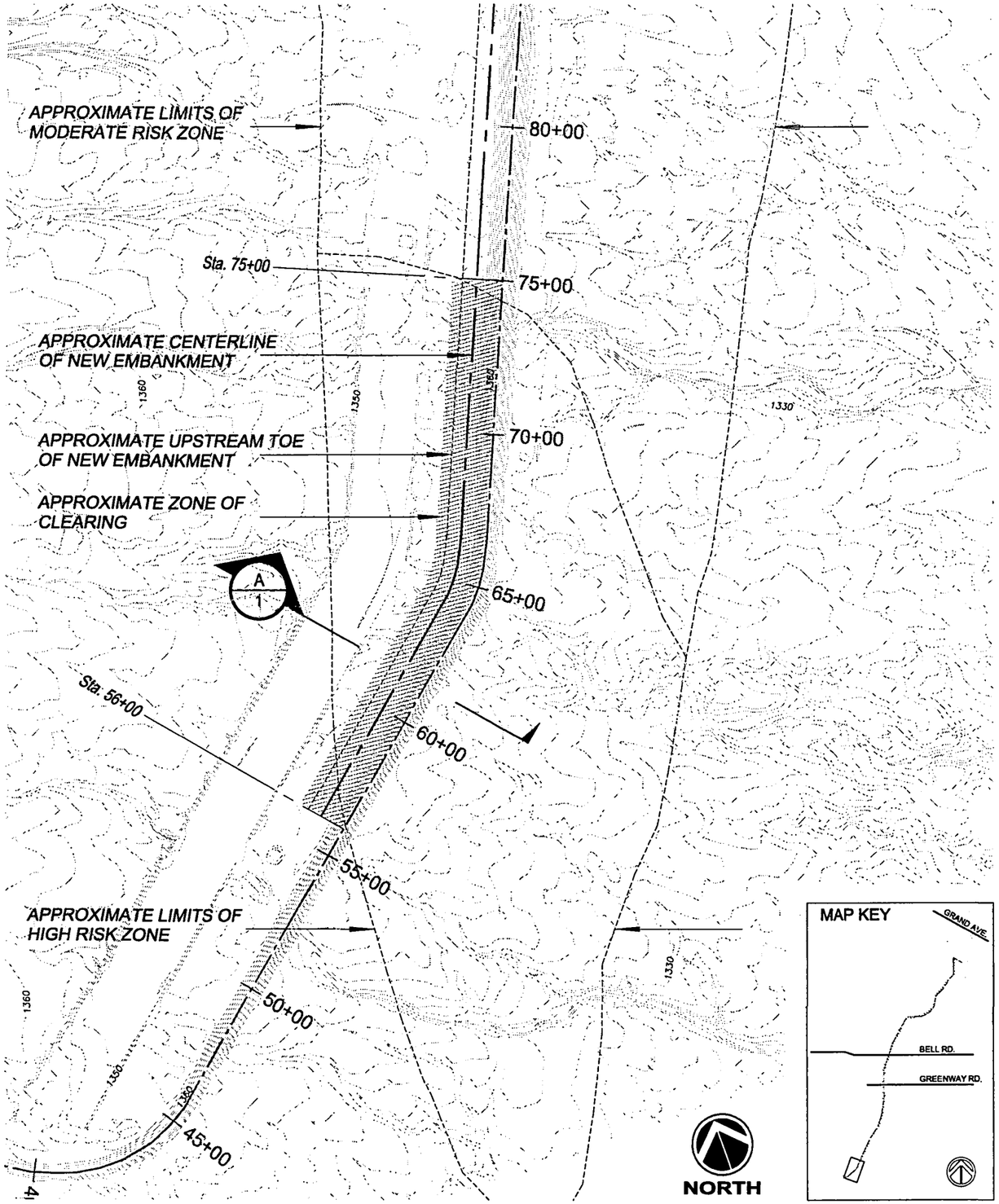
AMEC Earth & Environmental, Inc., 2003c, Risk Analysis Memorandum, McMicken Dam Fissure Risk Zone Remediation Project, Contract FCD 2002C011, Work Assignment No. 1, September 17.

AMEC Earth & Environmental, Inc., 2003d, Final Zoning of Earth Fissure Risk & Determination of Part(s) of the Dam that Require Dam Safety Recommendations, McMicken Dam Fissure Risk Zone Remediation Project, Contract FCD 2002C011, Work Assignment No. 2A, November 5.

SiteTek, 2003, Preferred Alternative Analysis, McMicken Fissure Risk Zone Remediation Project, Contract FCD 2002C006, Assignment No. 2, Final Report, April 10.

Stantec Consulting, Inc., 2003, McMicken Dam Fissure Risk Zone Remediation Project Dam Breach Alternatives, Stantec Project No. 82000257, September 9.

FIGURES



ALTERNATIVE 3A (Sta. 56+00 to 75+00)

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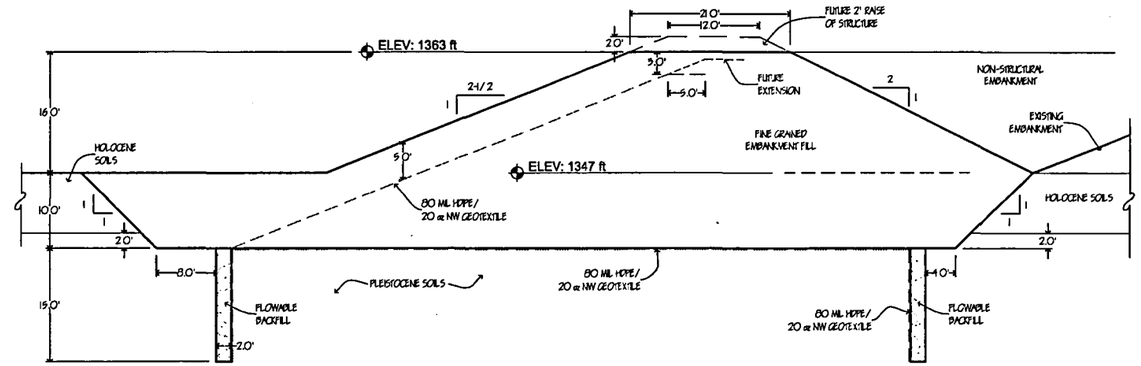

SECTION A - STATION 61+00, EMBANKMENT (ALT. 3A)

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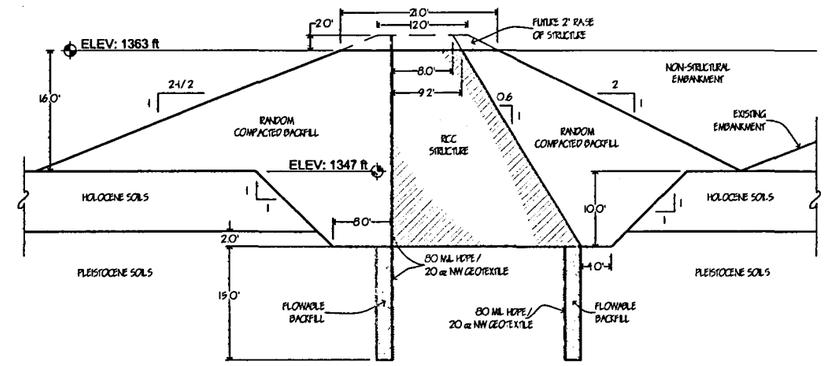

SECTION A - STATION 61+00, RCC EMBANKMENT (ALT. 3D)

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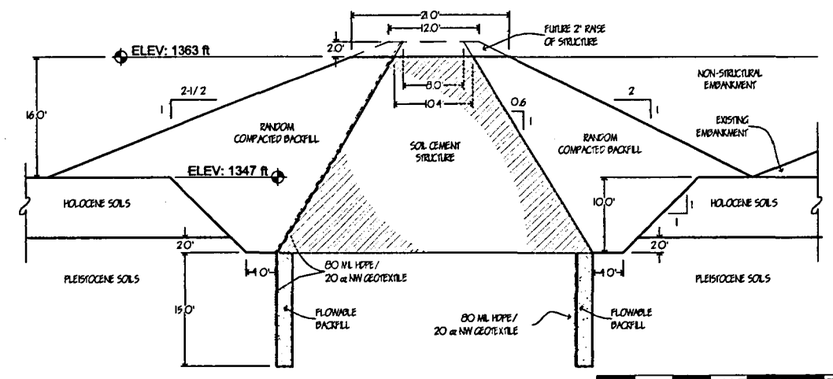

SECTION A - STATION 61+00, SOIL CEMENT (ALT. 3G)

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SCALE: 1" = 20'

NOTE: Refer to Table 2 for cost estimates

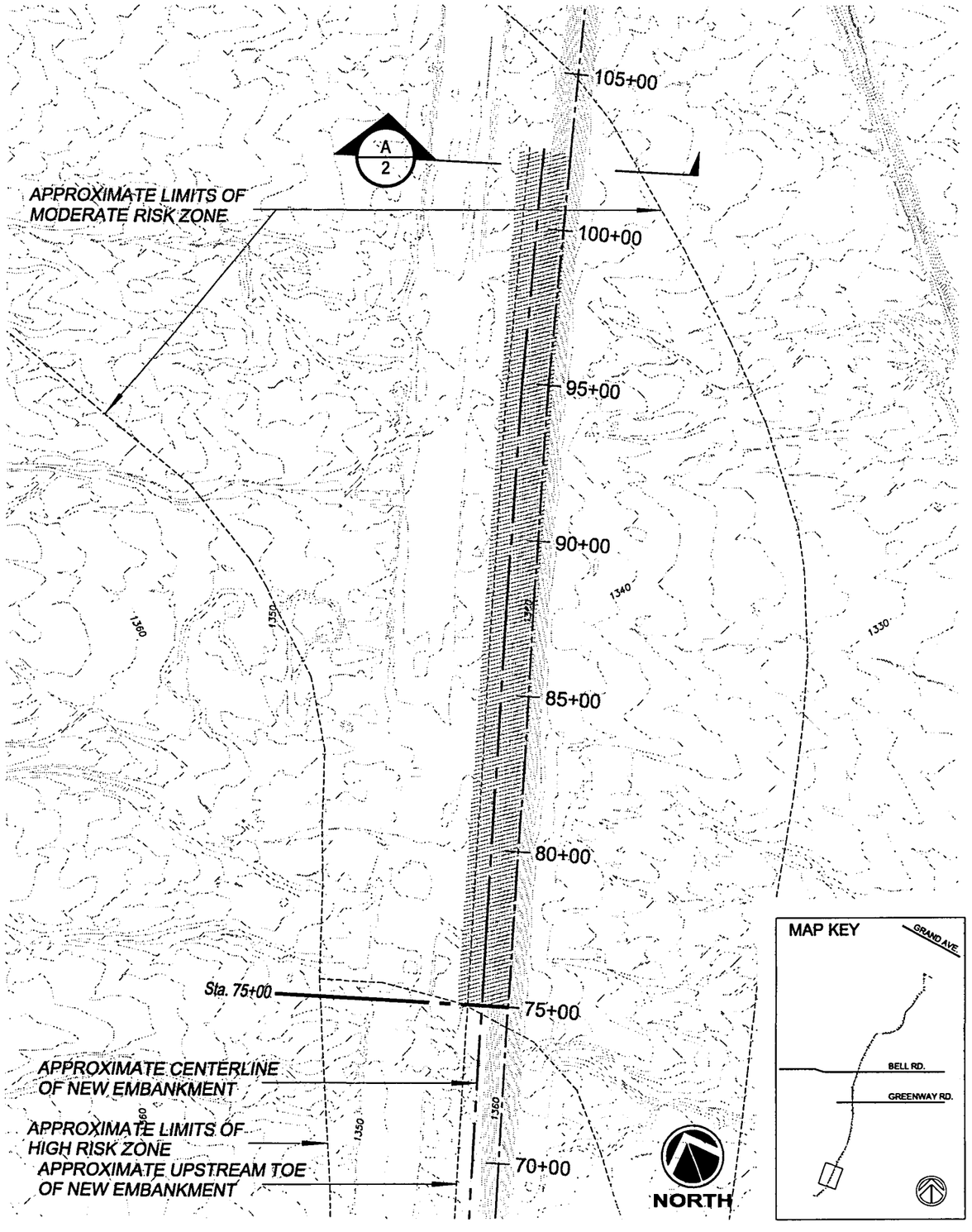
JOB NO.	2-117-001066
DESIGN:	LAH
DRAWN:	EHS/GWH
DATE:	AUGUST 2003
SCALE:	AS SHOWN

ALTERNATIVE 3A - HIGH RISK ZONE
Station 56+00 to 75+00

McMICKEN DAM FRZR PROJECT
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1

FIGURE 1

amec



ALTERNATIVE 3A (Sta. 75+00 to 105+00)

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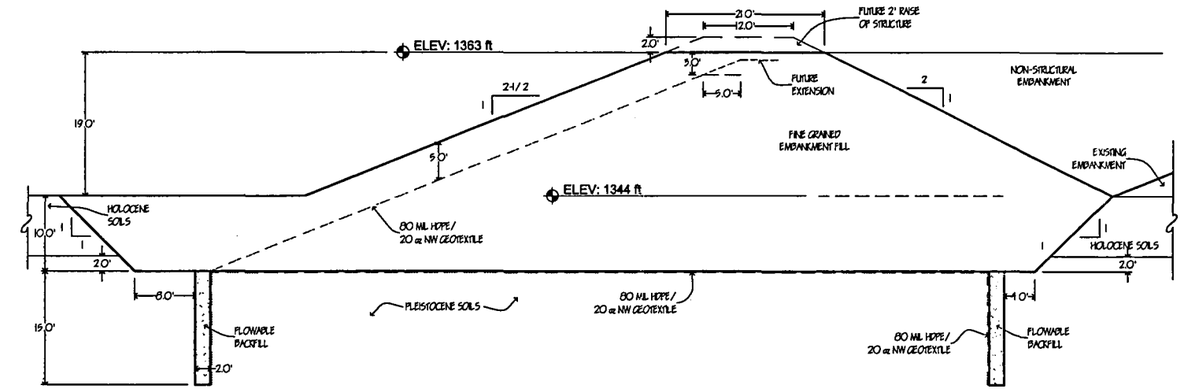
SCALE: 1" = 400'



SECTION A - STATION 102+00, EMBANKMENT (ALT. 3A)

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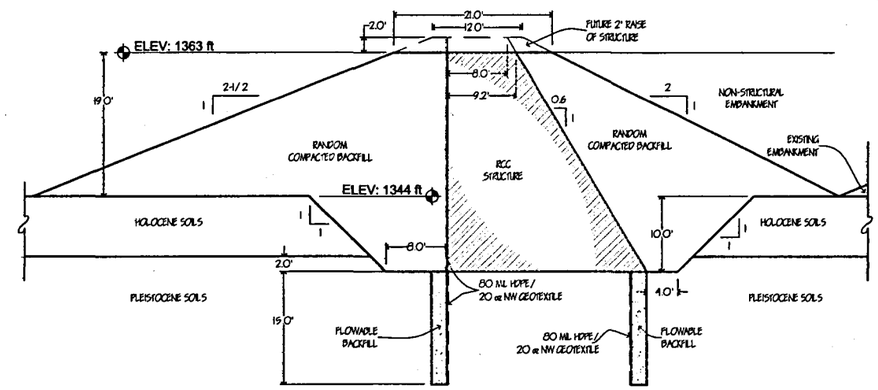

SECTION A - STATION 102+00, RCC EMBANKMENT (ALT. 3D)

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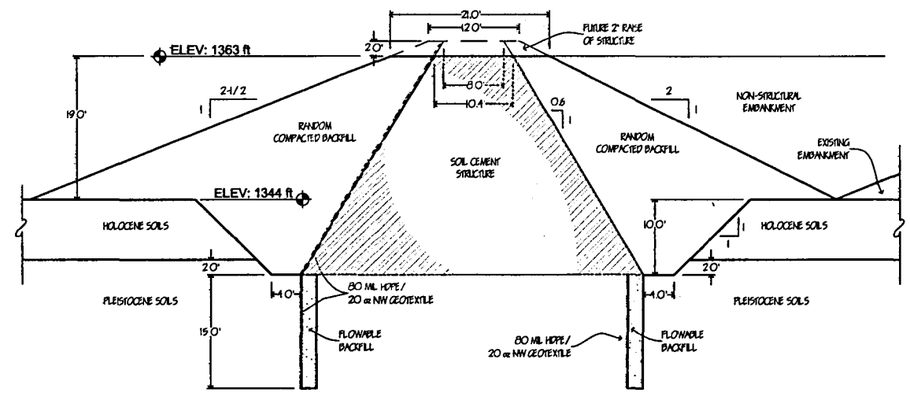

SECTION A - STATION 102+00, SOIL CEMENT (ALT. 3G)

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SCALE: 1" = 20'

NOTE: Refer to Table 3 for cost estimates

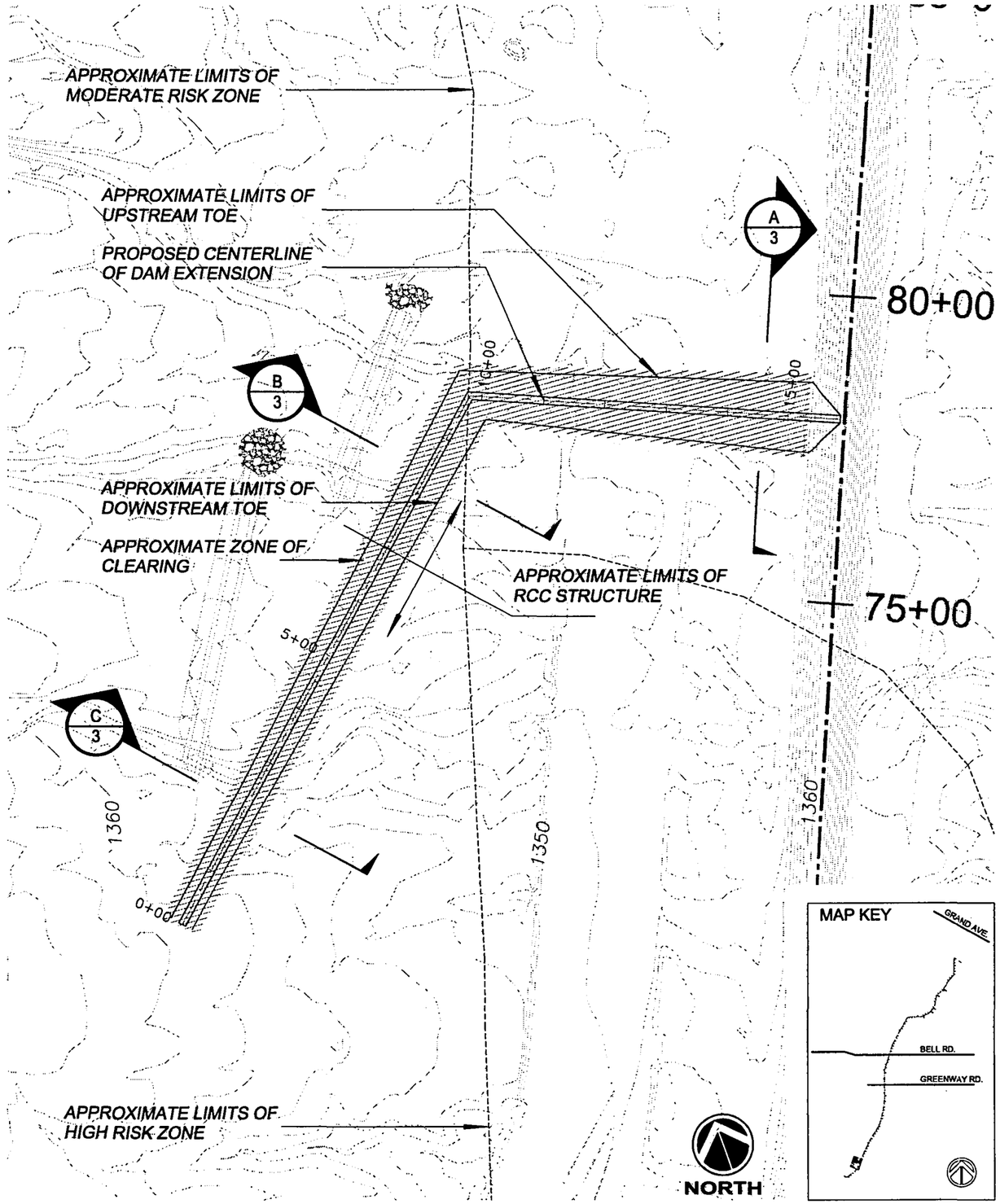
JOB NO.	2-117-001066
DESIGN:	LAH
DRAWN:	EHS/GWH
DATE:	AUGUST 2003
SCALE:	AS SHOWN

ALTERNATIVE 3A - MODERATE RISK ZONE
Station 75+00 to 105+00

McMICKEN DAM FRZR PROJECT
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1

FIGURE
2

amec



ALTERNATIVE 5C

0 100 200 400

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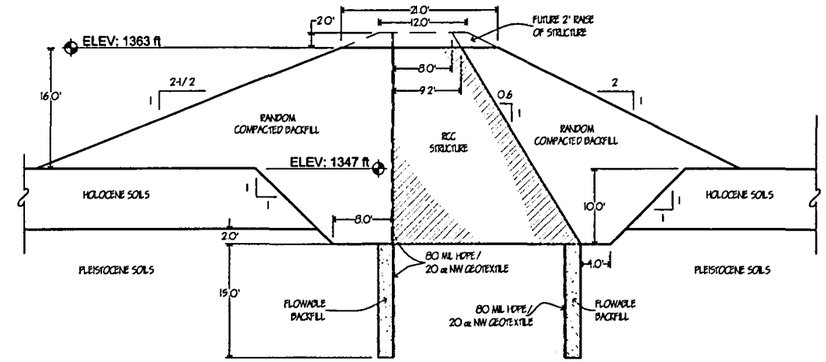

SECTION A - STATION 14+60

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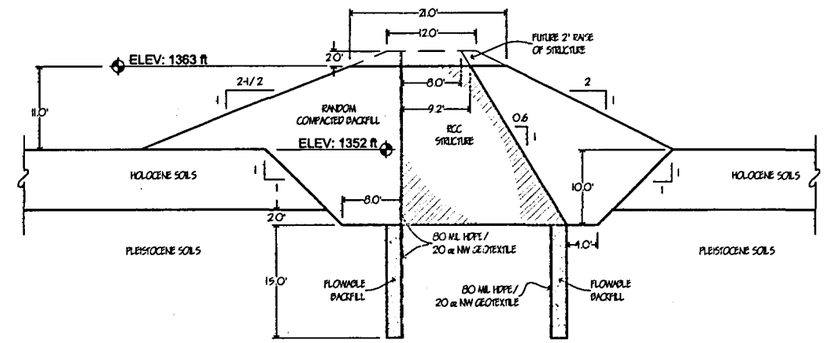
SCALE: 1" = 20'



SECTION B - STATION 8+35

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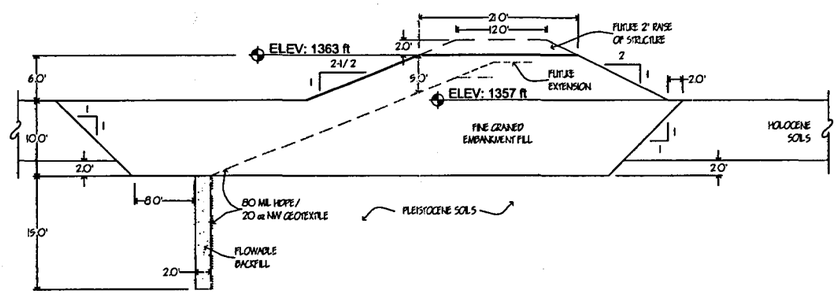


SECTION C - STATION 2+20

0 10 20 40

SCALE: 1" = 20'

NOTE: Refer to Table 4 for cost estimates

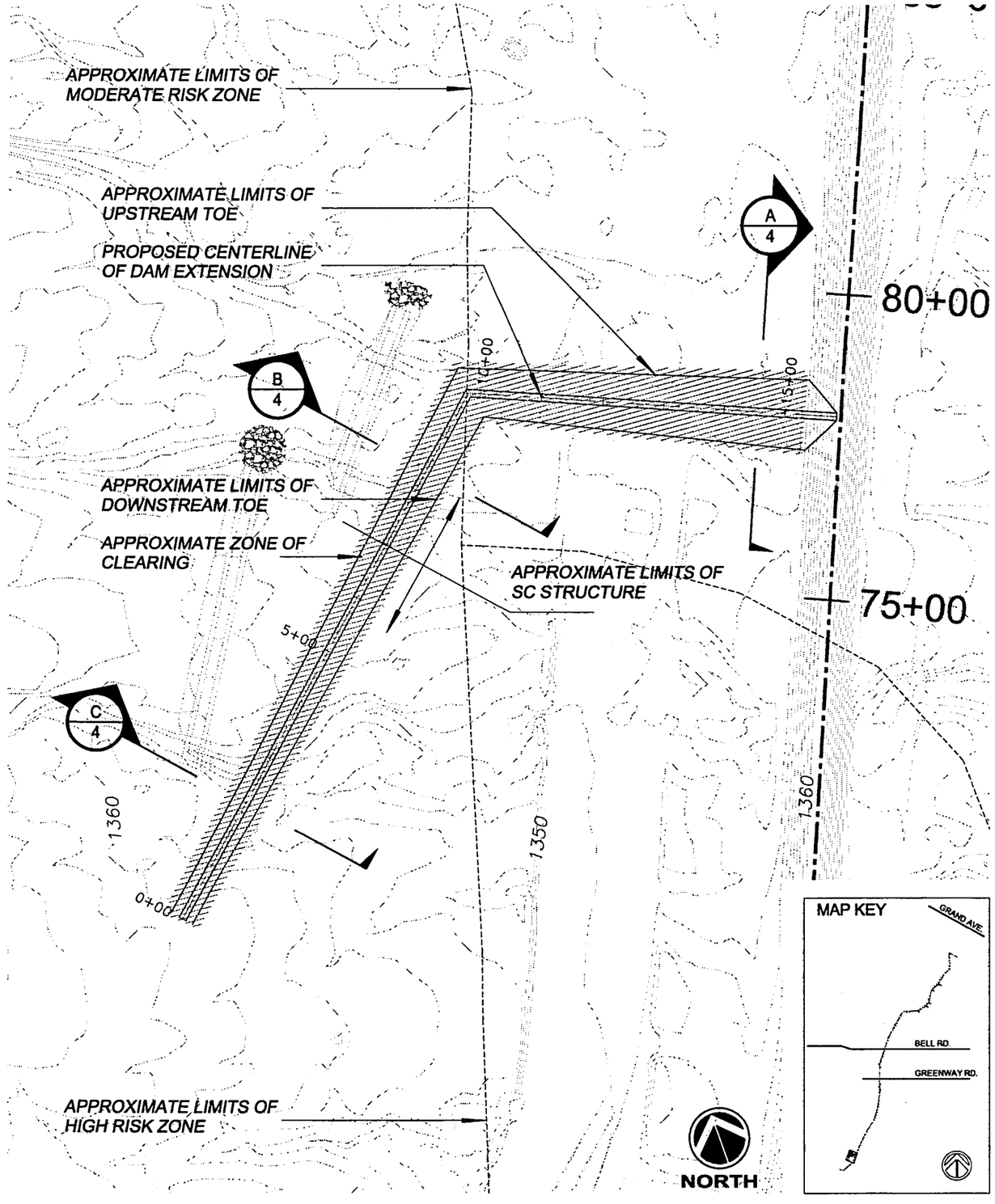
JOB NO.	2-117-001066
DESIGN:	LAH
DRAWN:	EHS/GWH
DATE:	AUGUST 2003
SCALE:	AS SHOWN

ALTERNATIVE 5C
RCC DAM EXTENSION

McMICKEN DAM FRZR PROJECT
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1

FIGURE 3

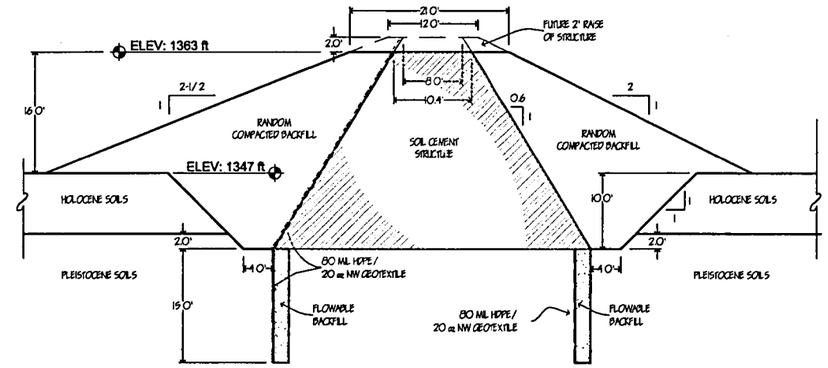
amec



ALTERNATIVE 5C

0 100 200 400

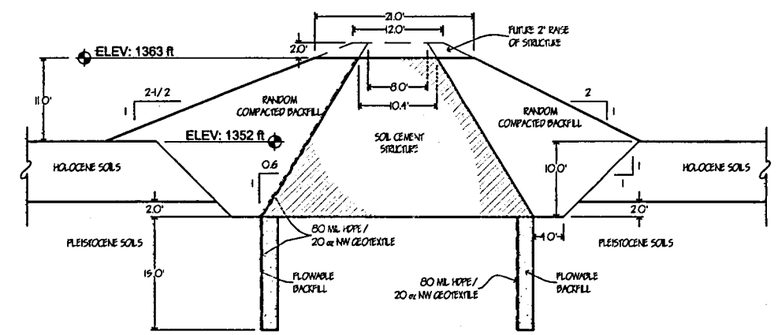
SCALE: 1" = 200'



SECTION A - STATION 14+60

0 10 20 40

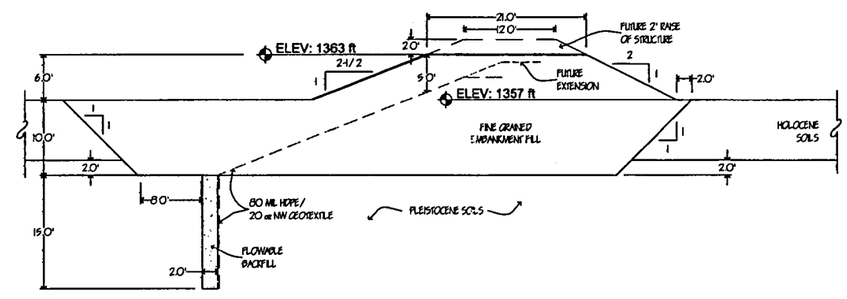
SCALE: 1" = 20'



SECTION B - STATION 8+35

0 10 20 40

SCALE: 1" = 20'



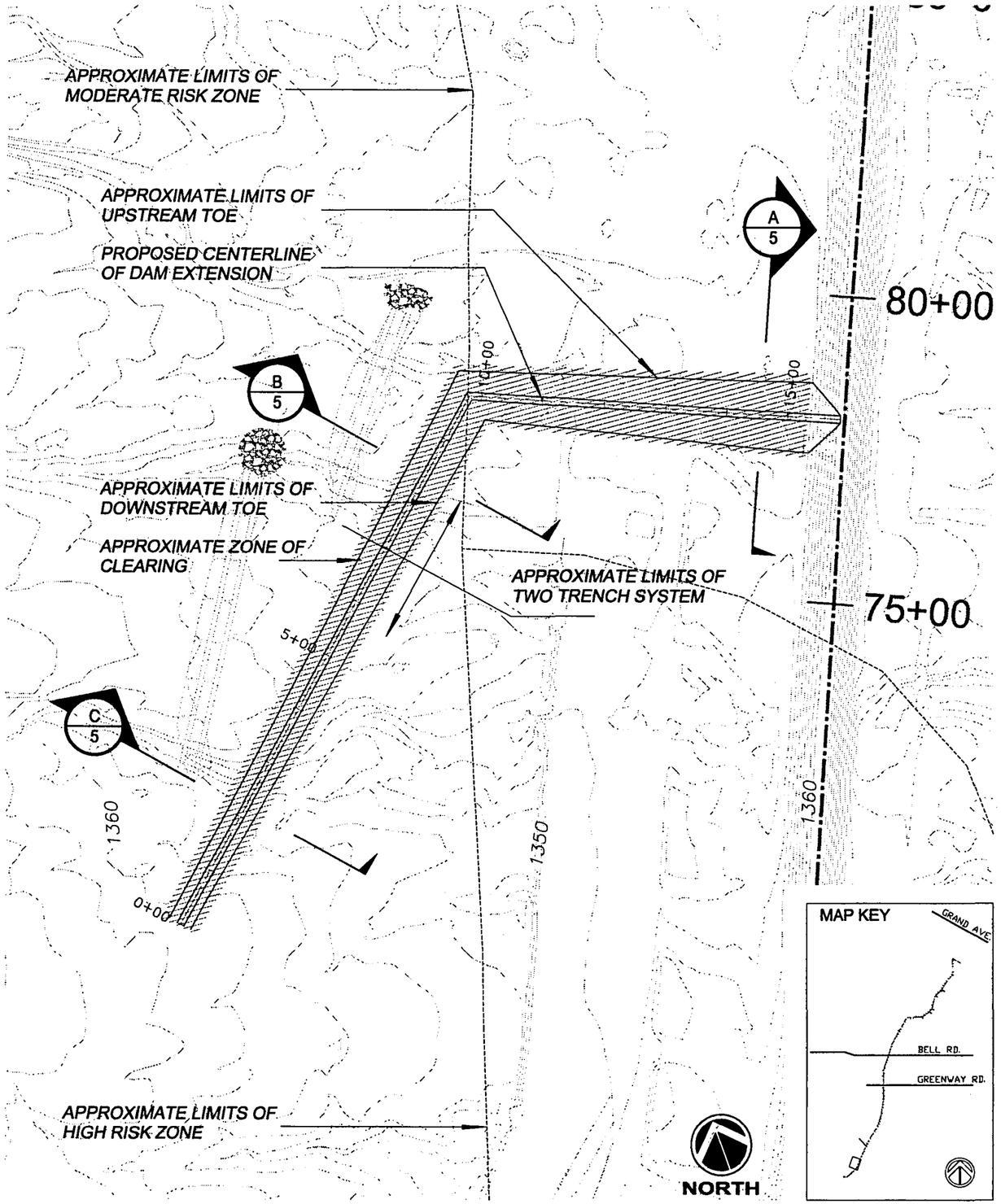
SECTION C - STATION 2+20

0 10 20 40

SCALE: 1" = 20'

NOTE: Refer to Table 5 for cost estimates

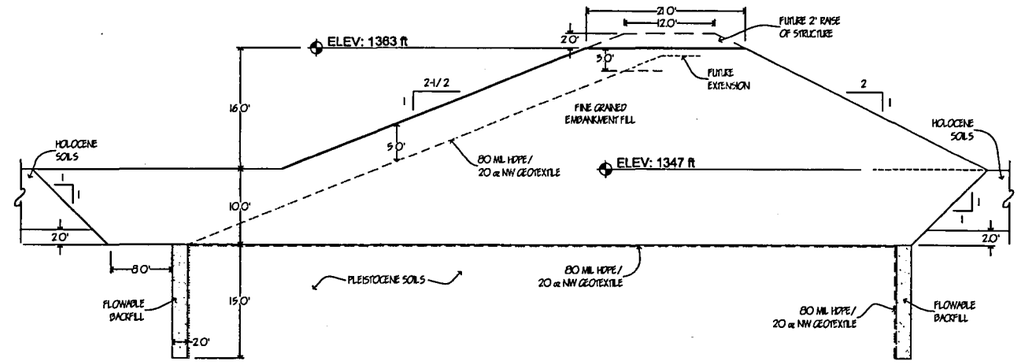
JOB NO. 2-117-001066	ALTERNATIVE 5C SOIL CEMENT DAM EXTENSION		amec
DESIGN: LAH			
DRAWN: EHS/GWH	McMICKEN DAM FRZR PROJECT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1	FIGURE 4	
DATE: AUGUST 2003			
SCALE: AS SHOWN			



ALTERNATIVE 5C

0 100 200 400

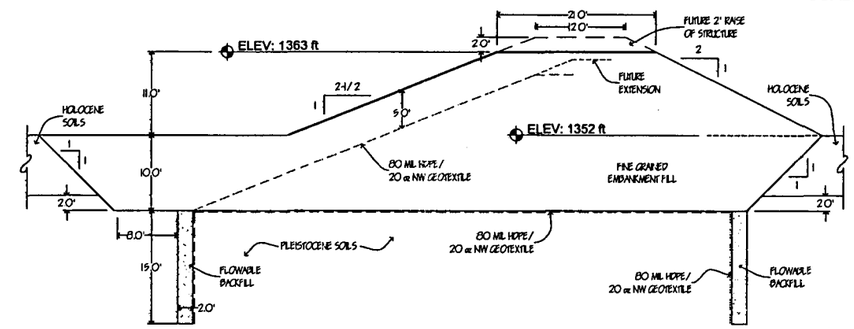
SCALE: 1" = 200'



SECTION A - STATION 14+60

0 10 20 40

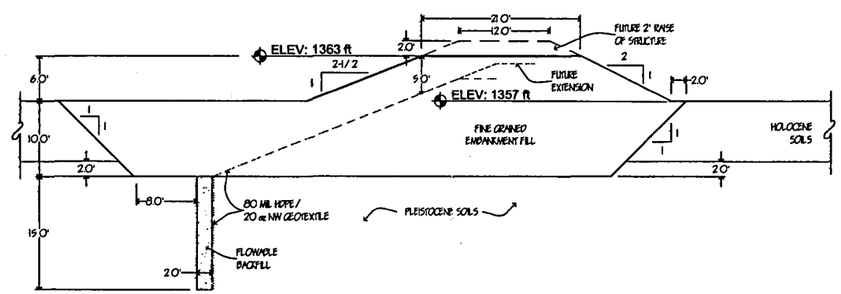
SCALE: 1" = 20'



SECTION B - STATION 8+35

0 10 20 40

SCALE: 1" = 20'



SECTION C - STATION 2+20

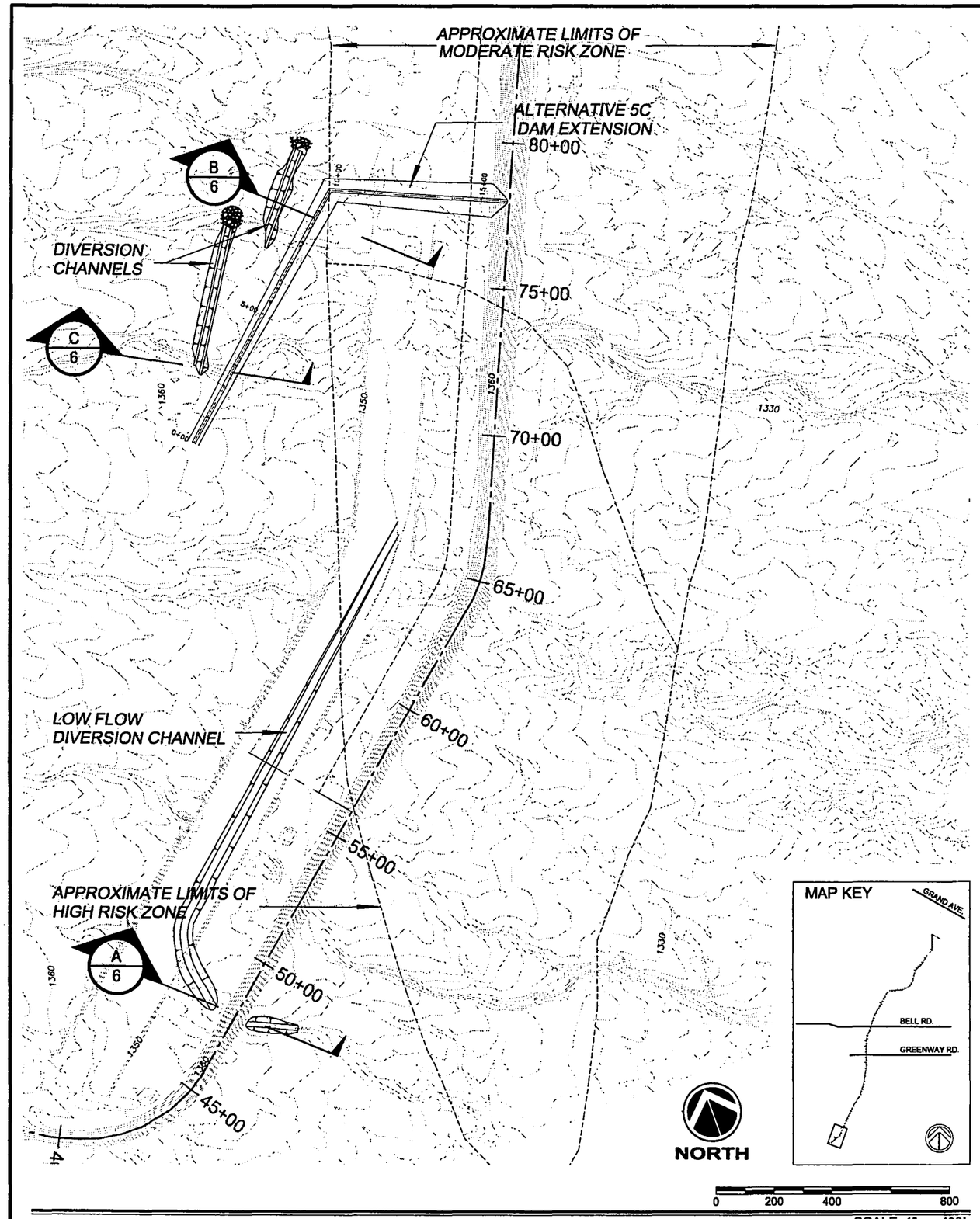
0 10 20 40

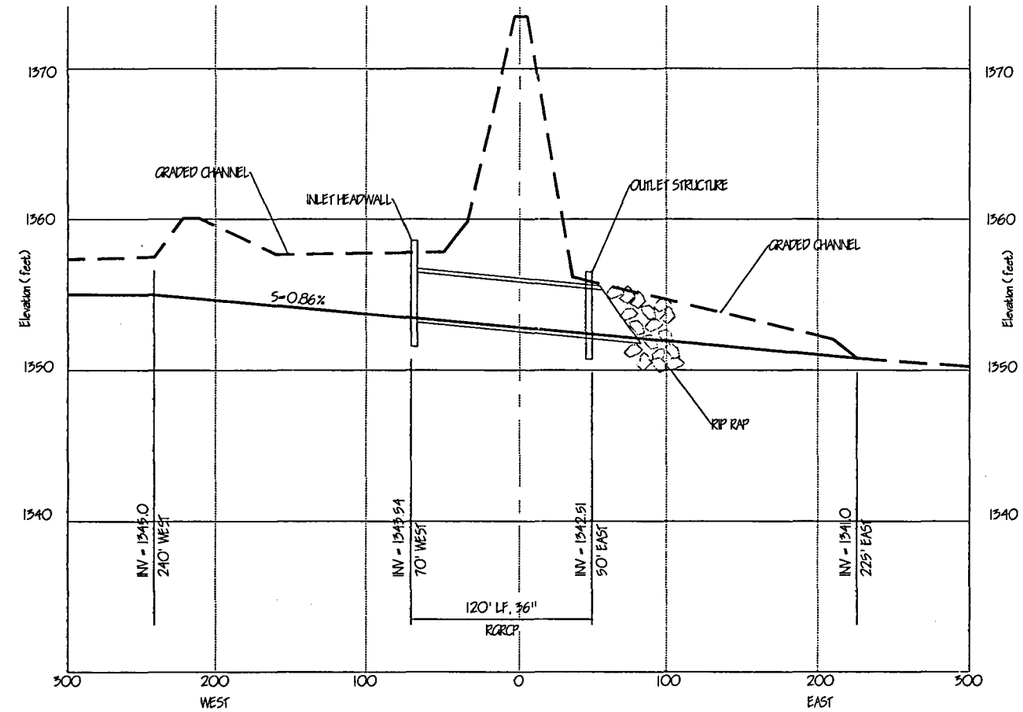
SCALE: 1" = 20'

NOTE: Refer to Table 6 for cost estimates

JOB NO. 2-117-001066	ALTERNATIVE 5C DAM EXTENSION	
DESIGN: LAH		
DRAWN: EHS/GWH		
DATE: AUGUST 2003	McMICKEN DAM FRZR PROJECT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1	FIGURE 5
SCALE: AS SHOWN		

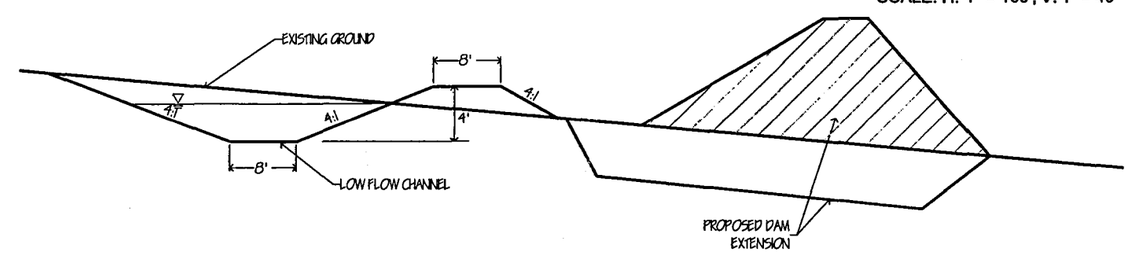
amec





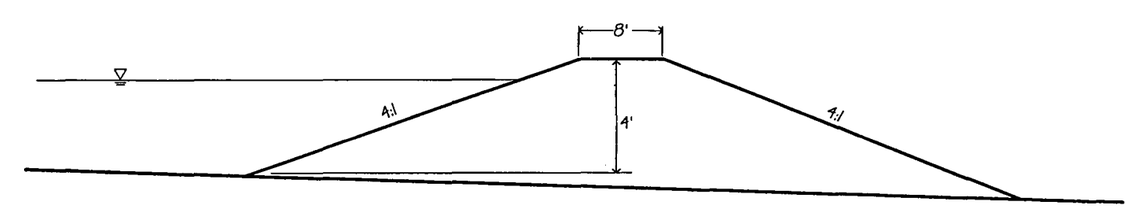
SECTION A - LOW LEVEL DRAIN

SCALE: H: 1" = 100', V: 1" = 40'



SECTION B - LOW FLOW CHANNEL

NOT TO SCALE



SECTION C - SECTION THROUGH WASH

NOT TO SCALE

JOB NO.	2-117-001066
DESIGN:	LAH
DRAWN:	EHS/GWH
DATE:	AUGUST 2003
SCALE:	AS SHOWN

ALTERNATIVE 5C
DIVERSION CHANNEL LOCATIONS

McMICKEN DAM FRZR PROJECT
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD 2002CO11, WORK ASSIGNMENT NO. 1

FIGURE 6

amec

TABLES

TABLE 1
COST ESTIMATE SUMMARY
MCMICKEN DAM FRZR ALTERNATIVES ANALYSIS

Alternative	Cost (1,000s)
High Hazard Zone Only	
3A – Embankment	1,702
3D – RCC	3,049
3G – Soil Cement	3,330
5C – RCC/Embankment	1,649
5C – Soil Cement/Embankment	1,753
5C – Embankment	1,082
Moderate & High Hazard Zones	
3A – Embankment	4,624
3D – RCC	8,466
3G – Soil Cement	9,534

Table 2
Flood Control District of Maricopa County
McMicken Dam FRZR Project
Cost Estimates for Alternatives 3A, 3D, 3G (High Risk)

Estimated Structure/Modification Length (ft): 1900

				Alternative 3A			Alternative 3D			Alternative 3G		
	Earthwork	**UNIT**	**Estimated Unit Cost (2002)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**
A	Clear and Grub Sloped Surface	SY	$ 0.10	130	LF	$ 2,744	95	LF	$ 2,006	95	LF	$ 2,006
B	Excavation of Trenches (15 feet hard dig)	LF	$ 3.50	2	No.	$ 13,300	2	No.	$ 13,300	2	No.	$ 13,300
C	Provide and Place Flowable Fill	CY	$ 35.00	60	SF	$ 147,778	60	SF	$ 147,778	60	SF	$ 147,778
D	Mass Excavation	CY	$ 0.75	1060	SF	$ 55,944	370	SF	$ 19,528	500	SF	$ 26,389
E	Mass Excavation of Slopes	CY	$ 0.90	100	SF	$ 6,333	100	SF	$ 6,333	100	SF	$ 6,333
F	Grading of Slopes	SY	$ 0.63	80	LF	$ 10,640	80	LF	$ 10,640	80	LF	$ 10,640
G	Random Compacted Backfill	CY	$ 1.25	0	SF	$ -	930	SF	$ 81,806	840	SF	$ 73,889
H	Fill and Compact Fine Grained Buttress Material (over liner)	CY	$ 2.75	330	SF	$ 63,861	0	SF	$ -	0	SF	$ -
I	Fill and Compact Fine Grained Buttress Material (mass)	CY	$ 2.00	1740	SF	$ 244,889	0	SF	$ -	0	SF	$ -
J	Excavate Downstream Slope to 1:1	CY	$ 1.25	0	SF	$ -	0	SF	$ -	0	SF	$ -
K	RCC Section Downstream	CY	$ 45.00	0	SF	$ -	450	SF	$ 1,425,000	0	SF	$ -
K.1	Cement (10% by weight)	TON	$ -	0	TON	$ -		TON	$ -	0	TON	$ -
L	Soil Cement Structure	CY	$ 35.00	0	SF	$ -	0	SF	$ -	675	SF	$ 1,662,500
L.1	Cement (7% by weight)	TON	$ -	0	TON	$ -	0	TON	$ -	5387	TON	$ -
	Non-Structural Embankment Fill	CY	$ 1.00	510	SF	$ 35,889	510	SF	$ 35,889	510	SF	$ 35,889
	Upstream Diversion Structure (Stantec)	Lump	$ -		Lump	$ -		Lump	$ -		Lump	$ -
	Liner Materials	**UNIT**	**Estimated Unit Cost (2002)**									
M	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (v)	SF	$ 2.00	30	LF	$ 114,000	55	LF	$ 209,000	30	LF	$ 114,000
	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (h)	SF	$ 0.90	155	LF	$ 265,050	0	LF	$ -	30	LF	$ 51,300
	CONSTRUCTION SUBTOTAL:					$ 960,429			$ 1,951,279			$ 2,144,023
	Environmental Mitigation	AC	$ 10,000.00	30	AC	$ 300,000	20	AC	$ 200,000	20	AC	$ 200,000
	Design and Construction Engineering	LS	15%			$ 144,064			$ 292,692			$ 321,604
	Construction Staking and As-Builts	LS	2%			$ 19,209			$ 39,026			$ 42,880
	Construction water & dust control	LS	1%			$ 9,604			$ 19,513			$ 21,440
	Construction inspection & testing	LS	5%			$ 48,021			$ 97,564			$ 107,201
	Mobilization	LS	3%			$ 28,813			$ 58,538			$ 64,321
	MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL:					$ 549,712			$ 707,333			$ 757,446
	CONTINGENCY		20%			$ 192,086			$ 390,256			$ 428,805
	TOTAL			**Alternative 3A**		$ 1,702,226	**Alternative 3D**		$ 3,048,867	**Alternative 3G**		$ 3,330,274

NOTE: Refer to Figure 1 for Alternative Configuration(s)

Table 3
Flood Control District of Maricopa County
McMicken Dam FRZR Project
Cost Estimates for Alternatives 3A, 3D, 3G (Moderate Risk)

Estimated Structure/Modification Length (ft): 3000

				Alternative 3A			Alternative 3D			Alternative 3G		
	Earthwork	**UNIT**	**Estimated Unit Cost (2002)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**
A	Clear and Grub Sloped Surface	SY	$ 0.10	140	LF	$ 4,667	110	LF	$ 3,667	110	LF	$ 3,667
B	Excavation of Trenches (15 feet hard dig)	LF	$ 3.50	2	No.	$ 21,000	2	No.	$ 21,000	2	No.	$ 21,000
C	Provide and Place Flowable Fill	CY	$ 35.00	60	SF	$ 233,333	60	SF	$ 233,333	60	SF	$ 233,333
D	Mass Excavation	CY	$ 0.75	1190	SF	$ 99,167	390	SF	$ 32,500	535	SF	$ 44,583
E	Mass Excavation of Slopes	CY	$ 0.90	100	SF	$ 10,000	100	SF	$ 10,000	100	SF	$ 10,000
F	Grading of Slopes	SY	$ 0.63	95	LF	$ 19,950	95	LF	$ 19,950	95	LF	$ 19,950
G	Random Compacted Backfill	CY	$ 1.25	0	SF	$ -	1175	SF	$ 163,194	1025	SF	$ 142,361
H	Fill and Compact Fine Grained Buttress Material (over liner)	CY	$ 2.75	365	SF	$ 111,528	0	SF	$ -	0	SF	$ -
I	Fill and Compact Fine Grained Buttress Material (mass)	CY	$ 2.00	2140	SF	$ 475,556	0	SF	$ -	0	SF	$ -
J	Excavate Downstream Slope to 1:1	CY	$ 1.25	0	SF	$ -	0	SF	$ -	0	SF	$ -
K	RCC Section Downstream	CY	$ 45.00	0	SF	$ -	515	SF	$ 2,575,000	0	SF	$ -
K.1	Cement (10% by weight)	TON	$ -	0	TON	$ -		TON	$ -	0	TON	$ -
L	Soil Cement Structure	CY	$ 35.00	0	SF	$ -	0	SF	$ -	825	SF	$ 3,208,333
L.1	Cement (7% by weight)	TON	$ -	0	TON	$ -	0	TON	$ -		TON	$ -
	Non-Structural Embankment Fill	CY	$ 1.00	775	SF	$ 86,111	775	SF	$ 86,111	775	SF	$ 86,111
	Upstream Diversion Structure (Stantec)	Lump	$ -		Lump	$ -		Lump	$ -		Lump	$ -
	Liner Materials	**UNIT**	**Estimated Unit Cost (2002)**									
M	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (v)	SF	$ 2.00	30	LF	$ 180,000	60	LF	$ 360,000	30	LF	$ 180,000
	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (h)	SF	$ 0.90	180	LF	$ 486,000	0	LF	$ -	35	LF	$ 94,500
	CONSTRUCTION SUBTOTAL:					$ 1,727,311			$ 3,504,756			$ 4,043,839
	Environmental Mitigation	AC	$ 10,000.00	40	AC	$ 400,000	30	AC	$ 300,000	30	AC	$ 300,000
	Design and Construction Engineering	LS	15%			$ 259,097			$ 525,713			$ 606,576
	Construction Staking and As-Builts	LS	2%			$ 34,546			$ 70,095			$ 80,877
	Construction water & dust control	LS	1%			$ 17,273			$ 35,048			$ 40,438
	Construction inspection & testing	LS	5%			$ 86,366			$ 175,238			$ 202,192
	Mobilization	LS	3%			$ 51,819			$ 105,143			$ 121,315
	MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL:					$ 849,101			$ 1,211,236			$ 1,351,398
	CONTINGENCY		20%			$ 345,462			$ 700,951			$ 808,768
	TOTAL			**Alternative 3A**		$ 2,921,874	**Alternative 3D**		$ 5,416,943	**Alternative 3G**		$ 6,204,005

NOTE: Refer to Figure 2 for Alternative Configuration(s)

Table 4
Flood Control District of Maricopa County
McMicken Dam FRZR Project
Cost Estimates for Alternative 5C-RCC Dam Extension

	Estimated Structure/Modification Length (ft):	850	700										
							Alt. 5C (Sta. 7+00 to 15+50)			Alt. 5C (Sta. 0+00 to 7+00)			
	Earthwork	**UNIT**	**Estimated Unit Cost (2002)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	
A	Clear and Grub Sloped Surface	SY	$ 0.10		LF	$ -	83	LF	$ 784	85	LF	$ 661	
B	Excavation of Trenches (15 feet hard dig)	LF	$ 3.50		No.	$ -	2	No.	$ 5,950	1	No.	$ 2,450	
C	Provide and Place Flowable Fill	CY	$ 35.00		SF	$ -	60	SF	$ 66,111	30	SF	$ 27,222	
D	Mass Excavation	CY	$ 0.75		SF	$ -	355	SF	$ 8,382	630	SF	$ 12,250	
E	Mass Excavation of Slopes	CY	$ 0.90		SF	$ -	100	SF	$ 2,833	100	SF	$ 2,333	
F	Grading of Slopes	SY	$ 0.63		LF	$ -	67.5	LF	$ 4,016	30	LF	$ 1,785	
G	Random Compacted Backfill	CY	$ 1.25		SF	$ -	775	SF	$ 30,498	0	SF	$ -	
H	Fill and Compact Fine Grained Buttress Material (over liner)	CY	$ 2.75		SF	$ -	0	SF	$ -	205	SF	$ 17,748	
I	Fill and Compact Fine Grained Buttress Material (mass)	CY	$ 2.00		SF		0	SF		735	SF	$ 46,278	
J	Excavate Downstream Slope to 1:1	CY	$ 1.25		SF	$ -	0	SF	$ -	0	SF	$ -	
K	RCC Section Downstream	CY	$ 45.00		SF	$ -	387.5	SF	$ 548,958	0	SF	$ -	
K.1	Cement (10% by weight)	TON	$ -		TON	$ -		TON	$ -	0	TON	$ -	
L	Soil Cement Structure	CY	$ 35.00		SF	$ -	0	SF	$ -	0	SF	$ -	
L.1	Cement (7% by weight)	TON	$ -		TON	$ -	0	TON	$ -	0	TON	$ -	
	Non-Structural Embankment Fill	CY	$ 1.00		SF	$ -	0	SF	$ -	0	SF	$ -	
	Upstream Diversion Structure (Stantec)	Lump	$ -		Lump	$ -		Lump	$ -		Lump	$ 55,110	
	Liner Materials	**UNIT**	**Estimated Unit Cost (2002)**										
M	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (v)	SF	$ 2.00		LF	$ -	55	LF	$ 93,500	30	LF	$ 42,000	
	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (h)	SF	$ 0.90		LF	$ -	0	LF	$ -	40	LF	$ 30,600	
	CONSTRUCTION SUBTOTAL:								-			$ 999,470	
	Environmental Mitigation	AC	$ 10,000.00		AC	$ -				15	AC	$ 150,000	
	Design and Construction Engineering	LS	15%			$ -						$ 149,920	
	Construction Staking and As-Builts	LS	2%			$ -						$ 19,989	
	Construction water & dust control	LS	1%			$ -						$ 9,995	
	Construction Inspection & testing	LS	5%			$ -						$ 49,973	
	Mobilization	LS	3%			$ -						$ 29,984	
	MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL:					$ -						$ 449,862	
	CONTINGENCY		20%			$ -						$ 199,894	
	TOTAL			0		$ -				Alt. 5C RCC		$ 1,649,226	

NOTE: Refer to Figure 3 for Alternative Configuration(s)

Table 5
Flood Control District of Maricopa County
McMicken Dam FRZR Project
Cost Estimates for Alternative 5C-Soil Cement Dam Extension

	Estimated Structure/Modification Length (ft):	850	700												
								Alt. 5C (Sta. 7+00 to 15+50)				Alt. 5C (Sta. 0+00 to 7+00)			
	Earthwork	**UNIT**	**Estimated Unit Cost (2002)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**		**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**		**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	
A	Clear and Grub Sloped Surface	SY	$ 0.10		LF	$	-	83	LF	$	784	85	LF	$	661
B	Excavation of Trenches (15 feet hard dig)	LF	$ 3.50		No.	$	-	2	No.	$	5,950	1	No.	$	2,450
C	Provide and Place Flowable Fill	CY	$ 35.00		SF	$	-	60	SF	$	66,111	30	SF	$	27,222
D	Mass Excavation	CY	$ 0.75		SF	$	-	470	SF	$	11,097	630	SF	$	12,250
E	Mass Excavation of Slopes	CY	$ 0.90		SF	$	-	100	SF	$	2,833	100	SF	$	2,333
F	Grading of Slopes	SY	$ 0.63		LF	$	-	80	LF	$	4,760	30	LF	$	1,785
G	Random Compacted Backfill	CY	$ 1.25		SF	$	-	700	SF	$	27,546	0	SF	$	-
H	Fill and Compact Fine Grained Buttress Material (over liner)	CY	$ 2.75		SF	$	-	0	SF	$	-	205	SF	$	17,748
I	Fill and Compact Fine Grained Buttress Material (mass)	CY	$ 2.00		SF			0	SF			735	SF	$	46,278
J	Excavate Downstream Slope to 1:1	CY	$ 1.25		SF	$	-	0	SF	$	-	0	SF	$	-
K	RCC Section Downstream	CY	$ 45.00		SF	$	-	0	SF	$	-	0	SF	$	-
K.1	Cement (10% by weight)	TON	$ -		TON	$	-		TON	$	-	0	TON	$	-
L	Soil Cement Structure	CY	$ 35.00		SF	$	-	580	SF	$	639,074	0	SF	$	-
L.1	Cement (7% by weight)	TON	$ -		TON	$	-	0	TON	$	-	0	TON	$	-
	Non-Structural Embankment Fill	CY	$ 1.00		SF	$	-	0	SF	$	-	0	SF	$	-
	Upstream Diversion Structure (Stantec)	Lump	$ -		Lump	$	-		Lump	$	-		Lump	$	55,110
	Liner Materials	**UNIT**	**Estimated Unit Cost (2002)**												
M	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (v)	SF	$ 2.00		LF	$	-	30	LF	$	51,000	30	LF	$	42,000
	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (h)	SF	$ 0.90		LF	$	-	30	LF	$	22,950	40	LF	$	30,600
	CONSTRUCTION SUBTOTAL:										-			$	1,070,543
	Environmental Mitigation	AC	$ 10,000.00	0	AC	$	-					15	AC	$	150,000
	Design and Construction Engineering	LS	15%			$	-							$	160,581
	Construction Staking and As-Builts	LS	2%			$	-							$	21,411
	Construction water & dust control	LS	1%			$	-							$	10,705
	Construction inspection & testing	LS	5%			$	-							$	53,527
	Mobilization	LS	3%			$	-							$	32,116
	MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL:													$	468,341
	CONTINGENCY		20%			$	-							$	214,109
	TOTAL					$	-					Alt. 5C SC		$	1,752,993

NOTE: Refer to Figure 4 for Alternative Configuration(s)

Table 6
Flood Control District of Maricopa County
McMicken Dam FRZR Project
Cost Estimates for Alternative 5C Dam Extension

	Estimated Structure/Modification Length (ft):	850	700												
								Alt. 5C (Sta. 7+00 to 15+50)				Alt. 5C (Sta. 0+00 to 7+00)			
	Earthwork	**UNIT**	**Estimated Unit Cost (2002)**	**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**		**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**		**Sectional Area/Length**	**UNIT**	**Estimated Cost ($)**	
A	Clear and Grub Sloped Surface	SY	$ 0.10		LF	$	-	117.5	LF	$	1,110	85	LF	$	661
B	Excavation of Trenches (15 feet hard dig)	LF	$ 3.50		No.	$	-	2	No.	$	5,950	1	No.	$	2,450
C	Provide and Place Flowable Fill	CY	$ 35.00		SF	$	-	60	SF	$	66,111	30	SF	$	27,222
D	Mass Excavation	CY	$ 0.75		SF	$	-	947.5	SF	$	22,372	630	SF	$	12,250
E	Mass Excavation of Slopes	CY	$ 0.90		SF	$	-	100	SF	$	2,833	100	SF	$	2,333
F	Grading of Slopes	SY	$ 0.63		LF	$	-	70	LF	$	4,165	30	LF	$	1,785
G	Random Compacted Backfill	CY	$ 1.25		SF	$	-	0	SF	$	-	0	SF	$	-
H	Fill and Compact Fine Grained Buttress Material (over liner)	CY	$ 2.75		SF	$	-	297.5	SF	$	25,756	205	SF	$	17,748
I	Fill and Compact Fine Grained Buttress Material (mass)	CY	$ 2.00		SF			1458	SF	$	91,769	735	SF	$	46,278
J	Excavate Downstream Slope to 1:1	CY	$ 1.25		SF	$	-	0	SF	$	-	0	SF	$	-
K	RCC Section Downstream	CY	$ 45.00		SF	$	-	0	SF	$	-	0	SF	$	-
K.1	Cement (10% by weight)	TON	$ -		TON	$	-	0	TON	$	-	0	TON	$	-
L	Soil Cement Structure	CY	$ 35.00		SF	$	-	0	SF	$	-	0	SF	$	-
L.1	Cement (7% by weight)	TON	$ -		TON	$	-	0	TON	$	-	0	TON	$	-
	Non-Structural Embankment Fill	CY	$ 1.00		SF	$	-	0	SF	$	-	0	SF	$	-
	Upstream Diversion Structure (Stantec)	Lump	$ -		Lump	$	-		Lump	$	-		Lump	$	55,110
	Liner Materials	**UNIT**	**Estimated Unit Cost (2002)**												
M	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (v)	SF	$ 2.00		LF	$	-	30	LF	$	51,000	30	LF	$	42,000
	80 mil HDPE, 20 oz. NW Geotextile Supply and Install (h)	SF	$ 0.90		LF	$	-	140	LF	$	107,100	40	LF	$	25,200
	CONSTRUCTION SUBTOTAL:										-			$	611,202
	Environmental Mitigation	AC	$ 10,000.00	0	AC	$	-					15	AC	$	150,000
	Design and Construction Engineering	LS	15%			$	-							$	91,680
	Construction Staking and As-Builts	LS	2%			$	-							$	12,224
	Construction water & dust control	LS	1%			$	-							$	6,112
	Construction Inspection & testing	LS	5%			$	-							$	30,560
	Mobilization	LS	3%			$	-							$	18,336
	MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL:					$	-							$	348,913
	CONTINGENCY		20%			$	-							$	122,240
	TOTAL			0		$	-					Alt 5C Dam Ext.		$	1,082,355

NOTE: Refer to Figure 5 for Alternative Configuration(s)

TABLE 7

Flood Control District of Maricopa County
McMicken Dam FRZR Project

Alternative 5C - Segment Dam
Reconnaissance Level Design

Engineers Estimate
Prepared March 20, 2003

DESCRIPTION	QTY	UNIT	UNIT PRICE	AMOUNT
Excavation, Channel, Low Flow	2900	CY	$2.00	$5,800
Excavation, Channel, Low Level Drain	5600	CY	$2.00	$11,200
Embankment, Channel Berm	300	CY	$4.00	$1,200
Riprap, Dumped	250	CY	$35.00	$8,750
Pipe, 36 inch RGRCP, Class V	120	LF	$75.00	$9,000
Sand Diaphragm	440	CY	$30.00	$13,200
Filter Fabric	440	SY	$2.00	$880
Headwall, 36 inch	2	EA	$2,000.00	$4,000
Hydroseed	385600	SF	$0.05	$19,280
			CONSTRUCTION SUBTOTAL	**$55,110**
Design and Construction Engineering	15%	LS	$8,267	$8,267
Construction Staking and As-Builts	2%	LS	$1,102	$1,102
Construction water & dust control	1%	LS	$551	$551
Construction inspection, testing, quality control	5%	LS	$2,756	$2,756
NPDES/SWPPP Permit	1	LS	$10,000	$10,000
Mobilization	3%	LS	$1,653	$1,653
			MOBILIZATION, PERMITS AND ENGINEERING SUBTOTAL	**$24,329**
	20%		**CONTINGENCY**	**$11,022**
Right of Way	0	SF	$0.50	$0
			TOTAL	**$90,500**

Notes:
1. Doesn't include construction of dam extensions
2. Doesn't include dam rehabilitation or lowering of dam

TABLE 7 (cont.)

Flood Control District of Maricopa County
McMicken Dam FRZR Project

Alternative 5C - Segment Dam | **Engineers Estimate Details**
Reconnaissance Level Design | **Prepared March 20, 2003**
Prepared by: cvg | Checked by: | Revisions

Excavation, Channel, Low Flow — added

Length	Bot width	Top width	Avg depth	Avg area	side slope	Excavation
800	8.00	40.00	4.00	96.00	4 :1	2,900
					Total excavation	2,900 cubic yards

Embankment, Channel Berm

assume 10% of excavation quantity 300.00 cubic yards — added

Excavation, Channel, Low Level Drain — added

Length	Bot width	Top width	Avg depth	Avg area	side slope	Excavation
1,800	20.00	36.00	2.00	56.00	4 :1	3,800
400	20.00	48.00	3.50	119.00	4 :1	1,800
					Total excavation	5,600 cubic yards

Riprap, Dumped

location	number	length	width	thickness	quant riprap
low flow channel	2	30	30	2	130
pipe inlet	2	20	20	2	60
pipe outlet	2	20	20	2	60
				total	250

added

Pipe, 36 inch RGRCP, Class V

Length 120 ft 1 each — shortened

Sand Diaphragm

location	Length	Width	Height	Area	Total Volume (CY)
outlet pipe	120	10.0	10.0	100.00	440

shortened

TABLE 7 (cont.)

Flood Control District of Maricopa County
McMicken Dam FRZR Project

Alternative 5C - Segment Dam | **Engineers Estimate Details**
Reconnaissance Level Design | **Prepared March 20, 2003**
Prepared by: cvg | Checked by: | Revisions

Filter Fabric

location	length	width	number	Area (sf)		
low flow channel	34	34	2	2312		added
headwalls	20	20	4	1,600		
		Total		3,912	sf	
				440	sy	

Headwall, 36 inch 2 ea

Hydroseed

location	length	width	number	Area		
low level drain channel	1800	36	1	259200		added
low level drain channel	400	48	1	76800		added
low flow channel	800	60	1	48000		added
around headwalls	20	20	4	1,600		
		Total		385,600	square feet	