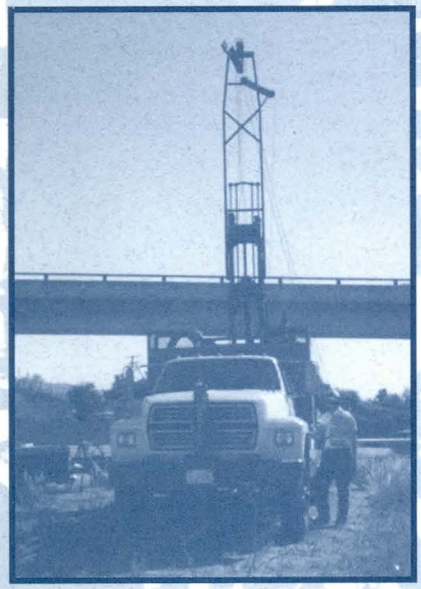
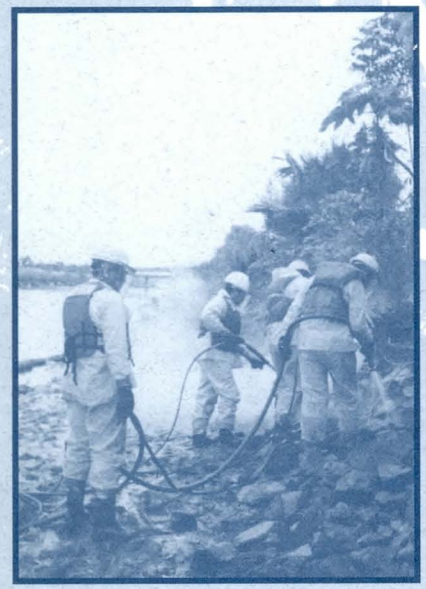
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS HELD JUNE 1 AND 2, 2005





Geotechnical

and

Environmental

Sciences

Consultants

Ninyo & Moore

WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS HELD JUNE 1 AND 2, 2005

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March 3, 2006
Project No. 600996002

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Mr. Dan Lawrence, P.E.
Maricopa County Flood Control District
2801 West Durango Street
Phoenix, Arizona 85009-6399

Subject: Workshop on Utility Penetrations through Embankment Dams
Contract FCD 2004C029
Work Assignment No. 2 (PCN 050.03.01)

Dear Mr. Lawrence:

We are pleased to submit the report on the Workshop on Utility Penetrations through Embankment Dams. This report details the preparations for, the proceedings of, and the recommendations from the workshop and Failure Modes and Effects Analysis (FMEA).

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments regarding this report, please contact us at your convenience.

Sincerely,
NINYO & MOORE

A. Tom MacDougall, P.E.
Project Engineer

Robert W. McMichael, P.E.
Principal Engineer

Steven D. Nowaczyk, P.E.
Principal Engineer

ATM/SDN/RM/rko

Distribution: (6) Addressee
(2) CD-ROM

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1. INTRODUCTION

In accordance with the Notice to Proceed issued by the Flood Control District of Maricopa County (the District) dated February 9, 2005, Ninyo & Moore planned and assisted the District in holding a two-day workshop on the subject of utility penetrations through embankment dams. The workshop consisted of a conference on day one and a Failure Modes and Effects Analysis (FMEA) on day two. The conference, day one, consisted of presentations by the District, a utility company, design engineers, a contractor, and dam safety engineers. On Day 2, an FMEA was performed on likely scenarios for potential utility penetrations. This report details the purpose of the project, the preparations for the two-day workshop, the proceedings of the conference held on June 1, 2005, and the considerations, discussions, and recommendations resulting from the FMEA held on June 2, 2005.

1.1. Project Background

Established in 1959, the Flood Control District of Maricopa County is a municipal corporation funded by a secondary property tax. The stated mission of the District is:

> *To provide flood hazard identification, regulation, remediation, and education to the people in Maricopa County so that they can reduce their risks of injury, death, and property damage due to flooding while enjoying the natural and beneficial values served by floodplains.*

In accordance with this mission, the District operates and maintains 22 jurisdictional flood control dams in, and adjacent to, Maricopa County. Figure 1 shows the names and locations of these dams. Many of the dams are miles in length, with the sum of the 22 dam lengths being approximately 64 miles.

Although, when constructed, many of these dams were distant from population centers, as urbanization continues in Maricopa County, the flood control dams are now adjacent to developed or developing areas. As a result, requests from utility companies to cross the flood control dams with underground utilities are increasing. Moreover, based on the growth patterns and development projections used by the District, the District anticipates a large increase in these requests during the next 5 to 10 years.

To better manage activities by others and to help insure the integrity of District flood control dams and property, the District utilizes a right-of -way (ROW) permitting process. The review and approval process for ROW applications that impact a flood control dam involves multiple parties: the District (including the structures management branch, right-of-way department, lands division, and environmental division), the Arizona Department of Water Resources (ADWR), the U.S. Army Corps of Engineers (USACE), and/or the Natural Resource Conservation Service (NRCS). At the time of the workshop, ROW permit applications generally required multiple submittals, meetings, and reviews, as well as extensive dam safety education (by the District to the applicant), and clarifications. Extensive reviews of these ROW applications has often diverted limited District resources and impacted project schedules.

The primary reason that applications need extensive reviews and evaluations (from multiple agencies) is dam safety. Case histories indicate that many dams have failed due to conduit penetrations through the embankment. It is common for dam owners and jurisdictional agencies in the United States to categorically prohibit any underground utility from penetrating or crossing dams due to the potential for compromising safety. The District, however, has not categorically prohibited utility crossings for the following reasons:

1. Most District dams are miles in length and to avoid the dam could require many extra miles of utility installation resulting in higher utility costs to the public, and
2. As a municipal corporation, the District has the responsibility to honor the public's best interest and as such, does not wish to cause potential undue economic burden on community and public infrastructure development by categorically prohibiting all utility crossings of its flood control dams.

The District retained Ninyo & Moore to evaluate the feasibility of allowing penetrations through embankment dams, to provide recommendations for which types of penetrations should be considered and which should be categorically prohibited, and to assist in developing a unified guideline to aid ROW applicants through the permitting process.

1.2. Scope of Work

The scope of our services relating to the workshop and FMEA preparation generally included:

- Collecting and reviewing available literature, publications, design procedures, and other information relating to the development of the unified guidelines.
- Identifying requirements related to embankment dam penetrations from jurisdictional or sponsoring agencies including: ADWR, NRCS, and USACE. This was performed through research and interviewing selected personnel at each agency.
- Developing a list of utilities that could potentially cross one of the District's dams and obtaining contact information for representatives from those utility firms/agencies/companies.
- Developing and sending a questionnaire to parties potentially involved or otherwise interested in a utility penetration through an embankment dam, including utility owners, stakeholders, design engineers, contractors, and reviewers.
- Compiling and analyzing the questionnaire responses, deriving conclusions from the analysis, and creating a list of potential invitees to the two-day workshop.
- Planning and facilitating a two-day workshop. The purpose of the first day was to provide a forum for education and collaboration between the parties involved in a utility penetration through an embankment dam. The purpose of the second day was to systematically and qualitatively analyze the potential for failure posed by common installation scenarios. This was done by utilizing a modified FMEA format.
- Preparing this report presenting our methods, findings, conclusions, and recommendations regarding utility penetrations through District dams and the development of the unified guidelines document.

2. WORKSHOP AND GUIDELINE PREPARATIONS

Various activities were utilized to prepare for the workshop and collect information needed to develop an effective guidelines document. The activities are described below and include: researching existing guidelines and procedures (relating to utility penetrations) of other dam owners or flood control agencies, collecting and reviewing technical literature, collecting and reviewing literature relating to the existing District procedures for application review, developing and conducting a survey of potentially involved groups (owners, designers, contractors, review-

ers) to clarify the current practices and understandings, and interviewing representatives from the state jurisdictional agency and federal sponsors.

2.1. Existing Guideline Search

Ninyo & Moore conducted research to find existing documents that presented other dam owners' or regulators' policies regarding utility penetrations through embankment dams. The search was narrowed to include the following states: California, Nevada, Utah, New Mexico, and Texas; the following counties: Clark County, Nevada, San Bernardino, California; Iron County, Utah; and the Tennessee Valley Authority. Research was performed through the internet, email, telephone, and personal interviews.

According to James Lowe, P.E., and David Gutierrez, P.E. - Director of Dam Safety, of the California Department of Safety of Dams, new utility penetrations are categorically prohibited in California. Ninyo and Moore's research did not find a reference or code to support the prohibition. Nevada and New Mexico did not have any definitive stance but both acknowledged the preference to avoid penetrating a dam with a utility. David Betley of Clark County, Nevada, Drainage Engineering Department did not know of any guidelines regarding utility penetrations through dams, but opined that it was not allowed. Mr. Richard Chaimberland of the San Antonio, Texas Development Services was unaware of policies regarding utility penetrations through embankment dams. Mr. Steve Platt of Iron County, Utah referred Ninyo & Moore to the State Dam Safety Office and mentioned that he was not aware of utilities being allowed to penetrate earth dams in Iron County. Mr. David Marble, P.E. and Assistant Utah State Engineer informed Ninyo & Moore that the State of Utah did not have a specific or written policy on this matter, but that they are generally discouraged. Mr. Marble did mention that one or two instances of utility penetration may have been permitted in the past. According to the Tennessee Valley Authority Engineering Department, that agency categorically prohibits utility penetrations through their dams.

2.2. Technical Literature Review

Ninyo & Moore collected and reviewed technical literature relating to penetrations through embankment dams. The purposes of collecting the technical documents were to become familiar with the state-of-practice, to understand common design methodologies, and to have references on which to base (and to include in) the guidelines document. Many documents were collected and considered relevant. Phase I Individual Structural Assessments (ISAs) that were conducted by the District for each of their dams were also included as part of the literature collection. These were included so as to review the failure modes and case-specific circumstances in relation to potential utility penetrations. The collected documents were complied into binders for organization and Appendix A contains a list of the collected documents.

2.3. Procedural Review

Ninyo & Moore collected and reviewed documents that relate to the current application review process, permitting, and protocols. Table 1 contains a list of these documents. Although the focus of this work assignment relates to technical best-practices, explanations and diagrams of the review protocols will be included in the guidelines. Also, the District requested that Ninyo & Moore provide recommendations to the review process if needed.

Table 1 – Documents Related to Applications and Permitting

Document	Source
Rules and Regulations Pertaining to Dam Safety Procedure	Arizona Administrative Code, Title 12, Chapter 15, Article 12 (Authority:A.R.S.§ 45-101) Effective June 12, 2000
Right-of-Way Permit Application Process	Flood Control District of Maricopa County 05/07/2002, 08/07/2002
Conditions and Specifications	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Ingress/Engress Permit/PCN # 001.01.60	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Utility/Roadway Permit - PCN # 001.02.60	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Recreational Use Permit - PCN # 001.03.60	Flood Control District of Maricopa County
Filter, Drain and Sand Design Criteria	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Drainage/Storm	Flood Control District of Maricopa County

Table 1 – Documents Related to Applications and Permitting

Document	Source
Water Run-off Permit - PCN # 001.04.60	
General Pre-Permit Application Process	Flood Control District of Maricopa County, Rev. 11/2/98
Standard Operating Procedures for Right-of-Way Permits	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Recreational Use Permit PCN # 001.02.04	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Drainage/Storm Water Run-off Permit - PCN # 001.02.05	Flood Control District of Maricopa County
Right-of-Way Filing Checklist, Ingress/Engress Permit - PCN # 001.02.02	Flood Control District of Maricopa County

2.4. Survey and Survey Results

In an effort to better understand the practices and knowledge of those who would be involved in a utility penetration through an embankment dam, Ninyo & Moore, together with the District, developed and distributed a multiple-choice questionnaire. The questionnaire consisted of five sections: General Information, Past Experience with Utility Penetration Permitting, General Planning and Design Procedures, Future Plans, and Dam Safety. The sections each contained between five and 12 questions that allowed the respondent to give specific input on their organization's practices, priorities, and interest in the subject, as well as general feedback on how to improve the permitting process. The final section, Dam Safety, was included in the questionnaire to provide data on the respondents' understanding of dam operation, design, function, and safety.

Questionnaires were distributed to approximately 250 individuals that could be broadly categorized into three groups: utility owners/providers, designers, and contractors. Approximately 200 of the questionnaires were sent to members categorized as utility owners/providers, which included companies or agencies like Salt River Project, Southwest Gas, the City of Phoenix, APS, ADOT, Arizona American Water, Cox, Qwest, Sprint, and others. Approximately 30 of the surveys were distributed to design engineers employed at companies like Coe and Van Loo, Copperstate Engineering, CMX, HDR, Kirkham Michael, and other design firms that would likely be involved in a utility project. Approximately 20

surveys were mailed to contracting companies including FNF, Haydon, and others. The survey was also made available on the internet. Approximately three weeks following the initial distributing, follow up telephone calls were made to those who received surveys as a reminder to fill out and return the survey. Appendix B contains the survey distribution list.

At the time this report was prepared, Ninyo & Moore had received 18 responses to the survey. Due to the limited response, neither extensive data reduction nor analysis was performed. The survey responses were individually read and noted. Appendix B contains a blank copy of the questionnaire as well as the tabulated results from the 18 responses. In some cases, respondents did not answer questions; therefore, the results, when summed, do not indicate 18 responses. Although one of the purposes of the survey was to aid in preparing the workshop agenda as a result of the limited response, conclusions as to discussion topics that should be included in the workshop agenda could not be determined. In an effort to continue collecting survey data, the District has included the questionnaire in the *Guidelines* and requests completion of the survey by future ROW permit applicants.

2.5. Regulatory Agency Interviews

The District and Ninyo & Moore interviewed representatives from ADWR, NRCS, and the USACE. The purposes of the interviews were to better understand the answers to the following general questions:

- Which elements are required to be included in a utility penetration design?
- Are there other non-required, but preferred elements that the agency would like to see included in the design?
- At what step in the ROW permit review process would the agency like to be included?
- What is the normal review process and time frame of the agency?
- Does the agency have any general commentary relative to the guidelines being prepared by Ninyo & Moore and the District?

The following sections summarize the interview responses from each agency.

2.5.1. Arizona Department of Water Resources (ADWR)

On April 7, 2005, Mr. Steve Nowaczyk (Ninyo & Moore) and Mr. Brett Howey (the District), interviewed Mr. Jon Benoist, P.E. - Senior Dam Safety Engineer, of ADWR. The interview was conducted at the ADWR offices and utilized a conversational format (i.e., did not follow a scripted question list, but used prompt-style questions to continue discussion when needed). A more complete summary of the interview is included in Appendix C; however, important points are listed below.

- ADWR expressed support for the development of a unified guideline for utility penetrations through embankment dams.
- Penetrations through the freeboard or above are preferred to embankment or foundation penetrations. Penetrations proposed through or above the freeboard may streamline the permitting process.
- Generally, a filter diaphragm should be incorporated into the design of any utility penetration, unless above the freeboard elevation.
- The guideline should address the different sizes of utility conduits, the different types of utilities (wet, pressurized, etc.), the relative location of the penetration (freeboard, embankment, foundation, upstream parallel, etc.), and conduit materials.
- ADWR would like to be involved early in the review process.

2.5.2. National Resource Conservation Service (NRCS)

On April 7, 2005, Mr. Steve Nowaczyk and Mr. Brett Howey, interviewed Mr. Ilde Chavez, P.E. - State Conservation Engineer, Mr. John Harrington, P.E. - State Construction Engineer, and Mr. John Chua, P.E. - State Design Engineer, all with the NRCS. The interview was conducted at the NRCS Phoenix office and utilized a conversational format (i.e., did not follow a scripted question list, but used prompt-style questions to continue discussion when needed). A summary of the interview is included in Appendix C; however, important points are listed below.

- NRCS asked that they be included early in the permitting process, but only in a formal manner, after a complete design package has been submitted to the District for review.

- NRCS concurs with ADWR that penetrations through the freeboard or above are preferred to embankment or foundation penetrations and that penetrations above the freeboard may allow for a streamlined permitting process.
- The NRCS review and approval would be a minimum of 30 days, and may include different reviewers depending on workload.
- Detailed designs sealed by a registered engineer, showing excavation and backfilling, and a detailed work plan describing the installation and backfilling sequence should be part of the application submittal.
- If NRCS design methods are not used, then the applicant must show that the NRCS design requirements are met or exceeded by those utilized.

2.5.3. United States Army Corps of Engineers (USACE)

On April 25, 2005, Mr. Tom MacDougall (Ninyo & Moore) and Mr. Brett Howey (the District), interviewed Mr. Ted Ingersol, Senior Civil Engineer, P.E., G.E., Mr. Jim Farley, and Mr. Ted Masigat of USACE, Los Angeles District. The interview was conducted by telephone and utilized a conversational format (i.e., did not follow a scripted question list, but used prompt-style questions to continue discussion when needed). A summary of the interview is included in Appendix C; however, important points are listed below.

- On their dams, USACE methods should be used in the design.
- USACE would like to be included early in the review process and would like a "veto" option for proposed modifications to the structures under their perview.
- Geotextiles are not generally accepted for engineering purposes and installations requiring blasting will generally not be allowed.
- USACE would prefer that penetrations stay very shallow or go deep within the foundation of the dam.
- Construction techniques are important when penetrating a dam and USACE may have field inspections during construction.

3. WORKSHOP SUMMARY

On June 1 and 2, 2005, a two-day workshop on utility penetrations was held at the District offices. The purpose of the first day was to provide a forum for education and collaboration between the parties involved in a utility penetration through an embankment dam. Day 1 was generally referred to as "the conference." The purpose of Day 2, referred to as the FMEA, was to systematically and qualitatively analyze the potential for failure posed by common installation scenarios. The FMEA is described in Section 4 of this report. This section documents day one of the workshop (or conference), specifically, the invited guests, participants, those who presented, a review of the presentations, and a summary of the questions and discussion during open forum session.

3.1. Invitations and Participants

Invitations to the workshop were extended to representatives of specific companies that the District deemed as one "likely" to be involved in the design or construction of a utility penetration through a dam in the near future. Those who submitted a survey and expressed a desire to attend were also invited. A copy of the invitation is provided in Appendix D. In general, it was the desire of the District and Ninyo & Moore to have representatives from the utility owners/providers (especially the larger utility providers), the design engineers, and the contractors present so as to promote collaboration and cross-industry education. Those who attended and participated in the conference (Day 1) are listed in Table 2.

Table 2 – Conference Attendees

Name	Organization	Name	Organization
Al Field	ADOT	Dean Durkee, P.E.	Gannett Fleming
Bruce Cana	ADOT	Brett Gillespie	Haydon BC
Jon Benoist, P.E.	ADWR	Greg Wallace	Haydon BC
Larry Hansen, P.E.	AMEC	Bob Eichinger, P.E.	Kimley Horn
Darrin Francs	CAP	Dave Jensen, P.E.	Kimley Horn
Chris Scott	City of Mesa	Analu Villalvaso	Ninyo & Moore
Jim Nichols	City of Surprise	Shilpa Vepakomma	Ninyo & Moore
Eric Laurin, P.E.	Coe & Van Loo	S. Nowaczyk, P.E.	Ninyo & Moore

Table 2 – Conference Attendees

Name	Organization	Name	Organization
Jim Talbot, P.E.	Consultant	Tom MacDougall	Ninyo & Moore
D. Deathridge, P.E.	CSE	Danny McCook	NRCS
Angie Hardesty	District	Ilde Chavez, P.E.	NRCS
Bill Leal	District	Jim McHenry, P.E.	NRCS
Brett Howey, P.E.	District	John Chua, P.E.	NRCS
Dan Lawrence, P.E.	District	John Harrington,P.E.	NRCS
Jon Hughes	District	L. Maldonado, P.E.	PEC
M. Greenslade, P.E.	District	Claudia Fisher	Southwest Gas
Mike Ramirez	District	Pom Jintasawang	Southwest Gas
Shelby Brown	District	Joe Bergquist, P.E.	Stantec
Steve Rubin	District	Patrick Conroy, P.E.	USACE
Tom Renckly, P.E.	District	Chuck Cooper	USBR

3.2. Summary of Proceedings

As noted previously, the purpose of the workshop was to provide a forum for education and collaboration between the parties involved in a utility penetration through an embankment dam. The agenda included presentations from the District, Southwest Gas, Copper State Engineering, Coe & Van Loo, Haydon Building Corporation, NRCS National Soil Mechanics Center, and from Mr. Jim Talbot (a consultant to Ninyo & Moore and dam safety expert). Each presentation was followed with a short question-and-answer period. Following the final presentation, general questions and follow-up to the presentations were encouraged using an open forum format. Appendix D contains prints of the slides used by each presenter on Day 1. The following paragraphs summarize the presentations and the open forum discussion.

Mr. Tom Renckly, P.E., the Manager of the District's Structures Management Branch, presented general information about the District and its Dam Safety Program. A few of the main points he discussed include:

- The mission of the District is to provide flood hazard identification, regulation, remediation, and education to people in Maricopa County.

- There are 22 flood control dams in and around Maricopa County. Sixteen were originally constructed by the NRCS, five were constructed by USACE, and one was designed and constructed by the District without a federal sponsor.

- The dams total 64 miles in length.

- The dams are under the jurisdiction of the ADWR and most are classified as "High Hazard."

- The District's dam safety program is comprised of three major components: recurrent dam safety activities, structures assessment, and dam rehabilitation.

- Recurrent dam safety activities generally include: visual inspecting, monitoring through surveys and instrumentation, and developing and updating of emergency action plans.

- Structures assessment includes evaluating the physical condition of the District's 22 dams and assessing the long term safety and continued compliance with current regulations. This component goes beyond the normal recurrent dam safety activities and generally involves a two phase approach: Phase I and Phase II. A Phase I Assessment provides an overall evaluation of the dam in terms of dam safety and flood protection. The assessment starts with collection and review of available records for each dam followed by a detailed field inspection. The team then identifies potential failure modes and consequences of failure. The final stage is development of conceptual alternatives to mitigate the identified failure modes. A Phase II Assessment involves investigation and repair of site-specific dam safety issues. Many of the repairs are considered interim fixes until a rehabilitation of the entire structure can be accomplished.

- Dam rehabilitation is considered to be the most significant long-term need for dam safety. The District has identified 13 dams that require overall rehabilitation or replacement due to issues of dam safety, urbanization, and flood protection.

Mr. Brett Howey, P.E. - Dam Safety Engineer of the District's Structures Management Branch, introduced the project and explained the current permitting process used when applicants wish to cross a flood control dam. His main points included:

- Increased demand to penetrate dams with underground utilities, the anticipated future demand for the same, and the current difficulties in the process, have driven the District to work on developing a unified guideline.

- Crossing a dam has specific technical challenges that are often not well understood by designers. The District has spent significant time educating applicants and their consultants, as well as reviewing unacceptable designs.

- It is anticipated that the guidelines document will be a "win-win" solution for both the applicants and the District. The applicants should save time and resources as well as have more predictable schedules. The District benefits by promoting dam safety and reducing the stress on its limited resources.
- Education of dam safety is one of the objectives of this project.
- Some basic terminology related to dams was presented. Figure 2 through Figure 9 of this report were prepared to portray commonly used vocabulary associated with dams and the different types of dams the District operates and maintains.
- The District has the authority to regulate real property from resolution FCD 2002R002.
- Four permit types are granted: Ingress/Egress, Utility in District Right-of-Way, Recreational Use Permit, and Stormwater Runoff/Drainage.
- The current application review process generally follows these steps:
  1. Meet with District,
  2. Complete application forms,
  3. Submit completed form with fees, plans, and reports to the District permit specialist,
  4. Pay review fees,
  5. Involve state and federal regulators,
  6. District review and comment,
  7. State and Federal review,
  8. Final plan approval letter, and
  9. Right-of-way permit issued after contractor submits necessary documents.
- The District's permit specialist acts as the point of contact and liaison between the District and the applicant.

Ms. Claudia Fisher, a Distribution Engineer with Southwest Gas, described the route selection and planning process. A summary of the main points includes:

- Planning and route selection are related to forecasted consumer demand. The demand is estimated based on developer requests.

- The scheduling, from initial planning to operational status, including for permit approval time, weather considerations, the developer deadlines, and municipal issues (recent capital improvement projects, city events, etc.).

- When planning, Southwest Gas prefers to locate the utilities within existing rights-of way, using the shortest routes, and avoiding having to purchase private easements. Utilities are a heavily regulated industry and cost savings go to the consumer.

- Southwest Gas would prefer long, straight sections of utility conduit, installed using open-cut techniques within existing rights-of-way, and that avoid crossing railroads, rivers, freeways, and dams.

- Planning is dictated by demand and restricted by location of supply lines from El Paso Natural Gas (these are only a few lines in which to tie-in to).

- Southwest Gas identified four main difficulties when trying to cross a District dam: identifying the structure, knowing the design requirements, knowing the construction requirements, and being able to schedule the permitting time.

Mr. J. David Deathridge, P.E, an engineer with Copper State Engineering, Inc., presented a generalized description of design considerations when installing a penetration through an embankment dam. Main points of his presentation are summarized below:

- 60 percent of dam failures in the Western US are related to piping, and 60 percent of piping failures are related to penetrations. Therefore, conduit penetrations should be avoided, where possible.

- Failure modes due to utility penetrations include corrosion of metal conduit, lack of construction monitoring, piping of embankment material into conduit, piping of embankment material around the conduit, and erosive flows from a ruptured conduit.

- He described two past projects involving dry utilities crossing through the freeboard of a dam. The designs, as approved by the District and ADWR, included a square, open cut trench, backfilled with a cement slurry.

- The open trench had extensive cleaning, and during installation there was frequent testing and observation.

- For some penetrations, a streamlined review process could be utilized.

Mr. Eric Laurin, P.E., an engineer with Coe & Van Loo, presented a case history of installing a municipal sewer line beneath Adobe Dam using pipe ramming techniques. His presentation is summarized below:

- Due to a 200 acre residential development, a City of Phoenix stipulation that pump stations could not be included, and the need to avoid disturbing large portions of the dam structure, Coe & Van Loo suggested using a trenchless technology to install the sewer through the foundation of the dam.
- This project involved coordination between the District, the City, the consultants, ADOT, ADWR, and USACE.
- Using survey monuments and frequent monitoring, results indicated that the installation did not impact the dam.

Mr. Brett Gillespie, a project manager with Haydon Building Corporation, discussed the techniques commonly used to install underground utilities. The main points of his presentation are summarized below:

- The three most common techniques of underground utility installation are directional drilling, jacking and boring, and open cutting.
- Directional drilling does not require a bore pit, is relatively quick for a trenchless installation, is environmentally responsible, and can be directed along a general path. The disadvantages include the difficulty of maintaining a specific grade (needed for sewer lines), and it is ineffective in loose, cohesionless soils.
- Jack and bore techniques can be used to install large and small diameter conduits, grade control can be maintained with tolerances that are acceptable for gravity sewers, and voids can be sealed on the outside of the carrier pipe. Some disadvantages include large construction area for the jacking and receiving pits, and unsuitable material can render the process ineffective mid-project.
- Cut and cover techniques are generally preferred where possible because of the cost and time savings. However, large areas are impacted, and the excavation could affect dam integrity.
- Some of the aspects of construction that are overlooked during design include right-of way issues, space needed for equipment, and tolerances on control specified as compared to what is possible.

Following the presentations by the different groups involved in installing a utility through a dam (e.g., owners, designers, and contractors), presentations were made regarding dam safety and the lessons learned from past failures. Jim Talbot, P.E., presented case histories of failure due to penetrations. A copy of his presentation is included in Appendix D. His presentation is summarized below.

- Most seepage failures in dams occur around conduits.
- Anti-seepage collars seem to have performed poorly.
- A stormwater retention dam at the Raleigh, North Carolina airport failed three times following the replacement of an outlet conduit due to lack of knowledge regarding dam design. The failure involved dispersive clays and steep trench excavations. After the third failure, a filter diaphragm was installed and gently sloping excavation sides were used. The dam is performing well to date.
- Failure at a dam in Wyoming occurred around a corrugated metal pipe (CMP) conduit. The CMP deteriorated and anti-seep collars did not mitigate piping failure. Eventually a large section of the embankment failed and caused millions of dollars of damage downstream.
- Filter diaphragms perform much better than anti-seep collars at mitigating against piping failures.

Mr. Danny McCook, a geotechnical engineer with the NRCS National Soil Mechanics Center, presented case histories of NRCS dams failing around conduit penetrations. Main points are summarized below:

- James Sherard studied piping and internal erosion failures in clay dams in Oklahoma and Mississippi. He studied 11 dams, each failed near conduit penetrations. Sherard indicated that dispersive clays were predominant in each of the failures.
- Mr. McCook reviewed nine case histories in detail.
- Ten of the 11 dams failed on first filling. The failures began with an initial leak that gradually eroded a tunnel. In some cases, when the tunnel became large enough, the roof collapsed forming a full breach.
- Steep excavation side slopes and having to compact under pipe haunches exacerbates failure potential near conduit installations.

Mr. Jim Talbot then presented some of the common mechanisms that cause failure and discussed filter diaphragms. His presentation included a discussion of stresses that lead to hydraulic fracturing. He also reviewed how these stresses can be induced by wetting and by differential settlement. Mr. Talbot discussed compaction issues relating to dam failure, specifically compacting under the haunches of a pipe or along the excavation side walls. He discussed trenchless technologies and the potential for induced stresses during jacking operations, as well as voids remaining from directional drilling operations.

Near the end of day one, an open forum discussion allowed the participants to ask questions to the group or specific people in the group, or to provide comments and feedback. The major discussion points are summarized below:

- The requirement for the diaphragm to be three or more times the penetration diameter (as called for in the NRCS filter diaphragm design release) is based on engineering judgment, it is not a derived parameter in filter diaphragm design.

- Filter material should be specifically designed based on sieve testing of the soils that will be in contact with the filter. ASTM C-33 sand is often acceptable, but calculations should be performed to evaluate the appropriate filter gradation.

- Field and laboratory testing has shown that filters are effective in mitigating against internal erosion and piping failures. Vineyard FRS, a District dam, on which a full-scale internal erosion test was performed, displayed that with or without a filter, the cracks swelled closed and internal erosion was not observed.

- Filters can be ineffective if cracks are larger than what the filter is designed to accommodate; however, the cracks would generally have to be quite large (more than 1/2 inch).

- Breaching the dam to install a utility may be the least favorable alternative. The concept of building-up an earthen section to cross over the dam was presented and generally accepted as a preferred alternative to a penetration. However, this type of crossing may not be feasible for some types of utilities. Depth requirements vary for different utilities. For many utilities, 18 inches is the minimum cover required by existing laws.

- Careful geotechnical evaluations should be performed and should rely as much as feasible on existing data so as to not have to perform extensive sampling (i.e., disturbance) to the dam.

- Dams and levees are similar, but cannot be treated as the same structure type from an engineering or regulatory standpoint.

- Following the presentation and discussion of deep directional drilling, workshop participants considered it to be a more viable alternative than prior to the workshop.

4. SUMMARY OF THE MODIFIED FAILURE MODES AND EFFECTS ANALYSIS

Following the conference on the first day, a selected group of dam safety professionals convened on June 2, 2005 at the District offices to analyze potential failure modes of likely penetration scenarios. The group utilized a modified FMEA format to analyze the failure modes rather than a traditional FMEA format. An FMEA is a qualitative risk-based procedure that can be usefully applied to any engineered system, especially those with complex components. The FMEA process relies on the collective engineering judgment of experienced and diverse professionals in a workshop setting to describe potential failure modes, the likelihood of that potential failure mode, and the potential consequences resulting from failure. The purpose of the modified FMEA was to evaluate whether utility penetrations could be performed while maintaining an appropriate level of dam safety and, if so, which likely penetration scenarios should be considered appropriate, and which should be considered inappropriate. A corollary purpose was for the team to provide recommendations of technologies that may be used to mitigate noted failure modes. This section summarizes and reports on the FMEA proceedings, specifically: the participants, the modifications to a traditional failure mode analysis (including the reasons for the modifications), the scenarios and failure modes analyzed, the considerations for each scenario, and the recommendations resulting from the considerations.

4.1. Participants

Selected persons with specific knowledge of dam safety engineering and analysis were invited to participate in the FMEA. Of those invited, Table 3 lists those who participated.

Table 3 – FMEA TEAM

Name	Organization	Name	Organization
Jon Benoist, P.E.	ADWR	Shilpa Vepakomma	Ninyo & Moore
Jim Talbot, P.E.	Consultant	Steve Nowaczyk, P.E.	Ninyo & Moore
Bill Leal	District	Tom MacDougall	Ninyo & Moore
Brett Howey, P.E.	District	Danny McCook	NRCS
Dan Lawrence, P.E.	District	Ilde Chavez, P.E.	NRCS
Mike Ramirez	District	Jim McHenry, P.E.	NRCS
Steve Rubin	District	John Chua, P.E.	NRCS
Tom Renckly, P.E.	District	John Harrington, P.E.	NRCS
Dave Jensen, P.E.	Kimley Horn	Chuck Cooper	USBR
Analu Villalvaso	Ninyo & Moore		

4.2. Modified Format

The District throughout its Phase I Individual Structures Assessment program has used a FMEA process to evaluate its existing dam inventory. The evaluation includes the collection and review of technical information relating to the dam construction, operation, maintenance, monitoring, performance, etc; an inspection of the dam by the FMEA team; and a systematic evaluation of potential failure modes. The evaluation includes classifying specific data or circumstances as "likely to promote failure" or "unlikely to promote failure", analyzing the resulting lists, and qualitatively categorizing the potential failure mode based on the analysis. The categories assigned to the potential failure modes are presented in Table 4.

Table 4 – Categories of a FMEA

Category	Description
I	Highlighted – these failure modes have the greatest significance, considering: need for awareness, potential, and consequences.
II	Considered but not Highlighted – These failure modes are less significant than category I; but still were fully developed to weigh factors making the failure mode more or less likely.
III	More Information or Analysis Needed – This failure mode requires additional information and/or analysis to allow classification.
IV	Ruled Out – There is no physical possibility that this failure mode could occur, the concern is eliminated by considered information, and/or the possibility that the failure mode could occur is so remote as to be non-credible.

In some cases where specific modifications are proposed to an existing dam, an FMEA has been used to evaluate the likelihood of failure if the modification is made. For this application, the analysis process is generally the same: listing the known data, classifying relevant data as promoting dam failure or hindering it, and categorizing the potential for failure (according to Table 4) due to the proposed modification.

While preparing for the failure modes analysis, it became apparent to Ninyo & Moore and the District that the traditional Phase I FMEA approach would not be well suited for this project. It was anticipated that the analysis would include too many unknowns and variables (i.e., lacked specifics) to utilize the traditional FMEA format. Whereas a Phase I FMEA analyzes "knowns" and data, potentials and variables needed to be analyzed in this case. As a result, Ninyo & Moore, Mr. Talbot, and the District developed a modified FMEA format to accommodate the needs of this project.

The FMEA format was modified to address the need to shift from "knowns" to variables and from specific data to hundreds of possible combinations. The general variables that could make up a given scenario to be analyzed included:

- Type of utility (e.g., electric, fiber optic, non-pressurized liquid, pressurized liquid, pressurized gas, etc.);
- Conduit material (e.g., steel, concrete, plastic, etc.);
- Location of the penetration (e.g., overbuild/ residual freeboard, abutment, emergency spillway, flood freeboard, foundation, embankment, etc.);
- Installation technique (cut and cover, directional drill, jack and bore, pipe ramming, etc.);
- Size (large diameter, small diameter, etc); and
- Backfill material (slurry, soil, formed concrete, etc.)

By combining variables in different ways, scenarios were created. Each scenario could be specific enough to analyze qualitatively in a manner similar to the Phase I FMEA process. However, the number of potential combinations was large with many combinations of an

unlikely nature. The FMEA team therefore reduced the number of potential scenarios to analyze by:

- Deciding to address only the most likely scenarios - For example, it is unlikely that an entity would want to install an electric utility in a large diameter concrete conduit through the foundation using cut-and cover techniques.

- Simplifying the number of variables by eliminating size, backfill type or other potential variables groups - The variable groups were limited to the product, the conduit material, the location, and the installation technique. Figure 10 shows the variable groups and the variables within each group.

- Preliminarily ranking the variables within each group -Prior to the FMEA analysis, the variables were ranked within each variable group from lowest potential for failure to highest potential for failure. By doing this, if a combination of lower risk variables was analyzed and it was categorized as a penetration with too high a hazard to allow, then a scenario composed of higher risk variables would not be analyzed. It would be assumed that because the components were considered relatively more hazardous individually, the composite scenario would also be a higher risk. Figure 10 shows how the FMEA team ranked variables within each group in order of increasing potential for failure.

Two other modifications were made to the FMEA process: the category definitions were revised to better align with our purpose, and included a mitigation column in which to list recommended technologies that could be applied to reduce the risk of a penetration-related failure. The revised definitions are provided in Table 5. Figure 11 depicts a flowchart of the modified FMEA process. The mitigation columns are displayed in the analysis summaries in Section 4.4.

Table 5 – Categories for Revised FMEA

Category	Description
A	FMEA team recommends prohibiting this type of utility penetration because current dam technology does not adequately mitigate potential for dam failure or because generally there should be a lower impact alternative.
B	FMEA team recommends that this type of utility penetration be carefully evaluated on a case-specific basis (possibly using an FMEA) because although current dam technology can often adequately mitigate the potential for dam failure, the mitigation is generally more complex or uncertain.
C	FMEA team recommends that this type of utility crossing generally be allowed because current dam technology adequately mitigates the potential for dam failure. A more streamlined safety review may be used during permit approval.
D	Additional information is needed by the FMEA team to adequately categorize this type of utility penetration.

4.3. Scenarios and Failure Modes

As described in Section 4.2, generalized scenarios were developed for analysis. The scenarios that were analyzed by the FMEA team included those shown in Table 6.

Table 6 – Utility Penetrations Scenarios Analyzed

Scenario	Description
1	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Overbuild or Residual Freeboard
2	A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erosion Resistant) Emergency Spill
3	A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erodible) Emergency Spillway
4	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Abutment (Assuming the Abutment is Erosion Resistant and the Penetration is Above the Pool Elevation)
5	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard
6	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Foundation
7	A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Foundation
8	A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and

Table 6 – Utility Penetrations Scenarios Analyzed

Scenario	Description
	Bore Techniques through the Foundation
9	A Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard
10	A Pressurized Liquid Carried in a Steel Conduit Installed Using Directional Drilling Techniques through the Foundation
11	A Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation
12	A Pressurized Gas Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard
13	A Pressurized Gas Carried in a Steel Conduit Installed using Directional Drilling Techniques through the Foundation.

Three potential failure modes were considered for each scenario: failure of the dam from internal erosion near the penetration, failure of the dam due to pipe rupture, or failure of the dam due to a case-specific issue. To simplify the analysis of the failure consequences, the FMEA team concurred that any failure of a utility penetration could be considered high consequence. It was also assumed that all components of the utility and its installation would be done with commonly accepted engineering and construction techniques (i.e. pipe design, soil compaction, concrete strength, etc.). Table 7 summarizes the three potential failure modes developed for the scenarios listed above.

Table 7 – Potential Failure Modes Analyzed

Failure Mode	Description
1	Internal Erosion near the Utility Penetration
2	Pipe Rupture leads to Dam Failure (internal erosion or sudden breach)
3	Case specific

4.3.1. Failure Mode Descriptions

Internal Erosion near the Utility Penetration Failure Mode

Internal erosion is defined herein as seepage through a crack or opening which has sufficient force to transport (erode) soil particles. The erosion can continue to create a

larger opening and thus create a preferential seepage path. Internal erosion can lead to a cycle of increased erosion leading to increased seepage and, in turn, increased erosion. This cycle eventually may cause a dam to fail. The risk of internal erosion through the embankment could be influenced by various factors (e.g., un-compacted zones near a penetration, embankment disturbance due to disturbant trenchless installation techniques, dispersive soils, etc.).

Pipe Rupture Failure Mode

Pipe rupture occurs when the conduit material has stresses or strains that exceed the pipe material's strength or deformation limits. Rupture could be caused by internal forces, external forces, pipe deterioration, or a combination of the three. In a non-pressurized conduit rupture, there is a potential for loss of embankment soils into the open conduit. A non-pressurized rupture may be difficult to detect until dam failure is imminent. If the location of the rupture is relatively near the upstream face of the dam, pore water pressures at the rupture location may be high during an impoundment event, thus exacerbating the issue. In the case of a rupture of conduit carrying pressurized liquid or gas, the embankment soils could be eroded; the added pore pressures could cause embankment cracking, and lead to a dam breach upon reservoir filling. It is more likely that a pressurized conduit rupture would be detected shortly after occurring and thereby be repaired prior to a storm event. The FMEA team considered the possibility of an impoundment event and embankment saturation leading to pipe rupture. This could occur by the wetting causing volume change (primarily collapse) in the embankment or foundation soils, and the resulting soils movement overstraining the conduit. During the analysis of the various scenarios, these failure modes were considered when applicable.

Case Specific Failure Modes

During the analysis of each scenario, the FMEA team considered the possibility of case specific failure modes. For example, during the analysis of a penetration through the emergency spillway, the case specific failure mode of rapid surface erosion was consid-

ered. The team made an effort in each scenario to consider, generally, if a case specific failure mode should be addressed.

4.4. Summary of Analysis

As described in Section 4.2, the analysis consisted of classifying the givens for each scenario as "likely causes failure" or "unlikely causes failure" and applying mitigation technologies to the scenario to reduce the potential for dam failure caused by the penetration. The tables presented in this section summarize the considerations and analysis by the FMEA team. Mitigations are suggested as part of the analysis, and a category is assigned. The assigned category includes the general recommendations of the FMEA team; however, in some instances, additional recommendations are offered. A brief discussion and the resulting recommendations are included for each scenario that was considered.

4.4.1. Scenario 1: A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Overbuild or Residual Freeboard

The FMEA team analyzed the general scenario of a dry utility (e.g., electric, fiber optic, telephone, etc.) that is encased in a plastic conduit, penetrating the dam through the overbuild or residual freeboard using cut and cover installation techniques. Both failure Modes 1 and 2 were considered for this scenario. The team defined the overbuild and residual freeboard as the portions of the embankment that are at a higher elevation than the maximum inflow design flood (IDF) water surface elevation during full emergency spillway flows (see Figure 3).

Typical factors identified that would likely promote a failure included: the potential that on some of the District dams, the residual freeboard elevation is unclear or requires updating by an analysis; the assumed residual freeboard may not exist if regional subsidence has occurred or is occurring in the area of the dam; a plastic conduit may deform differently than the surrounding soils (if subsidence or settlement occurs) resulting in a void being created around the conduit; and it can be difficult to compact around the pipe resulting in potential for voids near the pipe. It should be noted that in areas of re-

gional and/or local subsidence, the utility elevation could change over time with respect to other elevations of key dam safety components. One result could be for Scenario 1 to become a Scenario 5. When considering the pipe rupture failure mode, if the conduit is too shallow, loads from an overlying roadway could overstress and rupture the conduit.

Typical factors identified that would make a dam failure (by either failure mode) less likely were: the surcharge duration above the emergency spillway crest elevation is generally hours and rarely exceeds days; a penetration through the overbuild or residual freeboard would be less prone to saturation; any head that develops would likely be very low; and a storm event large enough to raise the impounded water surface elevation to the residual freeboard is very infrequent.

The mitigation technologies recommended by the FMEA team for this scenario included backfilling the excavation with a cement slurry, trench excavations should be 5 feet wide (or more) at the bottom; have 3 (horizontal) to 1 (vertical) or flatter side slopes; have an updated hydrologic and hydraulic analysis using current data and analysis methods, site specific items should be considered in the design; and depending on the proposed design and circumstances, a design-specific FMEA should be considered to evaluate the proposed penetration.

Based on the analysis, the team assigned this scenario a Category C. The FMEA team concluded that these types of penetrations could generally be allowed if the recommended mitigation techniques are included in the design and site specific circumstance allow. Furthermore, for this type of scenario, a streamlined review and approval process could be used. Table 8 summarizes the analysis and recommendations for Scenario 1.

Table 8 – Scenario No. 1 – A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Overbuild or Residual Freeboard

FM - Internal Seepage Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Freeboard accuracy problem may exist • May be in area of regional subsidence • Flexible pipe may deform and create voids • Difficult to compact around pipe • Potential for live loads (road)	• Impoundment time is very short • Very low head • Very rare storm event	• Slurry backfill for excavation in dam • Excavation has five foot bottom and 3:1 slopes • Update Hydrology • Site specific items should be considered • FMEA and alternative analysis may be necessary
Category: C		

4.4.2. Scenario 2: A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erosion Resistant) Emergency Spillway

Analysis was performed considering a scenario where a dry utility encased in a plastic conduit would be installed using cut and cover techniques through an emergency spillway that is resistant to erosion. An erosion resistant spillway was generally understood by the FMEA team to consist of cemented soils or rock that would resist erosion even with high-velocity flows. The case-specific failure mode that was addressed was rapid erosion of the emergency spillway.

The considerations that were classified as promoting failure included: plastic pipe is flexible and may deform in a manner that would leave voids around the pipe, it can be difficult to compact around the pipe, and a granular backfill around the penetration would likely increase the potential for seepage along the conduit.

The factors that were classified as resisting failure included: the impoundment duration is generally relatively short and the emergency spillway flows would be a very short duration; with a penetration through the emergency spillway, any head that develops would likely be very low, the emergency spillway soils (or rock) were defined as ero-

sion resistant, and the configuration of an emergency spillway would generally not promote erosion (i.e., broad, low velocity flows).

The mitigation techniques recommended to be included with this type of penetration are: backfill the excavation with a cement slurry or concrete, use vertical side walls in the excavation (rather than disturb larger sections of intact, erosion resistant material, it was considered better to use vertical trench walls and a flowable concrete for backfill), test the erodibility of the emergency spillway material, place the penetration away from the embankment, and consider the site specific issues, possibly by conducting an FMEA.

Based on the analysis described above, the FMEA team assigned a Category C to this scenario. The FMEA team concluded that these types of penetrations could generally be allowed if the recommended mitigation techniques are included in the design and site specific circumstance allow. Furthermore, for this type of scenario, a streamlined review and approval process could be used. Table 9 summarizes the analysis and recommendations.

Table 9 – Scenario 2 –Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erosion Resistant) Emergency Spillway

FM - Rapid Loss of Reservoir Through Emergency Spillway Erosion		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Flexible pipe may deform and create voids • Difficult to compact around pipe • Potential for seepage along penetration	• Impoundment time is short • Low head • Rare storm event • Material is resistant to erosion • Spillway configuration ideal for preventing breaching by erosion	• Backfill with concrete • Excavation should have vertical sides • Verify erodibility nature of spillway material • Place penetration away from dam • Site specific items considered • FMEA and alternative analysis if necessary
Category: C		

4.4.3. Scenario 3: A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erodible) Emergency Spillway

Scenario 3 is similar to Scenario 2, except that the emergency spillway materials are not resistant to erosion. The District operates and maintains several dams that have earthen emergency spillways that could potentially erode rapidly during flows.

Typical considerations that were classified as promoting failure included: the emergency spillway soils were defined as erodible, installing a utility could either create a preferential seepage path (if granular backfill were used) or distinct material boundary (between erodible and non-erodible materials - this may lead to a concentrated flow point and increase erosion), plastic pipe is flexible and may deform in a manner that would leave voids around the pipe, it can be difficult to compact around the pipe, and a granular backfill around the penetration would likely increase the potential for seepage along the conduit.

Typical factors noted in this scenario that were classified as resisting failure included: the impoundment duration is generally relatively short and the emergency spillway flows would be a very short duration; with a penetration through the emergency spillway, any head that develops would likely be very low, and the configuration of an emergency spillway would generally not promote erosion (i.e., broad, low velocity flows).

The mitigation techniques recommended for this type of penetration are: backfill the excavation with a cement slurry or concrete, trench side-slopes should have a 3 (H) to 1 (V) ratio, test the erodibility of the emergency spillway material, place the penetration outside the spillway, and consider the site specific issues possibly using an FEMA. Based on the analysis described above, the team assigned a Category A (do not allow this type of penetration) to this scenario. Exceptions to this may be considered at either Powerline FRS or Vineyard FRS, due to the nature of their abutments and emergency spillways. In those cases, the team recommended a Category D (needs more information). Table 10 summarizes the analysis and recommendations.

Table 10 – Scenario 3 – A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erodible) Emergency Spillway

FM- Rapid Loss of Reservoir Through Emergency Spillway Erosion		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Potential for seepage along penetration • May be highly erodible material in spillway • Flexible pipe may deform and create voids • Difficult to compact around pipe • May create weak path through spillway	• Flow in spillway time is short • Low head • Rare storm event • Spillway configuration ideal for preventing breaching by erosion	• Encase conduit in concrete • Excavation has 3:1 side slopes • Verify erodibility of spillway material • Locate penetration outside the spillway • Site specific items considered • FMEA and alternative analysis if necessary
Category: A		

4.4.4. Scenario 4: A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Abutment (Assuming the Abutment is Erosion Resistant and the Penetration is Above the Maximum IDF Pool Elevation)

The FMEA team evaluated the case of a dry utility encased in a plastic conduit installed using cut and cover techniques in the abutment. The FMEA team assumed that the abutment was erosion resistant and that the penetration would be above the maximum IDF pool elevation. The analysis was considered to be very similar to Scenario 2 (therefore the discussion will not be repeated here - see Section 4.4.2). The team assigned a Category C to this scenario and specifically pointed out that the trench backfill should consist of a concrete slurry. Table 11 summarizes the considerations and recommendation.

Table 11 – Scenario 4 – A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Abutment (Assuming the Abutment is Erosion Resistant and the Penetration is Above the Maximum IDF Pool Elevation)

FM - Rapid Loss of Reservoir Through Abutment Erosion		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Flexible pipe may deform and create voids • Difficult to compact around pipe • Potential for seepage along penetration	• Impoundment time is short • Low head • Rare storm event • Material is resistant to erosion • Spillway configuration ideal for preventing breaching by erosion	• Backfill with concrete • Excavation should have vertical sides • Verify erodibility nature of abutment • Place penetration away from dam • Site specific items considered • FMEA and alternative analysis if necessary
Category: C		

4.4.5. Scenario 5: A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

The team evaluated the scenario of a dry utility in a plastic conduit installed within the flood freeboard using cut and cover techniques. The team defined the flood freeboard as the vertical section of the dam between the emergency spillway elevation (bottom) and the maximum IDF water surface elevation (top). It was noted that this scenario is common under roadway crossings and may be one of the more requested utility penetrations. Failure Modes 1 and 2 were considered for this scenario.

The factors identified by the FMEA team that were considered negative, or likely to promote failure, were: the potential for seepage along the conduit, the penetration increases the potential for hydraulic fracture, the plastic conduit is very flexible and may deform resulting in the creation of voids, and compaction around conduit can be difficult - thus increasing the potential for seepage through loose soils along the conduit. In the case where pavement overlies the utility penetration, the pavement may obscure indications of potential issues.

The factors identified as positive, or resisting failure included: the short duration of impoundments, it is rare to have a storm event large enough to raise water elevations to the emergency spillway level, and the excavation used to install the penetration is relatively shallow. Also, in the case where a pavement overlies the utility installation, issues (e.g., settlement of backfill) may be observed in pavement cracks.

The FMEA team recommended that the following mitigative measures be included for this scenario: include a filter diaphragm or extend the chimney drain, backfill with concrete to the residual freeboard and then with soil above that, extend the trench no deeper than 4 feet below the adjacent ground surface, and consider site specific issues possibly utilizing an FMEA to do so during design. The FMEA team assigned a Category C to this scenario. Table 12 displays a summary of the considerations and recommendations for this scenario.

Table 12 – Scenario 5 – A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

FM - Internal Seepage Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Potential for seepage along penetration • Potential for hydraulic fracturing • Flexible pipe may deform and create voids • Difficult to compact around pipe • If pavement overlies installation, may obscure distress	• Impoundment time is short • Rare storm event • Shallow excavation • If pavement overlies installation, cracking may reveal issues	• Filter diaphragm or extend chimney drain • Concrete backfill to residual freeboard • 4 foot maximum trench depth • Site specific items considered (FMEA and alternative analysis) including all identified FM from previous analyses
Category: C		

4.4.6. Scenario 6: A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Foundation

The possibility of dry (electric, fiber optic, telephone, cable, etc) utilities installed in a plastic conduit through the foundation using cut and cover installation methods was

considered. Rather than systematically addressing all factors associated with this scenario, it was noted that dry utilities do not have a reason to maintain grade lines (as do gravity flow utilities). Therefore the FMEA team assigned a Category A to this scenario because other viable alternatives are available.

4.4.7. Scenario 7: A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Foundation

For Scenario 7, Failure Modes 1 and 2 were considered. The scenario was developed to address the potential for gravity sewers (single pipe) to penetrate through the dam. Various factors were identified that were considered negative, or likely to cause failure. The potential for seepage along the conduit would increase the likelihood of internal erosion. The potential for differential settlement due to the backfilling could cause cracking or increase the potential for hydraulic fracturing upon saturation. If foundation soils are subject to volume change, the steel would likely deform differently than the surrounding soil and therefore voids around the pipe may form. The potential for internal erosion due to concentrated seepage would likely increase near a utility penetration because compaction can be difficult around a conduit. The cut and cover method would require that large portions of the dam be disturbed to install the utility conduit. This large disturbance would result in temporarily loosing flood protection during construction and leave a zone where old fill and new fill are in contact. These contacts have been locations of past dam failures due to poor compaction and tie in. The operation and maintenance of a utility buried through the foundation could be very difficult due to the conduit's inaccessibility once installed. The steel pipe would be susceptible to soil corrosion and, if ruptured, soil could erode into the conduit. This rupture could be difficult to detect in some cases until a storm event and dam failure was imminent.

Three considerations were classified as positive, or resisting failure. The seepage path along conduit would be relatively long. Given the short impoundment durations, the distance water would have to seep to exit the dam is long and seepage pressures may not remain long enough to cause an internal erosion failure. The second positive factor was

that, by using the cut and cover method to install the utility, careful and conventional earthwork observation and testing could be performed. Thirdly, a steel pipe would be generally resistant to the deflections associated with foundation settlement or collapse. It is likely that the pipe would not rupture.

The FMEA team recommended that the following mitigative measures be applied to the designs related to this scenario: a filter diaphragm should be used, the conduit should be encased in a slurry backfill, a cofferdam should be used in construction, the excavation side slopes should be 3(H):1(V) or flatter, and site specific considerations should be considered in a formal FMEA and alternative alignment analysis. Based on these factors the team assigned a Category B to this scenario.Table 13 summarizes the factors, considered, the mitigations recommended, and the assigned category.

An additional consideration for this type of utility penetration is that it may be installed during a dam rehabilitation or reconstrcution. If this were the case, then a carfully designed and constructed penetration could be performed in conjunction with the planned rehabilitation or reconstruction. A Category B would still apply to this scenario, but may have advantages over an uncoordinated penetration and more liklihood of being approved by District, State, and Federal regulators.

Table 13 – Scenario 7 – A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Foundation		
FM - Internal Erosion Near Penetration **FM - Pipe Rupture**		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Potential for seepage along penetration • Potential for hydraulic fracturing • Flexible pipe may deform and create voids • Difficult to compact around pipe • Disturbs large section of the dam • Contact between new and old dam • Loss of flood protection • Difficult operations and maintenance • Corrosion potential • Potential for piping into pipe • Saturation of dam and foundation around penetration (possible settlement and loss of strength)	• Long seepage path • Conventional construction and inspection • Steel pipe can withstand more deflection than rigid material	• Filter diaphragm • Positive water-tight joints • Concrete encasement • Site specific items considered (FMEA and alternative analysis if necessary) including all identified FM from previous analyses • Alternative consideration necessary • Cofferdam • Cut slopes 3:1 or flatter. • Concrete encasement through dam and upstream or other flotation mitigation • Provide shut-off measures
Category: B		

4.4.8. Scenario 8: A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation

The FMEA team analyzed the scenario of a non-pressurized liquid transmitted through a steel conduit that runs through the foundation and was installed using jack and bore techniques. Although the installation technique of directional drilling was considered less likely to cause failure, it was the understanding of the FMEA team that directional drilling did not provide adequate grade control for a gravity sewer. Although pipe rupture may be less likely due to the double encasement inherent in jack and bore installations, Failure Modes 1 and 2 were considered for this scenario.

During the analysis, the FMEA team identified factors that were considered likely to cause failure. Jacking and boring is unfeasible through certain soil or material deposits

(e.g., sand, gravel, and cobble "SGC" deposits, etc.). Therefore, a relatively comprehensive geotechnical study should be performed prior to any jack and bore operations. When crossing under a dam, however, an extensive geotechnical study would be difficult to accomplish without disturbing the dam embankment. It is possible that the installation technique would have to change mid-construction, resulting in the dam being in an unsafe state for a prolonged period. Alignment control can also be difficult when using jacking and boring to install a conduit. There is a significant potential to induce stresses in the soil adjacent to the conduit when using jack and bore methods. The stresses may lead to fracturing or an increased potential for hydraulic fracturing upon wetting. Grouting around the conduit may not fully penetrate the voids resulting from the installation. Conversely, the grouting pressures may exceed the overburden pressures and result in foundation and/or embankment cracking. Unlike a cut and cover installation, verification that voids are filled may not be possible. Another negative factor is the potential for the conduit to float in the upstream impoundment pool during a storm event. This could rupture the pipe and release the reservoir into the conduit. There is a potential that the pipe could rupture due to foundation settlement or collapse. It would be difficult to maintain or repair the conduit once installed and corrosion may compromise the integrity of the steel.

Given in the scenario, four factors were identified that would likely resist dam failure caused by internal erosion or pipe rupture. Disturbance to the embankment is avoided or limited (as compared with cut-and-cover techniques). Seepage along the conduit would have to travel a relatively far distance to exit the dam and, with the short impoundment duration, it is unlikely that a failure would occur from seepage. Steel conduit is both strong and ductile. It would likely resist pipe rupture caused by the relatively small movements associated with foundation settlement or collapse.

With these considerations, the FMEA team recommended that shut-off valves be installed on the upstream and downstream sides of the dam, and that site specific considerations be addressed in an FMEA performed specifically on a proposed design of this type. This scenario should be generally be avoided when at all feasible and an al-

ternative alignment analysis should be performed to evaluate whether either pressurizing the flow to go over the dam or microtunneling with a tunnel boring machine to go through the foundation is feasible. Given these considerations, the FMEA team assigned a Category B to this scenario. Table 14 summarizes the considerations and recommendations.

Table 14 – Scenario 8 – A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation

FM - Internal Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• May encounter material that prevents completion • Investigation limited • Filter diaphragm may not prevent failure because of embankment cracking • May not fully grout void space around pipe (no verification) • Potential for significant disturbance immediately around pipe • Alignment control difficult • Pipe may float upstream of dam during flood; possible pipe break • Possible corrosion • Potential for hydraulic fracturing • Saturation of dam and foundation around penetration (possible settlement and loss of strength) • Difficult operations and maintenance • Potential for seepage along penetration	• Limited disturbance area • Long seepage path • Steel pipe can withstand more deflection than rigid material • Impoundment time short	• Provide shut-off measures • Site specific items considered (FMEA and alternative analysis if necessary) including all identified FM from previous analyses • Must do FMEA and alternative analysis lift station + (microtunnelling with TBM) and realign
Category: B		

4.4.9. Scenario 9: A Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

The FMEA team evaluated the scenario of a pressurized liquid being carried in a steel conduit through the flood freeboard, with the conduit being installed using cut and cover techniques. The team identified that the considerations would be very similar to Scenario 5 (except that the pipe deformation did not need to be considered) when considering dam failure caused by internal erosion near the penetration. However, when considering a waterline rupture, the risk of embankment erosion caused the FMEA team to recommend that a carrier pipe with a grouted annulus be used for this scenario and categorized the scenario as a Category B. Table 15 presents a summary of the pertinent information for Scenario 9.

Table 15 – Scenario 9 – A Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

FM - Internal Seepage Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Potential for seepage along penetration • Potential for hydraulic fracturing • Difficult to compact around pipe	• Impoundment time is short • Rare storm event • Shallow excavation	• Provide carrier pipe for pressure pipe with grout in annular space • Filter diaphragm or extend chimney drain • Concrete backfill to residual freeboard soil above structural backfill • 4 foot maximum trench depth • Site specific items considered (FMEA and alternative analysis) including identified FM from previous analyses
Category: B		

4.4.10. Scenario 10: A Pressurized Liquid Carried in a Steel Conduit Installed Using Directional Drilling Techniques through the Foundation

A pressurized liquid carried in a steel pipe that was installed using directional drilling techniques through the foundation was the tenth scenario analyzed. Again, due to the conduit being installed in a carrier pipe, only internal erosion near or above the conduit was considered to be a viable failure mode. The factors identified as negative included the following:

- Similar to the difficulties with using jack and bore techniques, directional drilling may encounter material that causes the drilled hole to be abandoned mid-construction. The difficulties in obtaining appropriate geotechnical information also apply to this scenario.
- There is a potential for hydraulic fracturing of the overlying embankment.
- It can be very difficult to observe that the void space surrounding the drilling has been filled with grout.
- There is a potential to significantly disturb the soils surrounding the carrier pipe.
- The carrier pipe may corrode both internally and externally.

Many factors were considered unlikely to cause failure. The employment of experienced and qualified contractors and engineers in the area would tend to reduce the likelihood for design or construction error. The seepage path along the conduit from upstream to downstream is relatively long. Directional drilling methods would not disturb large portions of the embankment or surrounding areas. The depth of the conduit and distance of the "daylight" points could be deep and far. There is generally a short impoundment duration. Also, the penetration “daylight” point may be able to avoid the impoundment pool altogether.

The mitigation measures that the FMEA team recommends to be included are: seal the "daylight" points to provide a cut-off, use prudent drilling practices according to the Horizontal Directional Drilling (HDD) Consortium, provide shut-off valves on both the upstream and downstream sides of the dam, follow the USACE guidelines on HDD penetrations, and consider site specific issues using an FMEA and alternatives analysis.

The team assigned a category B to this scenario and Table 16 summarizes the pertinent information.

Table 16 – Scenario 10 – A Pressurized Liquid Carried in a Steel Conduit Installed Using Directional Drilling Techniques Through the Foundation

FM - Internal Erosion Near Penetration		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• May encounter material that prevents completion • Investigation limited • May not fully grout void space around pipe (no verification) • Potential for significant disturbance immediately around pipe (less than Jack and Bore) • Potential for seepage along penetration • Hydro-fracturing during drilling is possible • Possible corrosion	• Experienced contractors and engineers available • Long seepage path • Limited disturbance area • Depth and distance from dam • Impoundment time short • Steel pipe can withstand more deflection than rigid material • May be able to move entrance upstream of reservoir	• Provide shut-off measures • Seal entrance to provide cutoff • Prudent drilling practice according to HDD consortium • Follow Corps of Engineers guidelines • Must do FMEA and alternative analysis (i.e. microtunnel with TBM, pressure line over the dam and realign) • Site specific items considered (FMEA and alternative analyses including all identified FM from previous alternative analyses)
Category: B		

4.4.11. Scenario 11: A Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation

Many of the considerations for this scenario relating to utility type, location of installation, and conduit material are similar to Scenario 10, except that the installation technique utilized jack and bore techniques rather than direction drilling. The FMEA team did not systematically reconsider each factor, but upon a review decided to categorize Scenario 11 as a Category A. This is because a viable alternative that was considered less likely to cause failure had been considered and not prohibited (either Scenario 8 or 10).

4.4.12. Scenario 12: A Pressurized Gas Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

The scenario of a steel, pressurized natural gas line installed through the flood freeboard was considered as Scenario 12. The FMEA team discussed that the considerations for dam failure due to internal erosion were similar to Scenario 5. However, when considering pipe rupture as a failure mode, the FMEA team was unable to resolve important questions. These included:

- How much deflection can the standard steel conduit tolerate over a short distance without rupturing? This was noted as a specific concern due to the potential for foundation and embankment settlements.
- What is the likelihood of an explosion being associated with a pipe rupture?
- How long would a rupture likely leak before being detected and before being able to be shut off?
- Will encasement add any protection against rupture, or will it exacerbate stiffness and increase the potential for rupture?

Although the initial category assigned to Scenario 12 by the FMEA team was a Category D, based on information from Southwest Gas that explosions on a gas line rupture would require an ignition source and therefore are very rare, Ninyo & Moore recommends that this scenario be re-categorized to a B. The right-of-way permit applicant should specifically address the questions noted above early in the permitting process. Table 17 summarizes the considerations for this scenario.

Table 17 – Scenario 12 – A Pressurized Gas Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard

FM - Internal Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• Potential for seepage along penetration • Potential for hydraulic fracturing • Flexible pipe may deform and create voids • Difficult to compact around pipe	• Impoundment time is short • Rare storm event • Shallow excavation	• Filter diaphragm or extend chimney drain • Concrete backfill to residual freeboard soil above structural backfill • 4 foot maximum trench depth • Site specific items considered (FMEA and alternative analysis) including all identified FM from previous analyses
Category: B - Applicant should address the following questions: • How much deflection can the standard steel conduit tolerate over a short distance without rupturing? • What is the likelihood of an explosion being associated with a pipe rupture? • How long would a rupture likely leak before being detected and before being able to be shut off? • Will encasement add any protection against rupture, or will it exacerbate stiffness and increase the potential for rupture?		

4.4.13. Scenario 13: A Pressurized Gas Carried in a Steel Conduit Installed Using Directional Drilling Techniques through the Foundation

Following the workshop, and during the preparation of this report, the District requested that an additional scenario be addressed. Due to the logistics of re-convening the workshop participants, selected members of the workshop were consulted through telephone and email communications to address Scenario 13. Failure Modes 1 and 2 were considered although Failure Mode 2 (pipe rupture) was generally thought to pose less risk of causing dam failure. Many of the considerations for this scenario relating to utility type, location of installation, and conduit material are similar to Scenarios 10 and 12. The selected team did not systematically reconsider each factor in a group setting but agreed that the considerations made in Scenarios 10 and 12 were applicable to Scenario 13. Therefore, a detailed review of each positive and negative factor will not be provided

here. The selected team concurred to classify this scenario as a category B. Table 18 summarizes the considerations for this scenario.

Table 18 – Scenario 13 – A Pressurized Gas Carried in a Steel Conduit Installed Using Directional Drilling Techniques through the Foundation

FM - Internal Erosion Near Penetration FM - Pipe Rupture		
Likely/Negative	**Not Likely/Positive**	**Mitigation**
• May encounter material that prevents completion • Investigation limited • May not fully grout void space around pipe (no verification) • Potential for significant disturbance immediately around pipe (less than Jack and Bore) • Potential for seepage along penetration • Hydro-fracturing during drilling is possible • Possible corrosion Flexible pipe may deform and create voids	• Experienced contractors and engineers available • Long seepage path • Limited disturbance area • Depth and distance from dam • Impoundment time short • Steel pipe can withstand more deflection than rigid material • May be able to move entrance upstream of reservoir	• Provide shut-off measures • Seal entrance to provide cutoff • Prudent drilling practice according to HDD consortium • Follow Corps of Engineers guidelines • Must do FMEA and alternative analysis (i.e. microtunnel with TBM, pressure line over the dam and realign) • Site specific items considered (FMEA and alternative analyses including all identified FM from previous alternative analyses)
Category: B - Applicant should address pipe rupture questions noted in Scenario 12		

5. CLOSURE

Ninyo & Moore prepared for the workshop on Utility Penetrations through Embankment Dams by researching existing policies and technical best-practices, conducting a survey, interviewing regulators, and developing a modified FMEA format. The research of existing policies generally indicated that utility penetrations should be avoided when possible, and many jurisdictional agencies have either not specifically addressed the question, or categorically prohibited utility penetrations through embankment dams. Ninyo & Moore has compiled a reference list (which may be supplemented by additional relevant technical references) to support guidelines development.

A survey was created and sent to approximately 250 utility owners, designers, or contractors. The purpose of the survey was to gather information on the common practices and dam safety understanding of utility companies, their design engineers, and the contractors that commonly install underground utilities. Of the 250 surveys, 18 were returned. The information gathered was considered too limited to observe general trends or make well-founded conclusions.

In order to better understand the requirements of the regulatory agencies involved, the District and Ninyo & Moore interviewed selected representatives from ADWR, NRCS, and USACE. In general, those agencies would allow well designed and constructed utility penetrations that do not penetrate the dam embankment within the standard pool elevations (between the upstream toe elevation and the freeboard elevation). The agencies also would like to be involved early in the permitting process.

In preparation for the FMEA, Ninyo & Moore, working closely with Jim Talbot and the District, modified the traditional process used during an FMEA. The process was modified to account for the various possibilities and variables that could be proposed in a utility penetration. In general, the modifications included:

- Analyzing failure modes for a given penetration scenario, and assigning a category to the scenario - not the failure mode;
- Considering and recommending mitigation measures to apply to a given scenario;
- Adjusting the categories that are assigned to a scenario to accommodate for potential safety problems (see Table 19 below); and
- Using a step-wise process to be able to address many scenarios within a one-day time frame.

Table 19 – Categories for Revised FMEA

Category	Description
A	FMEA team recommends prohibiting this type of utility penetration because current dam technology does not adequately mitigate potential for dam failure or because generally there should be a lower impact alternative.
B	FMEA team recommends that this type of utility penetration be carefully evaluated on a case-specific basis (possibly using an FMEA) because although current dam technology can often adequately mitigate the potential

Table 19 – Categories for Revised FMEA

Category	Description
	for dam failure, the mitigation is generally more complex or uncertain.
C	FMEA team recommends that this type of utility crossing generally be allowed because current dam technology adequately mitigates the potential for dam failure. A more streamlined safety review may be used during permit approval.
D	Additional information is needed by the FMEA team to adequately categorize this type of utility penetration.

The general feedback from the participants and the District indicated that the format was functional and allowed the FMEA team to achieve their purposes.

The FMEA team considered twelve scenarios during the conference and a selected team analyzed one additional scenario following the workshop upon request from the District. The scenarios were identified as being the more likely types of penetrations that would be requested to cross a Flood Control Dam. Of these, three were designated as a Category A (Prohibited), six were assigned a Category B (more complex -requires extensive analysis), and four were assigned a Category C (lower risk - possible streamlined review). In each scenario, recommended mitigations were provided and it was noted that case specific considerations will always need to be addressed. The categories assigned to the scenarios by the FMEA team are summarized in Table 20.

Table 20 – Summary of Findings

Scenario	Description	Category
1	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Overbuild or Residual Freeboard	C
2	A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erosion Resistant) Emergency Spill	C
3	A Dry Utility in a Plastic Conduit Installed Using Cut and Cover Techniques through the (Erodible) Emergency Spillway	A
4	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Abutment (Assuming the Abutment is Erosion Resistant and the Penetration is Above the Pool Elevation)	C

Table 20 – Summary of Findings

Scenario	Description	Category
5	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard	C
6	A Dry Utility Carried in a Plastic Conduit Installed Using Cut and Cover Techniques through the Foundation	A
7	A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Foundation	B
8	A Non-Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation	B
9	A Pressurized Liquid Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard	B
10	A Pressurized Liquid Carried in a Steel Conduit Installed Using Directional Drilling Techniques through the Foundation	B
11	A Pressurized Liquid Carried in a Steel Conduit Installed Using Jack and Bore Techniques through the Foundation	A
12	A Pressurized Gas Carried in a Steel Conduit Installed Using Cut and Cover Techniques through the Flood Freeboard	B
13	A Pressurized Gas Carried in a Steel Conduit Installed using Directional Drilling Techniques through the Foundation.	B

Many potential scenarios were not analyzed due to the improbability of certain designs being realized. Other more likely scenarios were not analyzed due to time and logistical constraints of the workshop (e.g., concrete pipe, pipe ramming, etc.). In situations where the District is asked to review scenarios not addressed herein, it would be prudent to initially assume most scenarios would be classified as a Category A or B type penetration.

Based on the results of the workshop and the background research described herein, we recommend that the District allow selected types (Category C) of penetrations be allowed with a more streamlined permitting process. In some cases (Category B), an extensive evaluation should be performed during the design review to decide if the penetration will be allowed. We also recommend that penetrations assigned "Category A" by the FMEA participants should be generally prohibited. The proposed guidelines will explain these cases, the needed design components for given installation scenarios and other required permitting information. Appendix E contains a preliminary recommended outline for the guideline document.

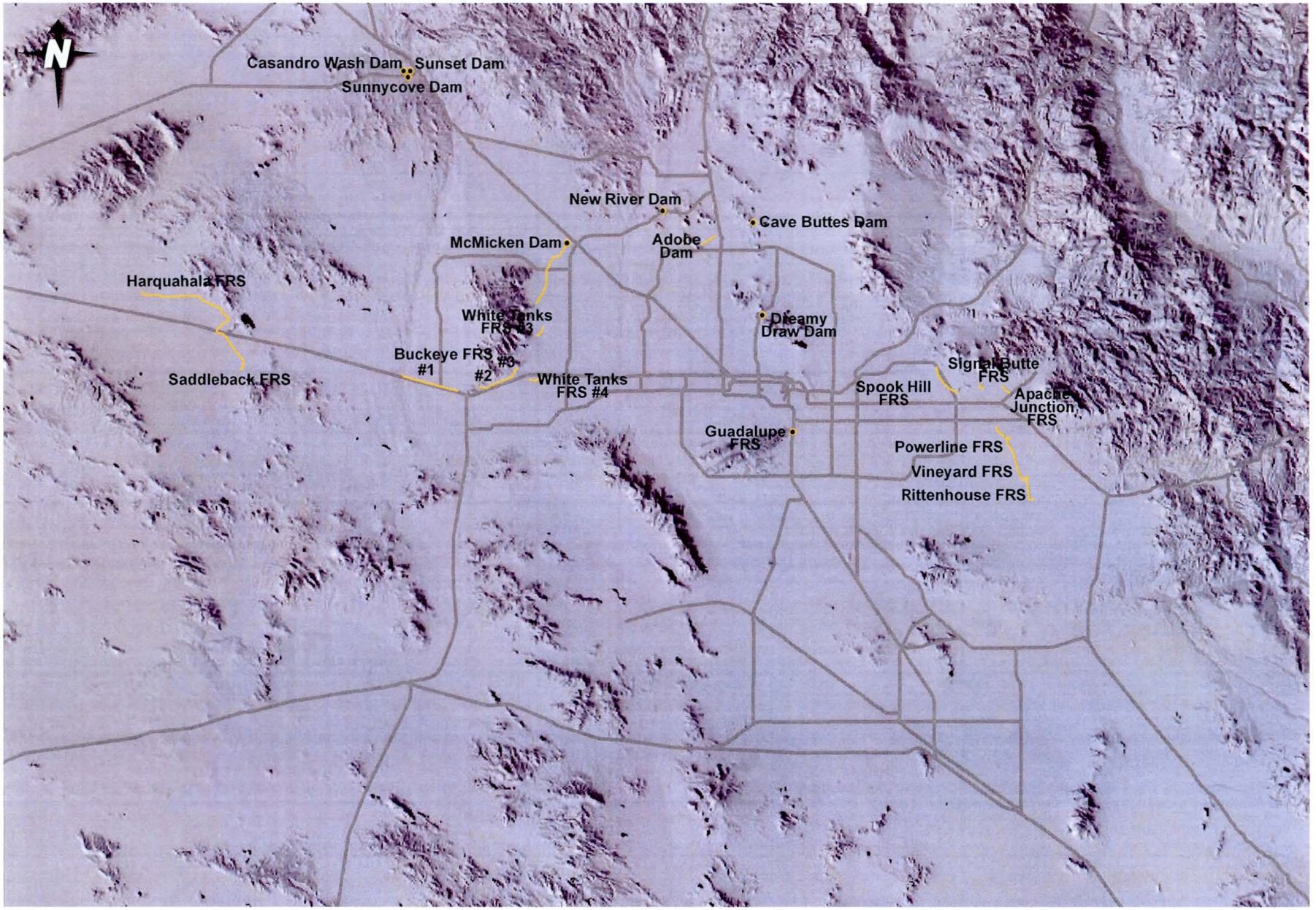
We recommend that the District continue the process of developing a Guideline for Utility Penetrations through Embankment Dams that is based on the information gathered and the results of the FMEA described herein. Future roadway crossings at dams should consider the likelihood of future requests for underground utility easements. When feasible, the vertical alignment of roadway crossings should designed to incorporate future utility crossings through the overbuild or residual freeboard. We also recommend that during future dam rehabilitation projects, vertical alignments of roadways that cross the dam be evaluated and possibly reconstructed so as to accommodate future utility crossings through the residual freeboard or overbuild.

During new dam construction or dam rehabilitation projects, the District should consider further evaluating the general concept of constructing a "Utility Corridor" through a dam near roadway crossings. This "Utility Corridor" would consist of a large, engineered penetration through which subsequently installed utilities could traverse the dam within the same penetration, thus reducing the potential for internal erosion at multiple penetrations.

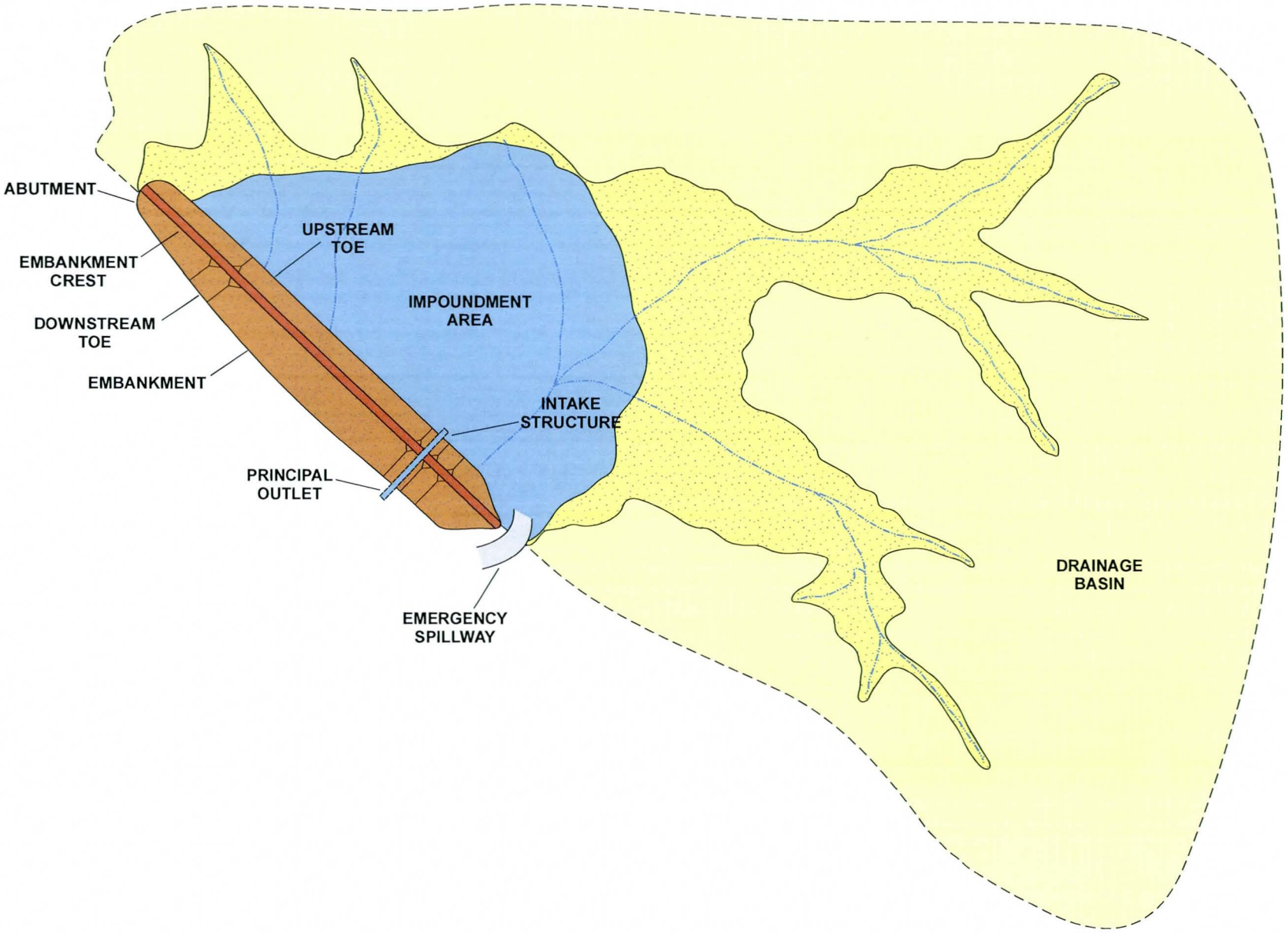
6. LIMITATIONS

The services described in this report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. Our conclusions and recommendations are based on an analysis of the assumed scenarios. No entity other than the Flood Control District of Maricopa County may rely on this document.

Ninyo & Moore



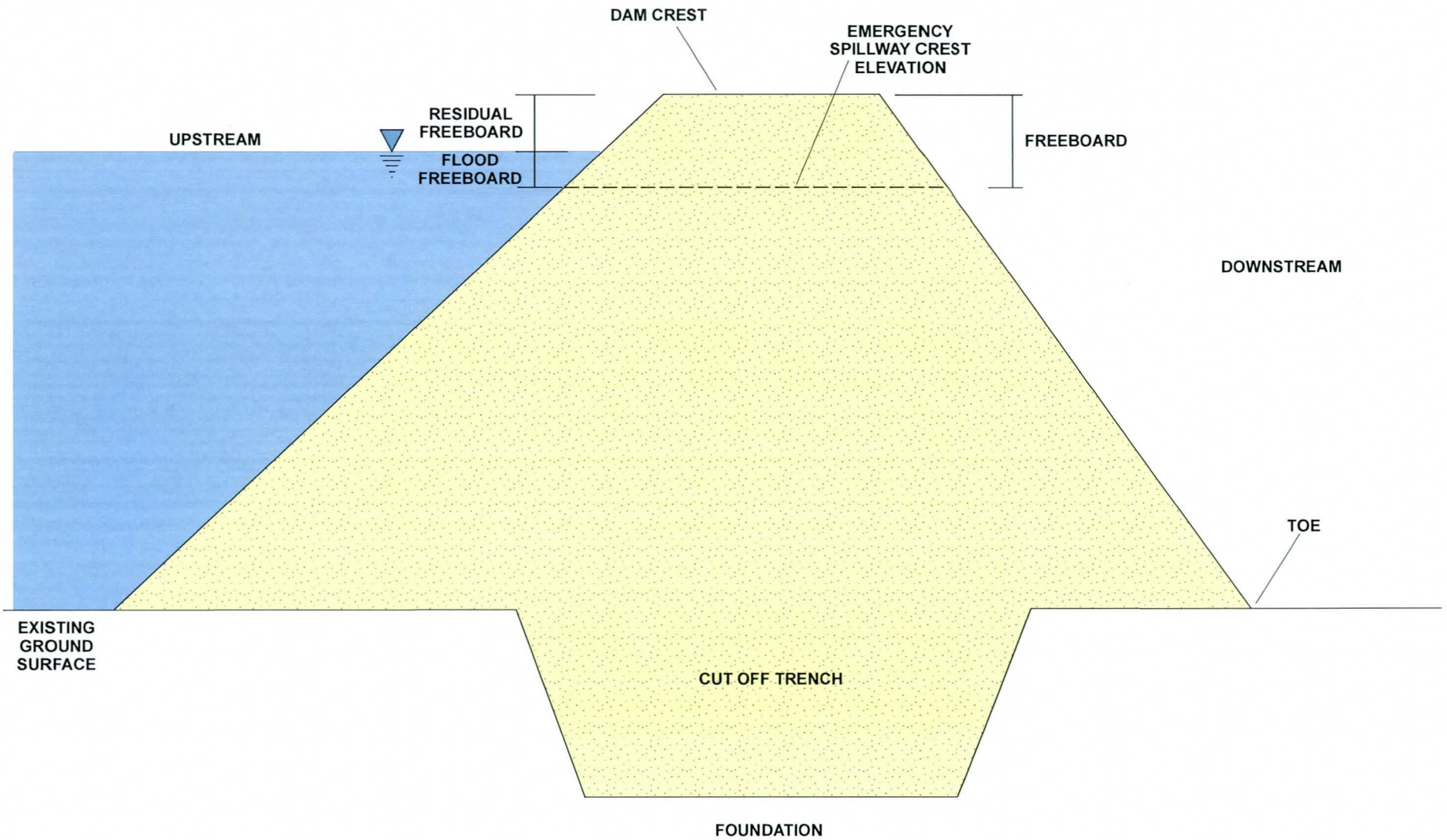
Ninyo & Moore	DISTRICT STRUCTURES MAP		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 1
PROJECT No: 600996001	FILE No: 996dist0106	DATE: 03/06	



NOT TO SCALE

Ninyo & Moore		DRAINAGE AREA AND DAM DETAILS	
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 2
PROJECT No: 600996002	FILE No: 996over0705d	DATE: 03/06	

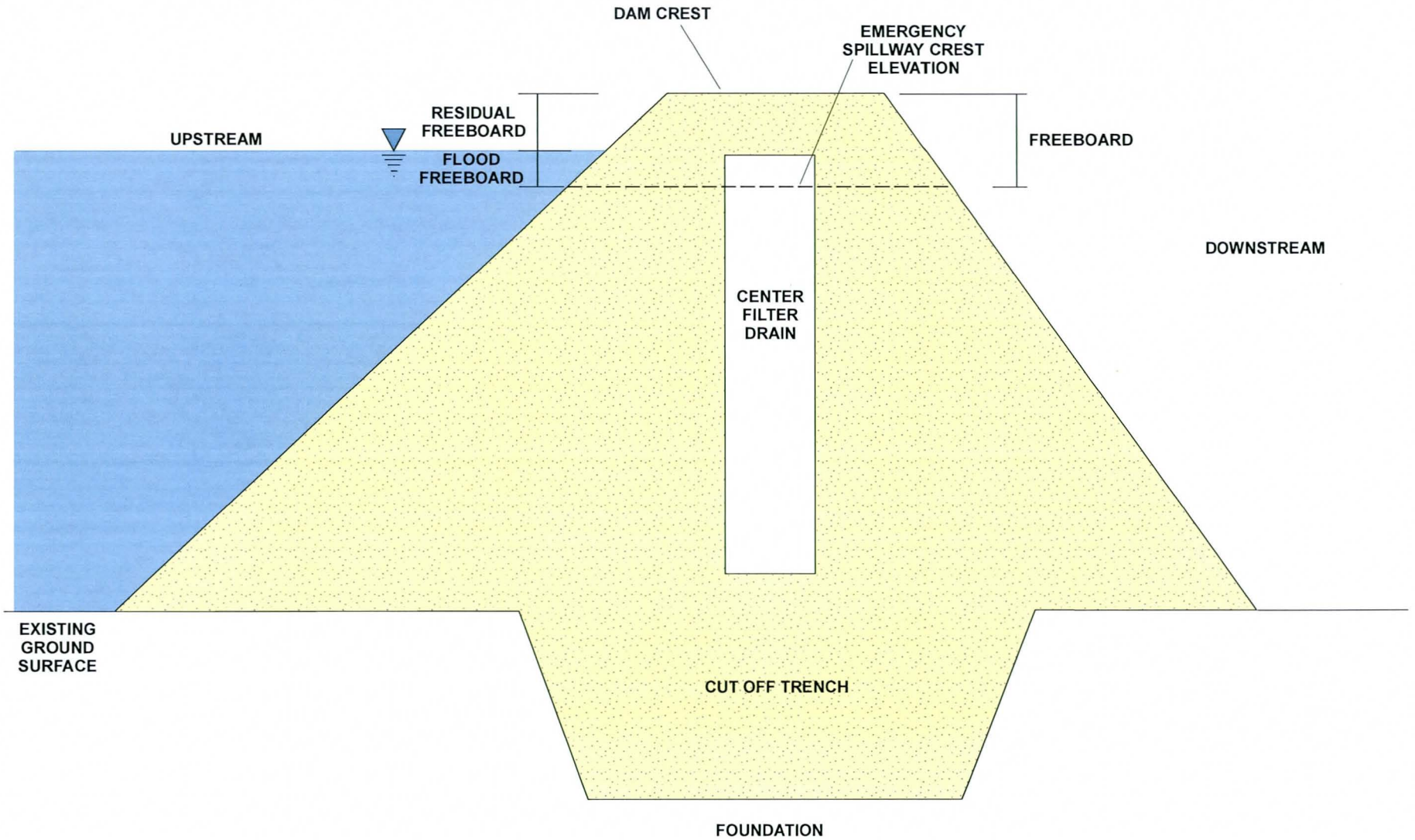
HOMOGENEOUS EARTH DAM



NOT TO SCALE

Ninyo & Moore			DAM DETAILS - HOMOGENEOUS EARTH DAM
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 3
PROJECT No: 600996002	FILE No: 996plan0705b	DATE: 03/06	

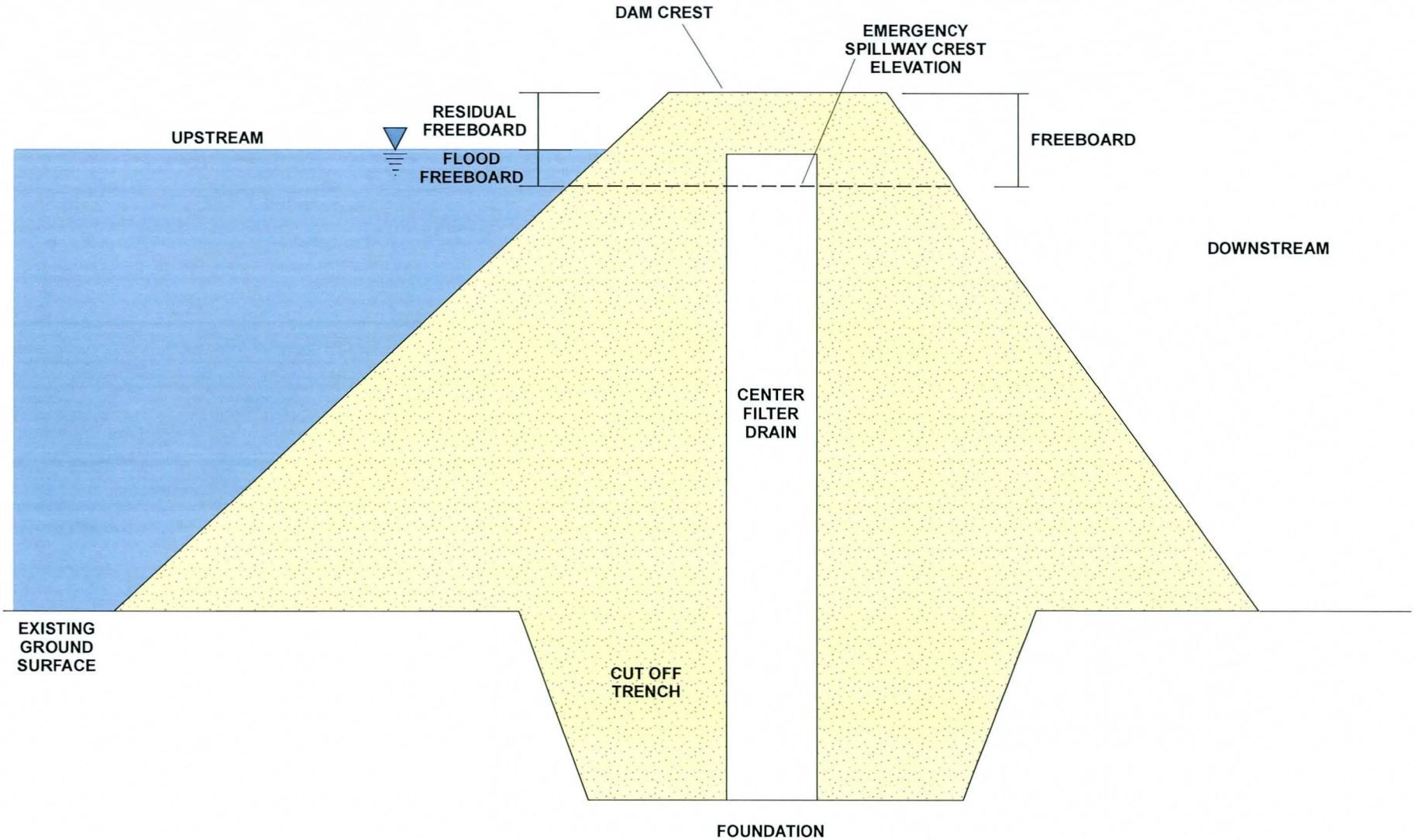
HOMOGENEOUS EARTH DAM WITH PARTIALLY PENETRATING CENTER FILTER DRAIN



NOT TO SCALE

Ninyo & Moore	DAM DETAILS - HOMOGENEOUS EARTH DAM WITH PARTIALLY PENETRATING CENTER FILTER DRAIN		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 4
PROJECT No: 600996002	FILE No: 996plan0705c	DATE: 03/06	

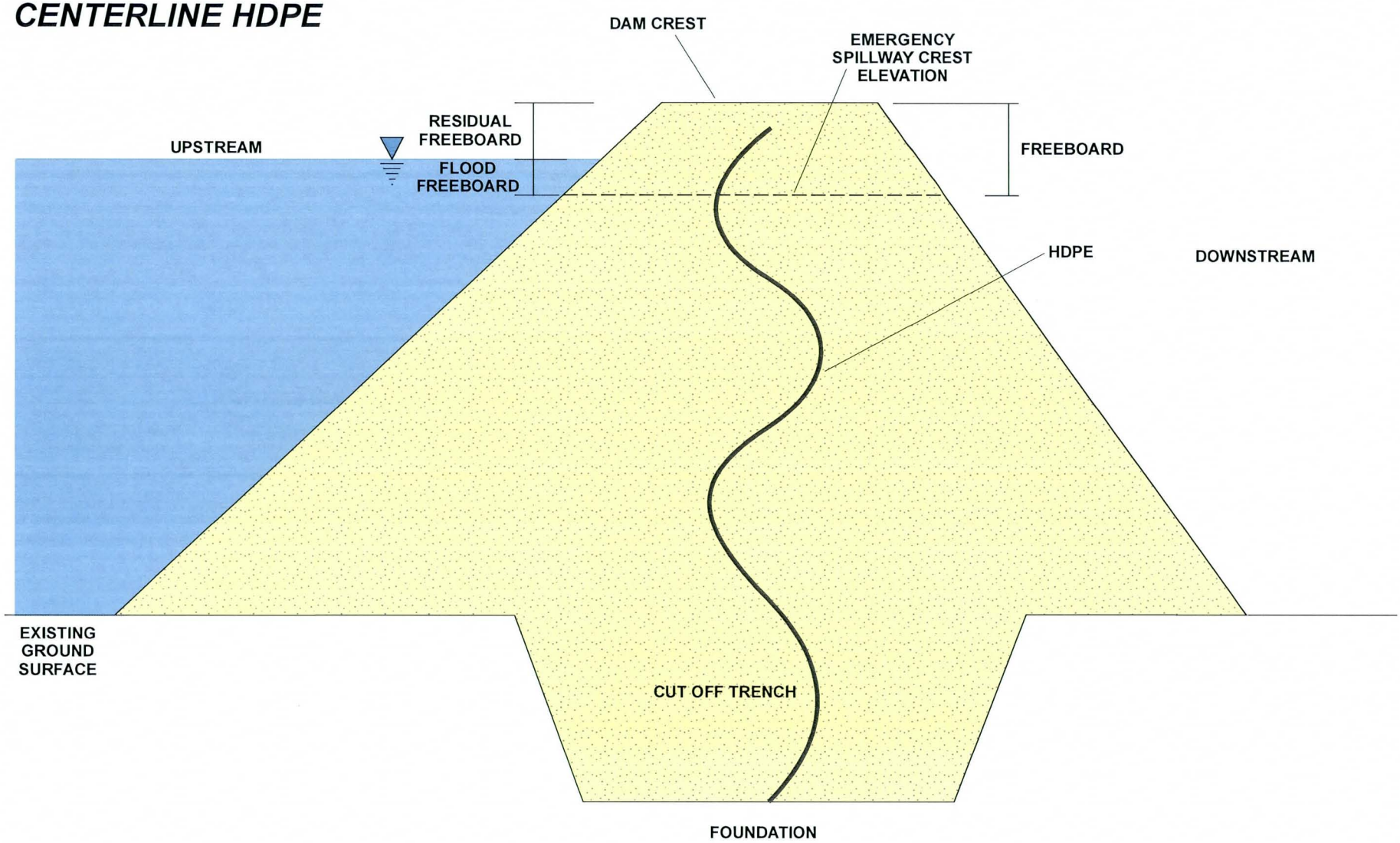
HOMOGENEOUS EARTH DAM WITH FULLY PENETRATING CENTER FILTER DRAIN



NOT TO SCALE

Ninyo & Moore	DAM DETAILS - HOMOGENEOUS EARTH DAM WITH FULLY PENETRATING CENTER FILTER DRAIN		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 5
PROJECT No: 600996002	FILE No: 996plan0705a	DATE: 03/06	

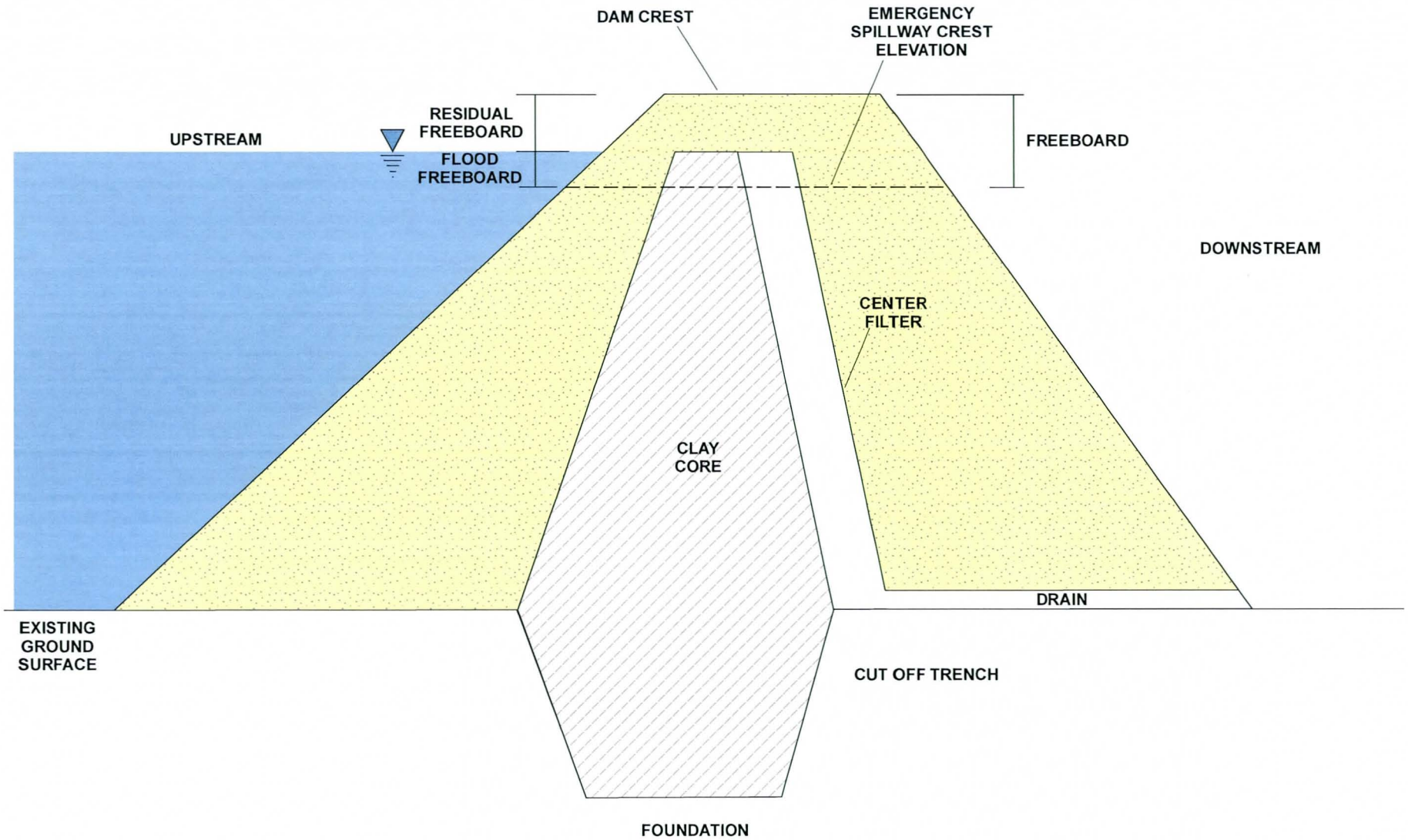
EARTH DAM WITH CENTERLINE HDPE



NOT TO SCALE

Ninyo & Moore	DAM DETAILS - EARTH DAM WITH CENTERLINE HDPE		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 6
PROJECT No: 600996002	FILE No: 996plan0705h	DATE: 03/06	

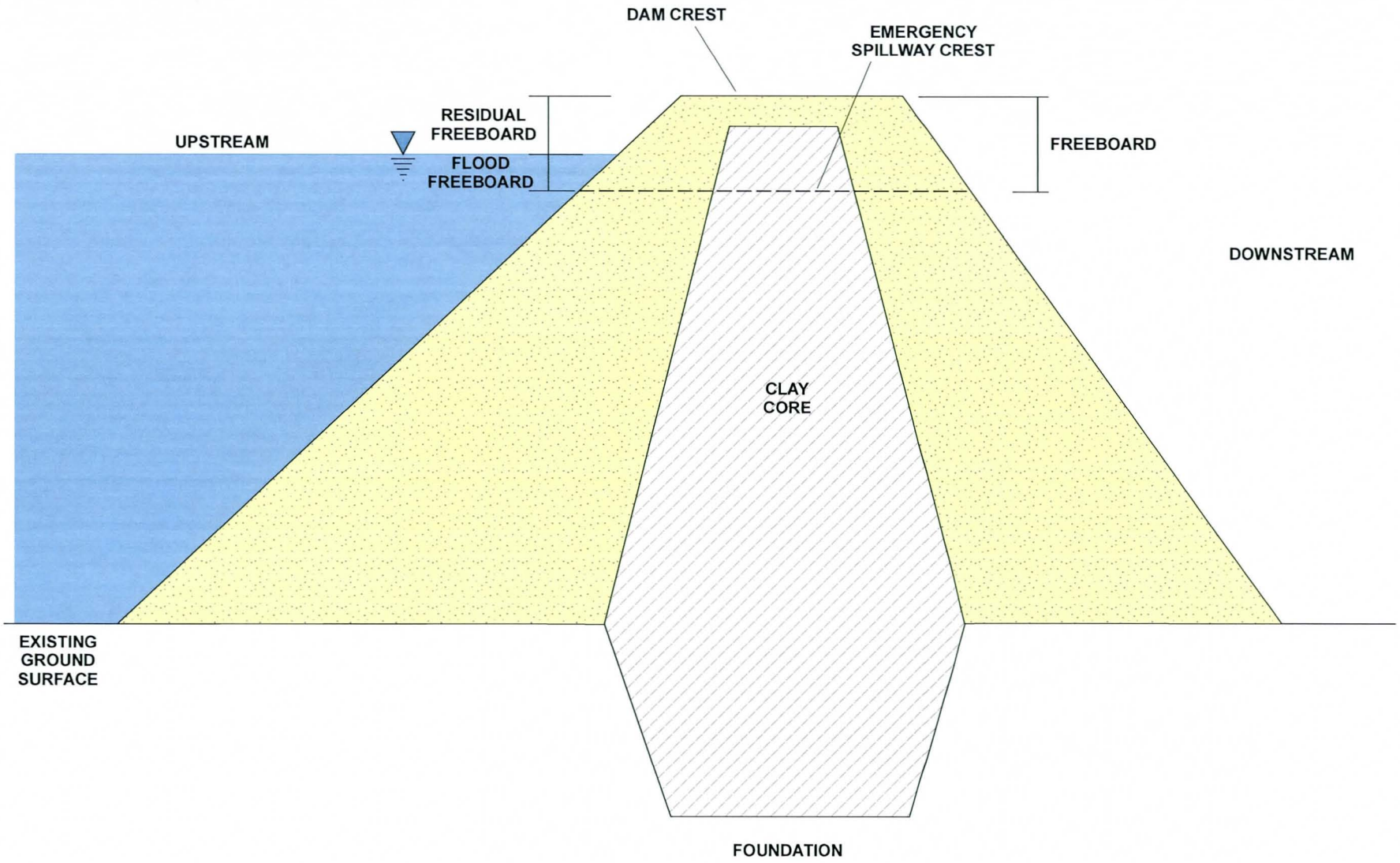
ZONED EARTH DAM



NOT TO SCALE

Ninyo & Moore			DAM DETAILS - ZONED EARTH DAM
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 7
PROJECT No: 600996002	FILE No: 996plan0705e	DATE: 03/06	

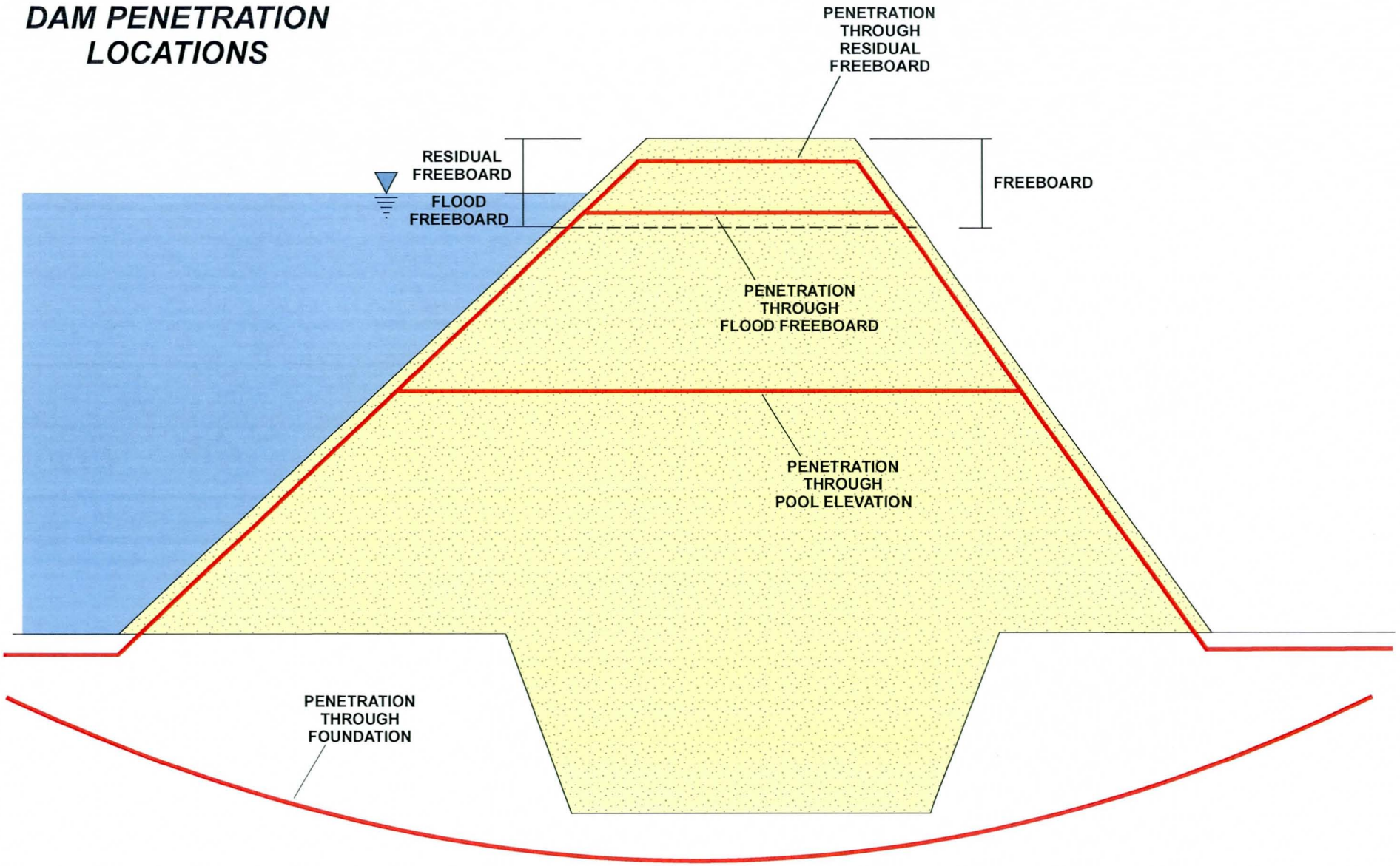
CLAY CORE EARTH DAM



NOT TO SCALE

Ninyo & Moore			DAM DETAILS - CLAY CORE EARTH DAM
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 8
PROJECT No: 600996002	FILE No: 996plan0705f	DATE: 03/06	

DAM PENETRATION LOCATIONS

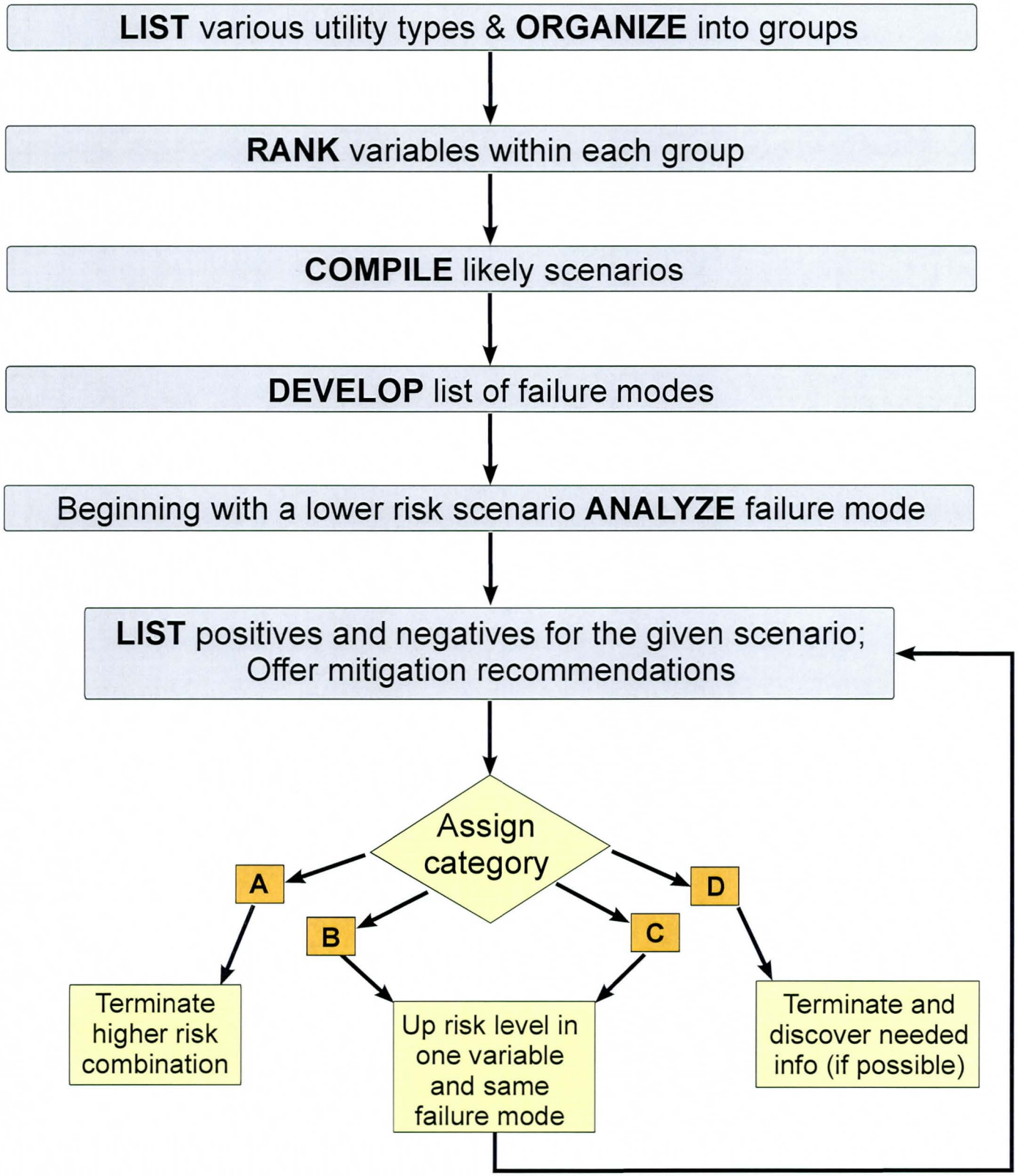


NOT TO SCALE

Ninyo & Moore	DAM PENETRATION LOCATIONS		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 9
PROJECT No: 600996002	FILE No: 996plan0705k	DATE: 03/06	

Variable Group	→ **Increasing Potential for Failure** →					
Product	Dry (Electric, Fiber Optic, Telephone, etc.)	Non-Pressurized Liquid	Pressurized Liquid	Pressurized Gas		
Conduit Material	Steel	Concrete	Plastic			
Location	Overbuild/ Residual Freeboard	Abutment (Native)	Emergency Spillway	Flood Freeboard	Foundation	Embankment
Installation Technique	Cut and Cover	Directional Drill	Jack and Bore	Pipe Ramming		

Ninyo & Moore	VARIABLES		
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 10
PROJECT No: 600996001	FILE No: 996plan0705g	DATE: 03/06	



Ninyo & Moore			MODIFIED FMEA PROCESS
WORKSHOP ON UTILITY PENETRATIONS THROUGH EMBANKMENT DAMS			FIGURE 11
PROJECT No: 600996001	FILE No: 996plan0705i	DATE: 03/06	

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APPENDIX A

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APPENDIX B

QUESTIONNAIRE AND RELATED ITEMS:

SURVEY DISTRIBUTION LIST
BROCHURE SENT WITH QUESTIONNAIRE
QUESTIONNAIRE
TABULATED QUESTIONNAIRE RESPONSES

Survey Distribution List			
	Company	**Contact Name**	**Type**
1	Accipiter Communications	Rob Richards	Owner
2	Achin-Gardner	Steven Brinkerhoff	Contractor
3	APS	Byron Conrad	Owner
4	Arizona American Water Co	Justin Rundle	Owner
5	Arizona Blue Stake, Inc.	Sandra M. Holmes	Owner
6	Arizona Dept. of Transportation	Bruce Vana	Owner
7	Arizona Dept. of Transportation	David W. Zimbro	Owner
8	Arizona Dept. of Transportation	John Syers	Owner
9	Arizona Dept. of Transportation	Scott Vollrath	Owner
10	Arizona Public Service	Bobby Garza	Owner
11	Arizona Public Service	Caral V. Hall	Owner
12	Arizona Public Service	Cary Ann Bailey	Owner
13	Arizona Public Service	Dennis D. Goodman	Owner
14	Arizona Public Service	Diane Blizzard	Owner
15	Arizona Public Service	John Herrera, Jr.	Owner
16	Arizona Public Service	John Rael	Owner
17	Arizona Public Service	Lois Winkler	Owner
18	Arizona Public Service	Phil Hobday	Owner
19	Arizona Public Service	Phil Macias	Owner
20	Arizona Public Service	Randy Clawson	Owner
21	Arizona Public Service	Rey Macias	Owner
22	Arizona Public Service	Ron Gandara	Owner
23	Arizona Public Service	Scott Hildebrand	Owner
24	Arizona Public Service	Steve Goodman	Owner
25	Arizona Public Service	Wendell Ross	Owner
26	Arizona State University	Doug Sanford	Owner
27	Arizona Water Co.	Michael Whitehead	Owner
28	Arizona Water Co.	Richard J. Distler	Owner
29	Arizona Water Co.	William D. Kerley	Owner
30	Arizona Water Co.	William Garfield	Owner
31	AT&T	Dennis Christie	Owner
32	AT&T	Pete Funk	Owner
33	AT&T	Roger Koening	Owner
34	B&F	Al DeLaCerda	Contractor
35	Black Mountain Gas Company	Saul Carrasco	Owner

Survey Distribution List			
	Company	**Contact Name**	**Type**
36	Broadwing Communications	Orren "Doc" Clackson	Owner
37	Buckey Irrigation District	Jackie A. Meck	Owner
38	Cable America Corp.	Bryan Williams	Owner
39	Cable America Corp.	Fred Butler	Owner
40	Cave Creek Valley Way	Dave Adams	Owner
41	Cave Creek Valley Way	Jay Gerorge	Owner
42	Cave Creek Water Company	Dave Adams	Owner
43	Cave Creek Water Company	Jay Gerorge	Owner
44	Citizens Water Resources	Blane Akine	Owner
45	City of Apache Junction	Ron Grittman	Owner
46	City of Avondale	Anthony Farier	Owner
47	City of Avondale	Jim Badowich	Owner
48	City of Avondale	Jim Mitchell	Owner
49	City of Avondale	Ken Sowers	Owner
50	City of Avondale	Tim Ernster	Owner
51	City of Avondale	Tony Ayala	Owner
52	City of Chandler	Beth Huning	Owner
53	City of Chandler	Bryan Patterson	Owner
54	City of Chandler	Lisa Crossman	Owner
55	City of Chandler	Mark Jerseritz	Owner
56	City of Chandler	Paul Young	Owner
57	City of Chandler	Paula Brown	Owner
58	City of Chandler	Sharon Joyce	Owner
59	City of Glendale	Daniel Sherwood	Owner
60	City of Glendale	Kathie A. Sholly	Owner
61	City of Glendale	Kenneth Reedy	Owner
62	City of Goodyear	Davis Ramirez	Owner
63	City of Goodyear	Kieth Brown	Owner
64	City of Goodyear	Larry Martinez	Owner
65	City of Goodyear	Steve Ruppenthal	Owner
66	City of Litchfield Park	Bob Gaunt	Owner
67	City of Mesa	Jim Neibergall	Owner
68	City of Mesa	Kelly Jensen	Owner
69	City of Mesa	Peter Knudson	Owner
70	City of Peoria	Burton Charron	Owner

Survey Distribution List			
	Company	**Contact Name**	**Type**
71	City of Peoria	Dan Nissen	Owner
72	City of Peoria	Stacy W. Caudell	Owner
73	City of Peoria	William Mattingly	Owner
74	City of Phoenix	Aaron Jensen	Owner
75	City of Phoenix	Carlos Lara	Owner
76	City of Phoenix	Catherine Rogers	Owner
77	City of Phoenix	Cindy White	Owner
78	City of Phoenix	Davis M, Nieto, Jr.	Owner
79	City of Phoenix	Gerald Arakaki	Owner
80	City of Phoenix	Jacob Rhyan	Owner
81	City of Phoenix	Kenny Harris	Owner
82	City of Phoenix	Larry Valenzuela	Owner
83	City of Phoenix	Marina Smith	Owner
84	City of Phoenix	Pat Griffin	Owner
85	City of Phoenix	Roy Alvarado	Owner
86	City of Phoenix	Rozanna Brown	Owner
87	City of Phoenix	Steve Rivas	Owner
88	City of Phoenix	Tammy Resendez	Owner
89	City of Phoenix	Thomas Fisher	Owner
90	City of Phoenix	Tran Gutierrez	Owner
91	City of Phoenix	Veronica Alvarez	Owner
92	City of Scottsdale	Alex Mclaren	Owner
93	City of Scottsdale	Bill Erickson	Owner
94	City of Scottsdale	George Bringe	Owner
95	City of Scottsdale	Larry Tritz	Owner
96	City of Surprise	Brett Huskey	Owner
97	City of Surprise	Jim Nichols	Owner
98	City of Surprise	Jim Swanson	Owner
99	City of Surprise	Rich Williams	Owner
100	City of Telleson	Manuel Dominguez	Owner
101	City of Tempe	Andy Goh	Owner
102	City of Tempe	Howard Hargis	Owner
103	Clearwater Utilities Company	Tangye Whiting	Owner
104	Cox Communications	Bill Wight	Owner
105	Cox Communications	Cory Somerville	Owner

Survey Distribution List			
	Company	**Contact Name**	**Type**
106	Cox Communications	John O'Connell	Owner
107	Cox Communications	Randy Sims	Owner
108	Cox Communications	Rod Bassett	Owner
109	Cox Communications	Roger Yensen	Owner
110	Cox Communications	Scott Gusso	Owner
111	Cox Communications	Suzanne Holzer	Owner
112	Cox Communications	Tony DiNunzio	Owner
113	Cox Communications	Walter Coombs	Owner
114	Cox Xommunications	Randy Simes	Owner
115	Diving Inspections	Tony Smith	Owner
116	Eagle West Cable	Ellis Field	Owner
117	Eagle West Cable	Joe Flores	Owner
118	El Paso Natural Gas	Bill B. Furgason	Owner
119	El Paso Natural Gas	Dennis Calhoun	Owner
120	El Paso Natural Gas	Dennis W. Segars	Owner
121	El Paso Natural Gas	Grady Partin	Owner
122	El Paso Natural Gas	John H. McNeely	Owner
123	El Paso Natural Gas	Ray Presnall	Owner
124	El Paso Natural Gas	Ron Brown	Owner
125	El Paso Natural Gas	William Ward	Owner
126	Electric Light	Lee Stauber	Owner
127	Felix	Kevin Felix	Contractor
128	Fluor Global Services (Level 3 Communications)	Brad Wilcox	Owner
129	Fluor Global Services (Level 3 Communications)	John Yates	Owner
130	Fluor Global Services (Level 3 Communications)	Ray Rosado	Owner
131	FNF Construction	Tony L. Witt	Contractor
132	Geotechnical Consultants	Ken Euge	Designer
133	Haydon	Marty Demarse	Contractor
134	Kinder Morgan Energy Partners	Alan Woodard	Owner
135	Level 3 Communications, LLC	Tom Christ	Owner
136	Levine Non-Potable Water	Ned Overs	Owner
137	Maricopa County Dept of Transp.	Ollin S. Sutton	Owner
138	Maricopa Water Users Association	Glen Votherms	Owner

Survey Distribution List			
	Company	**Contact Name**	**Type**
139	McCarthy	Troy Larson	Contractor
140	MCDOT	Wayne Butch	Owner
141	MCI WORLDCOM	Cal VanWagner	Owner
142	MCI WORLDCOM	John Bachelder	Owner
143	MCI WORLDCOM	Michael Brennan	Owner
144	MCI WORLDCOM	Rick Thomas	Owner
145	Media Communications	Brenda Hopkins	Owner
146	Nextlink	Carl Brisson	Owner
147	Nextlink	Craig Middle	Owner
148	Nextlink	Danny Fry	Owner
149	Nextlink	Skip Wallace	Owner
150	Parsons Brinckerhoff	Gan Mukhopadhyay	Designer
151	Pinal County	Brad Gair	Owner
152	Pinal County	Doug Hansen	Owner
153	Pipeline Dynamics	Bill Holmes	Contractor
154	Queen Creek Irrigation District	Dean Griffith	Owner
155	Queen Creek Water Company	Paul Gardner	Owner
156	QWEST	Brian Janosz	Owner
157	QWEST	Cathy Espinoza	Owner
158	QWEST	Dan Constance	Owner
159	QWEST	Jason Hemphill	Owner
160	QWEST	Ken Hoeft	Owner
161	QWEST	Tom Wiseman	Owner
162	Robert Ward	Robert Ward	Owner
163	Service Solutions- APS	Larry Nelson	Owner
164	Southwest Gas	Bill Bauer	Owner
165	Southwest Gas	Bill Schrand	Owner
166	Southwest Gas	Eddie Reyes	Owner
167	Southwest Gas	Edwin Longwell	Owner
168	Southwest Gas	Gene Florez	Owner
169	Southwest Gas	Gerardo Lopez	Owner
170	Southwest Gas	Hengameh Najafi	Owner
171	Southwest Gas	Jerry Schmitz	Owner
172	Southwest Gas	Jody McDougall	Owner
173	Southwest Gas	Jorge Rodriguez	Owner

Survey Distribution List			
	Company	Contact Name	Type
174	Southwest Gas	Jose Esparza	Owner
175	Southwest Gas	Julie M. Williams	Owner
176	Southwest Gas	Kathy Senseman	Owner
177	Southwest Gas	Kyle Tilghman	Owner
178	Southwest Gas	Marcus Watanabe	Owner
179	Southwest Gas	Penny Allee Taylor	Owner
180	Southwest Gas	Pom Jintasawang	Owner
181	Southwest Gas	Robert Sprague	Owner
182	Southwest Gas	Robert Womble	Owner
183	Southwest Gas	Sue Mosley	Owner
184	Southwest Gas	Vivian J. Hunsaker	Owner
185	Specialized Service Co.	Arvid Veidmark	Contractor
186	Sprint	Colin M. Sword	Owner
187	Susanne Leckband	Susanne Leckband	Designer
188	Tankersley Water	Robert Summers	Owner
189	Texas A&M	Chuck Aubeny	Designer
190	Town of Buckeye	Ron Long	Owner
191	Town of Gila Bend	Ralph Vasquez	Owner
192	Town of Gilbert	Bill Birdwell	Owner
193	Town of Gilbert	Bill Taylor	Owner
194	Town of Gilbert	Guy Carpenter	Owner
195	Town of Gilbert	Larry Farmer	Owner
196	Town of Gilbert	Lonnie Frost	Owner
197	Town of Gilbert	Mark Horn	Owner
198	Town of Gilbert	Mark S. Weiner	Owner
199	Town of Gilbert	Rick Allred	Owner
200	Town of Gilbert	Terry Fawley	Owner
201	Town of Paradise Valley	Bob Ciccarelli	Owner
202	Town of Queen Creek	Don Noble	Owner
203	Town of Queen Creek	Tom Narva	Owner
204	TRAIX Cablevision	Brenda Hopkins	Owner
205	Water Utilities Community Facilities District	Kevin B. Cox	Owner
206	Western Area Power Administration	J. Tyler Carlson	Owner
207	Western Area Power Administration	Robert Johnson	Owner
208	Williams Communication	Frank Wileson	Owner

Survey Distribution List			
	Company	**Contact Name**	**Type**
209	Williams Communication	George Otey	Owner
210	Williams Communication	Janel Minyard	Owner
211	Williams Communication	Jerry Brannon	Owner
212	Williams Communication	Margie Groves	Owner
213	Williams Communication	Russel Watkins	Owner
214	Williams Communication	Vernon Halter	Owner
215	Wood Patel	Ash Patel	Designer
216	X.O. Communications, Inc.	Craig Middle	Owner

Embankment Dam Utility Penetration Guidelines

The Flood Control District of Maricopa County (District), founded in 1959, is a municipal corporation and political subdivision of the State of Arizona. The District is governed by a Board of Directors, which double as the County Board of Supervisors, with advice of a Citizens' Flood Control Advisory Board.

The mission of the District is to provide regional flood hazard identification, regulation, remediation, and education to Maricopa County residents so that they can reduce their risks of injury, death, and property damage from flooding, while still enjoying the natural and beneficial values served by floodplains.

To accomplish this mission, the District:

- Identifies flood hazards and problems
- Regulates floodplains and development
- Conducts County Watercourse and Drainage Planning
- Provides Flood Prevention and Safety Education
- Constructs Flood Control Structures and Facilities
- Provides Flood Warning and Early Detection Services
- Maintains and Operates completed structures

White Tanks FRS #3 - Upstream Side

Dam Safety Program

The District currently operates and maintains 22 flood control dams, which provide valuable flood protection for Maricopa County and its residents. All but one of the dams were originally constructed by the Natural Resource Conservation Service or the U.S. Army Corps of Engineers, the District took over operation and maintenance after completion. Presently the dams are under the jurisdiction and regulation of the Arizona Department of Water Resources.

These District dams average approximately 30 feet in height and total 64 miles in length. Most of the District's dams are long, earthen structures, which protect County residents from flooding. Flood control dams consist of other elements and features, which include an impoundment area, an emergency spillway, and a principal outlet. Long dams often also feature a low-flow channel, which is designed to transport the flood waters from one end to the other where water is then often released through the dam by means of a principal outlet.

Because of the infrequent nature of flood events in Maricopa County, these dams infrequently hold significant amounts of water and are generally referred to as "dry dams." However, when floods happen, these dams must be ready at all times to operate safely and properly. To ensure that the dams are safe, the District's Structures Management Branch is responsible for coordinating the following components: Recurrent Dam Safety Activities, Individual Structures Assessment Program, and Dam Rehabilitation Program.

Working to Improve Our Services

Continued urbanization in Maricopa County has led to increased requests for utilities to cross District flood control dams, levees, and adjacent right-of-ways. Currently, each right-of-way (ROW) applicant has to be individually instructed as to the technical and administrative complexities of crossing a dam or other District structure. In many cases it takes the ROW applicant several submittals until they have satisfactorily planned and submitted all the required documentation to allow District review and consideration. The District intends to develop guidelines for utility penetrations to assist applicants through the design process and preparation of the necessary ROW permit documentation.

-continued

Utility Penetration Guidelines

The District has retained the services of a team of local and national civil engineering consultants to aid in the development of our utility penetration guidelines. These guidelines will assist those ROW applicants that wish to request a permit to install a utility across a District flood control structure. The guidelines are intended to do the following: provide clear navigation through the application process; provide a list of required submittals and fees; provide design engineers with pre-approved, industry-accepted technical resources; contain examples of expected design submittals; and provide other pertinent information that will expedite the applicant's design process and ultimately the District's review and approval process. Final versions of the guideline will be available for free download from the District's website or available on CD-ROM from the District.

Your Participation is Essential

Your participation may help your organization meet schedules, reduce potential risk and liability to you and the public, and lessen design costs. The District is striving to improve its ROW permitting process for utility crossings through its structures and would like to include you in our development by utilizing your valuable expertise and experience. A clear, simple, well-communicated utility crossing ROW application process and guideline, as well as realistic expectations from both applicants and the District will benefit everyone involved.

We envision the improved permitting process and guideline will save you time, money, and will allow you to better anticipate the schedule of your project planning, design and construction. Your input into the development of a utility penetration guideline will assist the District in reducing the ROW permit review and approval time frame as well as further educate you on the required components of a utility crossing ROW permit.

Enclosed Questionnaire

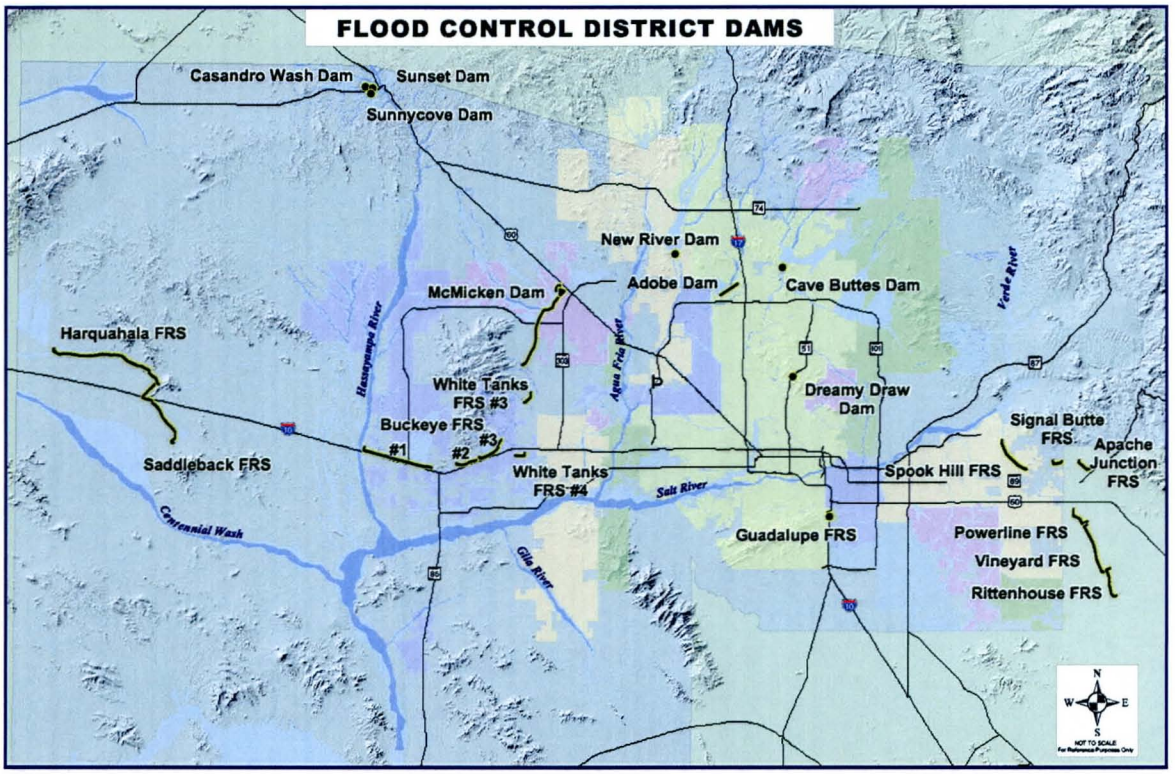
The District would like to better understand your past experience, your current practices, future plans and current understanding of dam safety. Please take approximately 15 minutes to answer the enclosed questions. We appreciate your response and look forward to your input. Upon completion, please return the questionnaire via fax to 602-506-8561 or mail (see contact and address below). Questionnaires can also be filled out via an online form found at the following web address: http://fcd.maricopa.gov/damsafetysurvey.asp

Two-Day Workshop

Once the results of the questionnaire are received, compiled, and reviewed, the District is planning a 2-day workshop for continued discussion on designing and installing buried utilities through dams. The workshop will bring together the District, utility companies, designers, and contractors to discuss and better understand the risks associated with utility installations in dams as well as assist the District in better understanding your industry's planning, design, and construction process. If you are interested in attending the workshop, presenting a case history, or providing additional input contact the District.

Contact

Brett Howey, P.E.
Dam Safety Engineer, Flood Control District
2801 W Durango St., Phoenix, AZ 85009
602-506-4609 or bah@mail.maricopa.gov



Embankment Dam Utility Penetration Survey

Your valuable input will help the Flood Control District of Maricopa County (District) better understand your past experience, your current practices, future plans, and current understanding of dam safety. Our goal is to improve our Right-of-Way (ROW) permitting process for utility crossings of flood control dams. When a utility crosses a District flood control dam a ROW permit must be prepared by a qualified dam safety engineer and approved by the District with concurrence from the dam's associated Federal sponsor. Additionally, an application with Arizona Department of Water Resources may be required. Improvements to the permitting process by the development of a guideline that details the necessary requirements for all submittals has the potential to save you time and money during planning, design, and construction. To assist us in making the permit process easier for you please take approximately 15 minutes to provide answers to the questions below. Questions may be directed to you or your organization. Please feel free to copy and distribute additional questionnaires to others who you think would provide valuable input.

Surveys may be submitted electronically by accessing the following Web page: http://fcd.maricopa.gov/damsafetysurvey.asp. Additionally, surveys can be faxed to 602-506-8561 or mailed to Brett Howey, P.E., Flood Control District, 2801 W. Durango St., Phoenix, AZ 85009. Please call Brett at 602-506-4609 with any questions.

Name: _____

Business/Organization: _____

Address: _____

Phone Number: _____ **Email:** _____

GENERAL INFO

1. What type of utility do you own/install/design most often (check all that apply)?

☐ Electric ☐ Fiber Optic/ Cable/Telephone ☐ Water ☐ Sewer ☐ Natural Gas/ Petroleum ☐ Other

2. Approximately how many linear miles of utilities does your organization own (or have designed/installed) in Maricopa County?

☐ <50 ☐ 50-100 ☐ 101-500 ☐ 501-1000 ☐ >1000 ☐ N/A

3. Would you be interested in participating in a workshop to discuss utility penetrations through flood control dams?

☐ Yes ☐ No

4. Would you be interested in giving a presentation at the workshop?

☐ Yes ☐ No

5. May we contact you for additional information on this subject?

☐ Yes ☐ No

PAST EXPERIENCE WITH UTILITY PENETRATION PERMITTING

6. How many times has your organization installed a buried or underground utility through a District dam or levee?

☐ Never ☐ 1-5 ☐ 6-10 ☐ >10 ☐ N/A

7. Please rate how difficult is has been to obtain a ROW permit for a utility penetration through a dam or levee from the District.

☐ Much more difficult than expected ☐ More difficult than expected ☐ Met expectations ☐ Easier then expected ☐ N/A

8. What level of effort (in hours) does it take your organization's staff to prepare and obtain a District ROW permit for a utility penetration, including all associated documentation?

☐ 1-10 ☐ 11-50 ☐ 51-100 ☐ 101-200 ☐ >200 ☐ N/A

9. How many times has your District ROW permit application needed subsequent submittals after the initial submittal?

☐ 0 ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ >6 ☐ N/A

10. Please rate how helpful it has been to meet with the District prior to preparing the ROW application supporting documentation. (1 to 5)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

GENERAL PLANNING AND DESIGN PROCEDURES

11. What is the approximate diameter of the typical buried or underground utility you install (check all that apply)?

☐ 0-6 inches ☐ 6-12 inches ☐ 12-36 inches ☐ 36-60 inches ☐ >60 inches

12. Please rate the following project constraints in order of importance to your organization (1 is most important, 5 is least important).

☐ Alignment ☐ Cost ☐ Permitting ☐ Schedule ☐ Liability ☐ Other

13. For a typical alignment, approximately how much time does it take to construct / install your utility per mile?

☐ <2 weeks ☐ 1-2 Months ☐ 2-3 Months ☐ 3-4 Months ☐ >4 Months ☐ N/A

14. Who does the design of your utility installation?

☐ In-house Engineer ☐ Consulting Engineer ☐ Contractor's Engineer ☐ Other

15. Do you use an alternatives development/analysis process during your planning phase to select a preferred alignment?

☐ Yes ☐ No ☐ N/A

16. If yes, is permitting considered during this phase?

☐ Yes ☐ No ☐ N/A

17.For a typical alignment, at what phase do you consider required project permits?

☐ Planning ☐ Design ☐ Construction ☐ Other

18. At what phase do you know that you will cross a flood control dam or levee?

☐ Planning ☐ Design ☐ Construction ☐ Other

19. How frequently do you alter your alignment to avoid a flood control dam or levee?

☐ Never ☐ Seldom ☐ About 50% ☐ Usually ☐ Always

20. How often do you use an engineer with dam technology experience to design the utility installation when it crosses a flood control dam or levee?

☐ Never ☐ Seldom ☐ About 50% ☐ Usually ☐ Always

21. How often do you cross a flood control dam or levee using trenchless construction techniques?

☐ Never ☐ Seldom ☐ About 50% ☐ Usually ☐ Always

22. How often do you cross a flood control dam or levee using "cut-and cover" construction techniques?

☐ Never ☐ Seldom ☐ About 50% ☐ Usually ☐ Always

FUTURE PLANS

23. About how many miles of utility are you planning to install in the next 5 years?

☐ >10 ☐ 11-50 ☐ 51-100 ☐ 101-500 ☐ 500+

24. Are you aware that a ROW applicant must retain an Arizona registered civil engineer with dam technology experience to design the reaches where a utility crosses a DISTRICT flood control dam or levee?

☐ Yes ☐ No

25. Does your organization have any future plans to cross a District dam or levee with a buried or underground utility?

☐ Yes ☐ No

26. Do you have any additional information or suggestions to the District that you think would improve the ROW permitting process when crossing flood control dams or levees with a buried or underground utility?

DAM SAFETY

27. Relative to your typical utility installation, please rate the complexity of installing a utility penetration in a flood control dam or levee.

☐ Much easier ☐ Somewhat easier ☐ About the same complicated ☐ Somewhat more complicated ☐ Much more

28. Relative to other special utility crossings (e.g., rivers, major roadways/highways, environmentally sensitive areas), please rate your understanding of the complexity of installing a buried or underground utility across a flood control dam or levee.

☐ Much easier ☐ Somewhat easier ☐ About the same complicated ☐ Somewhat more complicated ☐ Much more

29. What is your level of understanding of how a flood control dam functions and operates safely?

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

30. How familiar are you with the design of a flood control dam or levee?

☐ Unfamiliar ☐ Slightly Familiar ☐ Familiar ☐ Very Familiar ☐ Expert

31. Are you aware of the case histories of dams that have failed due to a utility penetration?

☐ Yes ☐ No

32. What is your level of understanding of the potential for loss of life and damages caused by a failure of a flood control dam?

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

33. Are you aware of the potential liabilities associated with installing a utility in a flood control dam?

☐ Yes ☐ No

Thank you for taking the time to complete this survey.

Summary of Questionnaire Results

Question 1	count	%
electric	4	12%
fo/cable/tel	7	21%
water	9	27%
sewer	8	24%
gas/petro	4	12%
other	1	3%

Question 2	count	%
<50	2	11%
50-100	4	22%
101-500	2	11%
501-1000	3	17%
>1000	4	22%
N/A	3	17%

Question 3	count	%
yes	13	72%
no	5	28%

Question 4	count	%
yes	6	35%
no	11	65%

Question 5	count	%
yes	18	95%
no	1	5%

Question 6	count	%
Never	8	47%
1-5	6	35%
6-10	2	12%
>10		0%
N/A	1	6%

Question 7	count	%
Much more	3	18%
More	1	6%
Met	4	24%
Easier		0%
N/A	9	53%

Question 8	count	%
1-10		0%
11-50	2	12%
51-100	3	18%
101-200	1	6%
>200	2	12%
N/A	9	53%

Question 9	count	%
0		0%
1-2	4	24%
3-4	2	12%
5-6	1	6%
>6		0%
N/A	10	59%

Question 10	count	%
1	1	8%
2	2	15%
3	2	15%
4	1	8%
5	2	15%
N/A	5	38%

Question 11	count	%
0-6	6	22%
6-12	4	15%
12-36	9	33%
36-60	6	22%
>60	2	7%

Question 12	count	%
Alignment	5	21%
Cost	8	33%
Permitting	2	8%
Schedule	1	4%
Liability	6	25%
Other	2	8%

Question 13	count	%
<2 weeks	2	13%
1-2 months	7	44%
2-3 months	1	6%
3-4 months		0%
>4 months	1	6%
N/A	5	31%

Question 14	count	%
In-house Engineer	8	47%
Consulting Engineer	5	29%
Contractor's Engineer	3	18%
Other	1	6%

Question 15	count	%
yes	11	61%
no	2	11%
N/A	5	28%

Question 16	count	%
yes	10	56%
no	1	6%
N/A	7	39%

Summary of Questionnaire Results

Question 17	count	%
Planning	9	50%
Design	7	39%
Construction	2	11%
Other		0%

Question 18	count	%
Planning	17	89%
Design	1	5%
Construction	1	5%
Other		0%

Question 19	count	%
Never	1	7%
Seldom	4	29%
About 50%		0%
Usually	7	50%
Always	2	14%

Question 20	count	%
Never	3	27%
Seldom	3	27%
About 50%		0%
Usually		0%
Always	5	45%

Question 21	count	%
Never	5	38%
Seldom	4	31%
About 50%		0%
Usually	1	8%
Always	3	23%

Question 22	count	%
Never	5	38%
Seldom	2	15%
About 50%		0%
Usually	5	38%
Always	1	8%

Question 23	count	%
>10	2	14%
11-50	4	29%
51-100	2	14%
101-500	6	43%
500+		0%

Question 24	count	%
yes	10	59%
no	7	41%

Question 25	count	%
yes	6	40%
no	8	53%
Maybe	1	7%

Question 27	count	%
Much easier		0%
Somewhat easier		0%
About the same	2	13%
Somewhat more complicated	4	25%
Much more	7	44%
N/A	3	19%

Question 28	count	%
Much easier		0%
Somewhat easier	2	13%
About the same	3	19%
Somewhat more complicated	6	38%
Much more	3	19%
N/A	2	13%

Question 29	count	%
Very Low	1	6%
Low		0%
Moderate	6	38%
High	5	31%
Very High	4	25%

Question 30	count	%
Unfamiliar	3	19%
Slightly familiar	2	13%
Familiar	6	38%
Very familiar	2	13%
Expert	3	19%

Question 31	count	%
yes	5	31%
no	11	69%

Question 32	count	%
Very Low	1	6%
Low	2	13%
Moderate	4	25%
High	3	19%
Very High	6	38%

Question 33	count	%
yes	14	82%
no	3	18%

Ninyo & Moore

APPENDIX C

INTERVIEW SUMMARIES:

ARIZONA DEPARTMENT OF WATER RESOURCES
NATIONAL RESOURCES CONSERVATION SERVICE
UNITED STATES ARMY CORPS OF ENGINEERS

Interview of: Jon Benoist, P.E. - Senior Dam Safety Engineer
Agency: Arizona Department of Water Resources (ADWR)
Subject: Utility Penetration Guidelines
Interviewers: Brett Howey (The District)
Steve Nowaczyk (Ninyo & Moore)
Date: April 7, 2005

- The District informed ADWR of Ninyo & Moore's task to create unified guidelines regarding the protocols and technical best practices that need to be followed when one wishes to penetrate and earth dam with an underground utility.

- The District also informed ADWR of Ninyo & Moore's plans to host a workshop in May (later this workshop was rescheduled to June 1 and 2). The purpose of the workshop would be to discuss the following:

  - Case studies and dam safety.

  - Technical issues encountered when penetrating utilities through earth dams. Utility companies would be informed that these methods are more complex than the method of cutting and soil backfilling.

  - Update all parties attending so there is a general understanding as to what the direct issues are regarding earth dam penetrations.

  - Failure Modes and Effects workshop. During this portion of the workshop, Jim Talbot would discuss penetrations, failure, and designs that can be used in an effort to help establish the guidelines.

  - How ADWR has interacted in the past with these types of applications, how well it worked or did not.

- ADWR recommended separate guidelines for shallow utilities and deep utilities. Separate guidelines were also recommended for the different sizes of utility conduits.

- When asked if ADWR prefers a shallow utility to a deep one, ADWR mentioned that the shallow penetrations (about three feet beneath the crest) impose less damage on the dam than a deeper one. ADWR also mentioned that they do not foresee failure modes occurring to the residual freeboard (freeboard from the PMF water surface to the top of the crest). This is because for residual freeboard, theoretically, there is never water other than waves. ADWR also mentioned that a shallow penetration could be excavated, cleaned, and backfilled with a low-strength concrete. However, to be extra cautious with the shallow excavations, it was suggested that a filter diaphragm be added to the excavated area.

- If the work is being done in the roadway, ADWR does not consider that being in the dam due to the presence of fill between the dam and the road. It needs to be determined whether or not work is being done in the dam. If it is determined that work is not being done in the dam, ADWR will not be involved but would like to be informed of, and included in, this de-

cision making process. ADWR suggested that this is one of the first things that the owner should check.

- ADWR recommended that there be a pre-application process for utility companies who want to penetrate the dam.

- ADWR suggested that there be a program advising utility companies to contact the owner of the dam prior to excavation. This could be done by means of a sign along a dam, or by annual programs or flyers. Once contacted, the owner of the dam could tell the utility companies to follow the guidelines set by the District.

- ADWR suggested that a checklist be provided to utility companies to make sure all processes are completed. The District suggested that a letter of authorization from the District should be the first thing mentioned on the checklist, and then presented to ADWR.

- ADWR brought up the issue of pressurized versus non-pressurized pipes and how to encase the pressurized pipes penetrating the dam. The question that was raised concerned the necessity of steel reinforcement being utilized for casing, or if low strength concrete would be adequate for casing. The District mentioned that this was a good topic for discussion in the Failure Modes and Effects Workshop. Problems were discussed about the use of concrete casing. In past cases, companies have backfilled the excavation with concrete then weighed down the pipe with anchors and the pipe floated to the top of the concrete.

- ADWR expressed concern about pressurized pipes crossing over the dam. The agency wants certain guidelines for construction of such pipelines to be put in place. A notification to the dam owner, however, would suffice for non-pressurized lines that will cross over a dam. For notification, the utility owner should present a cross section and plan sketch to the dam owner for clearance.

- ADWR expressed concern with the accuracy of the maps provided by utility owners during the application process. These maps are sometimes completely different from the maps that ADWR has. The District proposed that utility owners locate their utilities on ADWR approved maps. Ninyo & Moore suggested the possibility of putting the county maps online for the utility companies to plot their lines on.

- Ninyo & Moore, ADWR, and the District discussed the future of the guidelines being published online for companies to access and concurred that it would be helpful in streamlining the application processes.

- The District brought up the issue of dams where the structure would be compromised by the penetration of utilities. Utilities are not permitted to penetrate these dams. The District suggested publishing a list of these dams and posting them on the internet for easy access for the utility companies. ADWR responded with a suggestion of introducing a special use permit for utilities to cross over these dams versus penetrating them, and covering the utility with fill.

- Ninyo & Moore asked which methods of excavation will be permitted and methods that will not be permitted while installing utilities through the dams. The District mentioned that Mike Greenslade typically does not allow "blind installation" (trenchless installation) because of concerns about voids forming around penetration. In addition, the District also mentioned that as far as cost and practicality, a cut and cover method would be the best method.

- The District suggested the use of as-built plans of the dam to be incorporated into the guidelines illustrating specific parts of the dam where they will be placing the utility, and for roadway utilities to be situated above the dams. ADWR mentioned that there should be simple guidelines for the roadway utilities, but when the penetration exceeds the roadway fill and penetrates into the dam, a separate set of guidelines must be followed. Ninyo & Moore concurred with this idea and mentioned that this would be ideal for the contractor to help better understand the cost and scope of work to be performed. It may also persuade contractors to design their plans in accordance with the less complex guidelines.

- The District questioned if backfill methods need to be changed for a non-pressurized pipe installed in a roadway versus installation within the freeboard of the dam. ADWR mentioned that the materials should be mentioned during the workshop while discussing failure modes. Appropriate materials to be used and what are not appropriate to use should be discussed during the workshop. ADWR does not support the use of soil backfilling and prefers the use of slurry.

- The District suggested that trenches should be cleaned prior to backfilling with slurry. ADWR suggested that an inspection be performed before the slurry is put in place. Ninyo & Moore questioned if there should be an inspection for shallow excavations. ADWR responded that they would not need to inspect a shallow excavation.

- The District wants to make the application process for utility penetrations to operate smoothly and to let the applicant know the general timeframe that they will receive a response from them. ADWR and the District want to streamline the application process to help the operations run smoothly.

- The District and ADWR both concur with the idea that any company that has their utility crossing a dam must obtain a special use permit.

- Ninyo & Moore asked ADWR about common situations that ADWR would not permit certain design or construction procedures. ADWR responded by stating that the applicant must understand the scope of what is required for an application. In a lot of cases they do not understand the scope required.

- The District asked about the inclusion of a modified ADWR checklist into their application process. The modified checklist would eliminate components that would not be restrictive for simple penetrations. Ninyo & Moore asked ADWR if they require any type of geotechni-

cal work to be performed as part of their checklist. ADWR said that geotechnical work is not necessary for shallow excavations, and that the engineer would need to determine the filter type based upon the soil classification at the roadway. For deeper penetration, however, geotechnical work would need to be performed.

- Ninyo & Moore, the District, and ADWR discussed the appropriate times that a dam safety engineer must be on site. For simple jobs that do not penetrate the dam, (i.e. roadway work), a civil engineer can do the application process. For jobs that penetrate the dam, a dam safety engineer should prepare the application. They discussed how to apply for a permit without the use of a dam safety engineer in cases of working with a high-pressure line encased in concrete or #4 steel bars, or double sleeves over the dam. For certain cases where the high-pressure line is secured, a civil engineer should be permitted to submit an application.

- Ninyo & Moore asked if parallel utility penetration criteria differ from perpendicular penetration criteria. The District mentioned that it is similar to the perpendicular penetration criteria. The concern lies with the size of the utility, whether it is a 4-inch to 48-inch line, and whether it is pressurized or non-pressurized.

- ADWR is concerned about what distance should be considered between a utility and the dam for a line to be safely placed. ADWR suggested that there be a standard set as to the distance from the dam dependent upon the diameter of the line.

- The District suggested creating a standard guideline for utilities that run through the upstream reservoir. The District mentioned that Cassandra Wash has watertight lines and manholes for the utilities. There is no concern with the dam safety; however, the agency does have a concern for common safety.

- A concern about a foundation installation beneath a dam was expressed and the District mentioned that this should be a case specific situation. Case histories would need to be reviewed before the installation.

- During the FMEA workshop, ADWR wants to emphasize that the risk of utilities crossing dams increases with depth.

Interview of: John Harrington, P.E., State Construction Engineer, John Chua, P.E., State Design Engineer and Ilde Chavez, P.E., State Conservation Engineer
Agency: National Resources Conservation Service (NRCS)
Subject: Utility Penetration Guidelines
Interviewers: Brett Howey (The District)
Steve Nowaczyk (Ninyo & Moore)
Date: April 7, 2005

- The District informed ADWR of Ninyo & Moore's goal to create standard guidelines that utility companies that wish to penetrate earth dams can follow.

- The District informed NRCS that Ninyo & Moore has been compiling data to generate these guidelines and that utility companies will have to follow them to apply for permission to penetrate utilities through dams.

- The District also informed NRCS that Ninyo & Moore and the District have sent questionnaires to local municipalities to gain their feedback on dam safety guidelines.

- The District wanted to get some insight as to what NRCS has done in past cases with the right-of-way permit application process that utility owners had to follow to penetrate a dam with their utility lines.

- The District informed NRCS about the planned Failure Mode Workshop in May to educate utility companies about technical and dam safety issues.

- The District mentioned that in past cases when work was being performed at its dams, as owner of the dam, it was responsible for the safety operations. The District mentioned that, typically, once it set safety guidelines NRCS has always accepted them. The District asked NRCS how this method is working for them and if there can be improvements on this process. NRCS mentioned that currently, this process is working well.

- NRCS raised some issues of ADWR questioning if they take precedence over all guidelines. NRCS mentioned that they feel that their input on dam guidelines is ignored.

- When asked when during the application process NRCS wants to be involved, they said that they prefer to be involved early in the process, because it simplifies the application process. Early involvement also saves time for the applicant allowing them to satisfy all concerns at that time versus later in the application process.

- The District informed NRCS that there are several parts of a dam where the design changes and the design of shallow utilities differ from deeper utilities. The District mentioned that ADWR is not as concerned with the roadway utilities since they are shallow and do not penetrate the dam; however, their concern is with utilities that penetrate the dam. When

asked if NRCS is concerned with the roadway utilities, the response from NRCS was in agreement with ADWR.

- Ninyo & Moore asked NRCS if they prefer a formal or informal meeting early in the application process. NRCS responded by saying that ADWR will look to them as the record holders, therefore they prefer a formal meeting and a packet that contains design plans for the utility crossings.

- The District wants to include in the guidelines a requirement for utility owners to provide an alternative analysis to avoid penetration through the dam. The District mentioned that it should be one of the initial steps of the application process.

- Ninyo & Moore discussed creating and publishing online, a flow chart that illustrates the different levels of complexity involved in the process that a utility owner must follow when applying for a permit to penetrate a dam with their utilities.

- NRCS mentioned that it would be a minimum of 30 days to review and respond to an application submitted by a contractor. NRCS also requested to have attached to the submittal, an alternative analysis of the utility alignment. This would save NRCS from having to generate the alternative analysis themselves.

- The District broached a scenario where a utility company must cross their utility through a dam. The District asked NRCS if the utility company must follow NRCS design criteria, or if there are some other acceptable design criteria. NRCS said that the contractor can use other design criteria, but it would be checked against, and must pass the NRCS criteria. NRCS stated that it would simplify the process and save time if the utility company used NRCS design criteria. FCDMC suggested that if the contractor chooses to use another design criterion other than NRCS, they must present documentation that illustrates that the design criteria of their choice meets or exceeds the criteria set by NRCS.

- Ninyo & Moore asked NRCS for their opinion on having a single reviewer at the District, ADWR, and NRCS to review all permit applications. Ninyo & Moore informed NRCS that a single reviewer at each entity would be implemented after the application process has been streamlined. NRCS said that it is dependent upon their workload, but someone would review them.

- When asked if they have a protocol they follow to review applications, NRCS said that they do not have a formalized protocol in place.

- The District asked NRCS if they require a qualified dam safety engineer to prepare a design for the utility. NRCS said that the term "dam safety engineer" is not a part of their policy, but they do require a stamp and seal of a registered engineer.

- Ninyo & Moore asked NRCS what common reasons are for a submittal to be denied by them. NRCS said that if they do not receive design plans for excavation and backfilling it

would be returned. Also, receiving limited information from an applicant is an issue for NRCS.

- The District suggested the idea of during the installation of shallow utilities, a notification would be adequate for NRCS. However, if the excavations penetrate the dam, NRCS needs to be involved early in the application process. NRCS concurred with this suggestion. NRCS favors the idea to incorporate this as part of the flow chart that Ninyo & Moore discussed earlier.

- Ninyo & Moore asked NRCS if there are particular methods they prefer not to use during construction. NRCS does not feel that they have the level of experience or expertise to mandate what construction methods are appropriate or inappropriate. NRCS mentioned that it is a case-by-case situation. Ninyo & Moore suggested that the applicant should provide a detailed sequenced technique for construction in the initial submittal. NRCS and the District agreed.

- Ninyo & Moore asked NRCS if they have a construction monitoring process. NRCS said that they rely on the District for the monitoring unless they have the time to inspect.

- The District mentioned that there have been past cases of applicants giving incomplete applications to perform work, and entities have returned the applications without commenting on what components of the application are missing. The District asked NRCS if they provide comments on an incomplete application, informing the applicant what they are missing or what standards they are not in compliance with. NRCS said that they do include comments as to what is missing in the returned application.

Interview of: Mr. Ted Ingersol, P.E., Jim Farley, and Ted Masigat
Agency: United States Army Corps of Engineers (USACE)
Subject: Utility Penetration Guidelines
Interviewers: Brett Howey (The District)
Tom MacDougall (Ninyo & Moore)
Date: May 12, 2005

- The District informed USACE the task given to Ninyo & Moore to compile a general set of guidelines for utility companies who wish to penetrate dams operated by the District. The District clarified that this set of guidelines is not intended to be a document that utility owners follow automatically granting them permission to penetrate dams.

- USACE was informed that the District and Ninyo & Moore met with ADWR and NRCS to find out what their requirements are for utilities to cross their dams. The purpose of the meeting was to learn about USACE requirements for dam penetration.

- In most cases USACE is involved in the early stages of the application process. USACE wants to be notified of any modification of the dam. There have been past cases when a contractor gave 2 weeks notice to penetrate the dam, and USACE and the District denied them permission. For this reason, USACE prefers to be involved early to avoid this conflict.

- Once USACE grants a utility owner permission to penetrate its dam, a file number is assigned to the application and then it is dispersed to the appropriate departments (i.e. hydrology, dam safety, environmental, real estate etc.) for review. USACE mentioned that the applicant is typically unsure what to do to meet requirements for dam penetration. The following step in the process is to schedule meetings between the reviewers and the applicant to discuss what information is needed from the applicant. The USACE wants the local sponsor included in the meeting to keep USACE and the local sponsor in agreement with the requirements for the penetration. USACE considers the reviewing process with the local sponsor to be dual reviews in which both entities will assist the applicant with coming up with the appropriate design for the utility to cross through the dam.

- USACE is not concerned with the budget the contractor has set to penetrate their dams. The contractor has no other option but to follow their guidelines. The District concurred.

- The District mentioned that they do not owe applicants permission to cross their dams and that it is an opportunity rather than a right.

- The District summarized this portion of the meeting by stating that the review process will be discussed between the local sponsor and the USACE until a design has been created by the applicant that satisfies all comments and concerns.

- Following the construction of the utility penetrating a dam, USACE requires that there be an inspection. The inspection would assist with identifying any settlement within their constructed zones. In certain instances, the USACE may place a comment on the design plans to contact them prior to construction so that they can be on site, or provide records to track events during construction. The District stated that depending on the complexity of the con-

struction, the USACE becomes involved either during or after construction, or both to insure the structures are acceptable.

- The District asked USACE about correspondence received from the applicant if the local sponsor should be involved with the applicant directly or if the USACE should be involved with the applicant directly. USACE replied that the applicant typically wants to work with them directly during preliminary meetings to gather information of the dam.

- Ninyo & Moore commented that there should be a streamlined set of guidelines produced to optimize the turnaround time and eliminate the involvement of politicians, which have been problems in past cases. USACE responded to this by stating that the dam was built by use of federal funding and that the USACE is mandated to protect that dam. USACE further added that due to the construction of the dam paid for by federal funds, they are involved in the political aspect as well; should the applicant take the issues to their politician. There are situations where the applicant is upset with the guidelines set by USACE and expresses their concern with their politician that the USACE guidelines cost too much requiring more money and time than budgeted. USACE stated that they will not change their guidelines and restated that they are not concerned about the applicant's budget for the project. It is USACE's job to protect the dam despite the cost and time it takes.

- USACE said that they could provide a list of their general concerns that commonly arise during projects involving penetrations through dams.

- For abandonment of dam penetrations, USACE generates a list of considerations that the applicants must address in their design prior to the design presentation to USACE. Ninyo & Moore asked USACE if the considerations are site specific, or if the considerations can be made into a generalized list. USACE responded that it is probable to make a generalized list for the applicant to use.

- USACE mentioned that during construction of a pipe penetration through an embankment, a soft spot in the dam is not created.

- USACE wants applicants to grout around the pipe instead of putting in collars to reduce transverse cracking. The grouting is to be designed so that hydraulic fracturing of the structure does not occur.

- USACE would require a filter diaphragm and drain constructed on the downstream side of the penetration. Should seepage occur, there would be a drain to collect the water. The applicant must know what materials are in place at the site, and that the penetration of the utility should be designed accordingly. The District mentioned that if the penetration occurs through a rock abutment a filter diaphragm is not necessary. However, a filter diaphragm is required for a penetration through an embankment. USACE agreed to this.

- In a zoned dam, the USACE requires the outlet works to go through the core to prevent settling in the dam. The District asked USACE their opinion about a post construction utility

installation in a zoned dam; what weaknesses could occur during the installation of the utility. The requirement that USACE has had in past cases is that the utility penetrate beneath constructed foundation. This was a case of a gravity sewer effluent and a water line.

- USACE indicated that they prefer penetration of utilities beneath the constructed foundation to penetration through the embankment.

- The District asked USACE whether they preferred freeboard or residual freeboard areas for penetration. USACE said that if penetration is to be in the freeboard area, they prefer to see a sloped trench versus a vertical trench. USACE prefers this because transverse cracking will occur in a vertical trench if water gets into it.

Ninyo & Moore

APPENDIX D

WORKSHOP RELATED ITEMS

ONE DAY INVITATION AND AGENDA
TWO DAY INVITATION AND AGENDA

PRESENTATIONS BY:

TOM RENCKLY, P.E.
BRETT HOWEY, P.E.
BRETT HOWEY, P.E.
CLAUDIA FISHER
J. DAVID DEATHERAGE, P.E.
ERIC LAURIN
BRETT GILLESPIE
JAMES R. TALBOT, P.E.
DANNY McCOOK, P.E.
JAMES R. TALBOT, P.E.
JAMES R. TALBOT, P.E.
JAMES R. TALBOT, P.E.

May 4, 2005

«Title» «FirstName» «LastName»
«JobTitle»
«Company»
«Address1»
«City», «State» «PostalCode»

«Title» «LastName»:

Continued urbanization in Maricopa County has led to increased right-of-way requests with the Flood Control District of Maricopa County (District) for utilities to cross District flood control dams. To assist right-of-way applicants and their engineers with the design process and preparation of permit documentation, the District has retained a team of local and national civil engineering consultants to aid in the development of permitting and design guidelines.

You have been identified as an important stakeholder with expertise related to utilities and/or dam technology. Your input and participation in the guideline development will be significant. Therefore, the District would like to invite you to a 1-day informational and technical workshop on Embankment Dam Utility Penetrations as follows:

Wednesday June 1st, 2005
Flood Control District of Maricopa County
2801 West Durango Street, Phoenix
Adobe Room – 1st Floor
Workshop 8:00 a.m. – 4:00 p.m.

A detailed agenda is enclosed for your information. A light lunch and morning refreshments will be provided. The workshop is free to attendees, however, other expenses incurred including time or travel will not be reimbursed by the District.

We look forward to your participation. Please **RSVP** by **Friday May 20, 2005** to my attention at bah@mail.maricopa.gov, (602) 506-4609 or contact me for more details on this exciting project.

Sincerely,

Brett A. Howey, P.E.
Dam Safety Engineer
Structures Management Branch

Embankment Dam Utility Penetration Workshop

Wednesday June 1st, 2005
Flood Control District of Maricopa County
2801 West Durango Street, Phoenix
Adobe Room – 1st Floor

AGENDA

Wednesday, June 1, 8:00AM – 4:00PM

7:30	*Light Refreshments*
8:00	General Introductions
8:15	Presentation of FCDMC Dam Safety Program, Guideline Development Project, and Current FCDMC Permitting Process (Tom Renckly, P.E. – FCDMC & Brett Howey, P.E. – FCDMC)
9:30	Presentation of Utility Planning and Common Industry Practices (Claudia Fisher – Southwest Gas)
10:00	*Break*
10:15	Presentation of Case Histories • Design Techniques (David Deatherage, P.E. – Copper State Engineering) • Design & Construction Techniques (Eric Laurin, P.E. – Coe & Van Loo) • Installation Techniques (Brett Gillian – Haydon Building Corporation) • Dam Failures Caused by Penetrations (Jim Talbot, P.E. – Consulting Engineer)
11:45	*Lunch (provided by FCDMC)*
12:45	Case Histories *Continued* • Dam Failures Caused by Penetrations (Danny McCook, P.E. – NRCS, Fort Worth Texas)
1:45	Mechanics of Dam Failures Caused by Penetrations (Jim Talbot, P.E. – Consulting Engineer)
2:45	*Break*
3:00	Open Discussion Forum
4:00	Adjourn

May 4, 2005

«Title» «FirstName» «LastName»
«JobTitle»
«Company»
«Address1»
«City», «State» «PostalCode»

«Title» «LastName»:

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You have been identified as an important stakeholder with expertise related to utilities and/or dam technology. Your input and participation in the guideline development will be significant. Therefore, the District would like to invite you to a 2-day informational and technical workshop on Embankment Dam Utility Penetrations as follows:

Wednesday June 1st & Thursday June 2nd, 2005
Flood Control District of Maricopa County
2801 West Durango Street, Phoenix
Adobe Room – 1st Floor
Workshop 8:00 a.m. – 4:00 p.m. each day

A detailed agenda is enclosed for your information. A light lunch and morning refreshments will be provided both days. The workshop is free to attendees, however, other expenses incurred including time or travel will not be reimbursed by the District.

We look forward to your participation. Please **RSVP** by **Friday May 20, 2005** to my attention at bah@mail.maricopa.gov, (602) 506-4609 or contact me for more details on this exciting project.

Sincerely,

Brett A. Howey, P.E.
Dam Safety Engineer
Structures Management Branch

Embankment Dam Utility Penetration Workshop

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Flood Control District of Maricopa County
2801 West Durango Street, Phoenix
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1:45	Mechanics of Dam Failures Caused by Penetrations (Jim Talbot, P.E. – Consulting Engineer)
2:45	*Break*
3:00	Open Discussion Forum
4:00	Adjourn

Thursday, June 2, 8:00AM – 5:00PM

7:30	*Light Refreshments*
8:00	Review of Failure Modes Analysis Approach
8:30	Failure Modes Analysis of Utility Penetrations (facilitated by Jim Talbot, P.E. – Consulting Engineer)
10:00	*Break*
10:15	Failure Modes Analysis *Continued*
12:00	*Lunch (provided by FCDMC)*
1:00	Failure Modes Analysis *Continued*
3:00	*Break*
3:15	Failure Modes Analysis *Continued*
5:00	Closing & Adjourn

FLOOD CONTROL DISTRICT OVERVIEW

DAM SAFETY PROGRAM

Presented by

Tom Renckly, P.E.

Embankment Dam Utility Penetration Workshop
June 1, 2005

Flood Control District Overview
Dam Safety Program

Tom Renckly, P.E.
Branch Manager
Structures Management Branch

Mission

To provide flood hazard identification, regulation, remediation, and education to the people in Maricopa County so that they can reduce their risks of injury, death, and property damage due to flooding while enjoying the natural and beneficial values served by floodplains.

District Background

- Founded in 1959
- Municipal Corporation
- Secondary Property Tax Funding
- Governed by BOD/BOS

2005 Challenges

- Growth
- Aging Infrastructure
- Environmental Requirements
- Public Expectations
- Rights-of-Way Costs
- Future Funding

Strategic Programs

Education — To provide information to the public so that they can be more knowledgeable about the risks of floods and flood hazards, and the projects, studies, and activities that will affect them.

Identification — To provide the identification of, and alternative solutions to flood hazards, and flood warning data to public and private organizations so that they can incorporate knowledge of flood hazards in their plans within presently developed and future urban growth areas.

Regulation — To provide guidance, direction, and enforcement for the public so that they can avoid causing adverse impacts to floodplains, and use their property safely and in compliance with applicable state and federal laws.

Remediation — To provide protection to the public from flood hazards through structural mitigation and buy-out so that they can live with an acceptable risk from loss of life or property due to flooding.

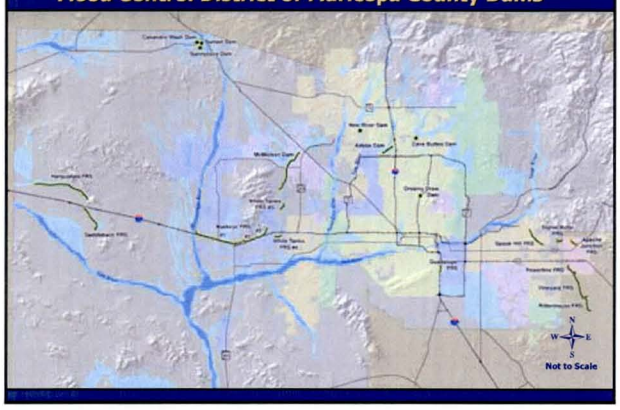
Strategic Goal

To balance the tools and resources provided to the District to maximize public protection and minimize risk from storm water flooding events.

Education
Identification
Regulation
+ Remediation

Optimum Flood Hazard Mitigation

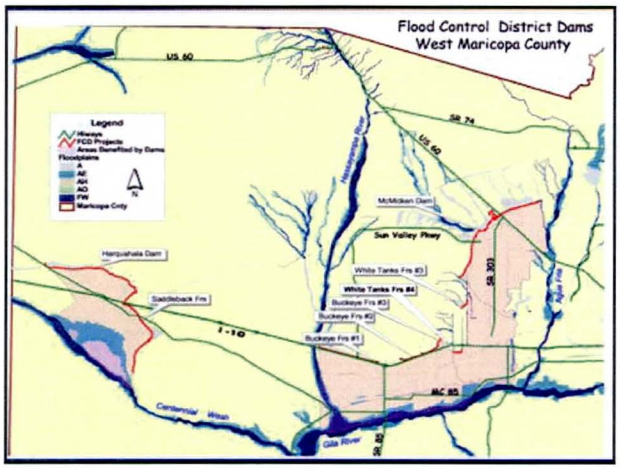
Flood Control District of Maricopa County Dams

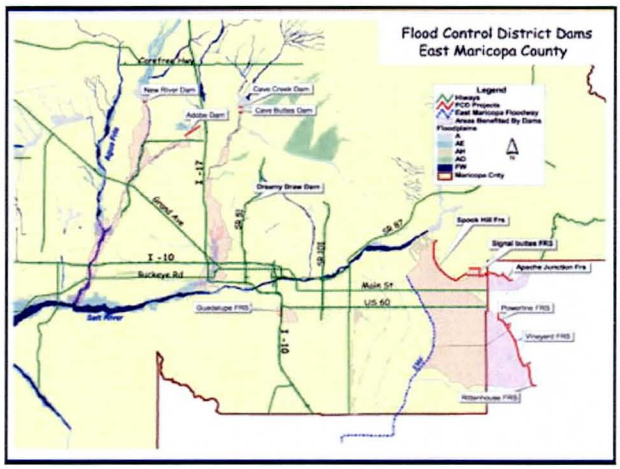


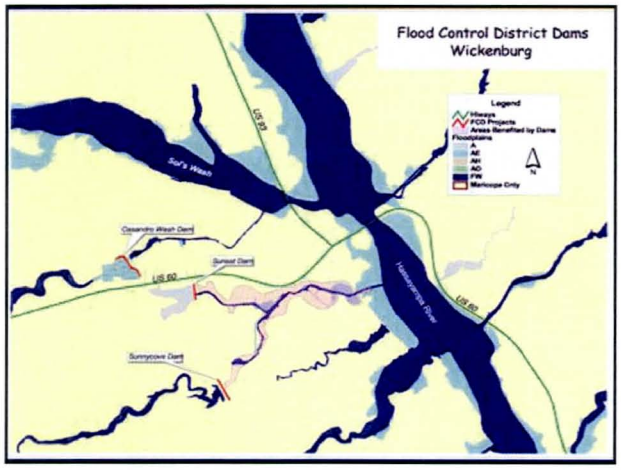
Flood Control District Dams

Background

- Operates and Maintains 22 Flood Control Dams
- 16 Dams Built by Natural Resources Conservation Service (NRCS - Formerly SCS)
- 5 Dams Built by Corps of Engineers
- 1 Designed and Built by District
- Dams Total 64 Miles in Length
- Was Local Sponsor for NRCS and Corps Dams
- Arizona Department of Water Resources is the Jurisdictional Agency







Powerline FRS, Vineyard Road FRS, Rittenhouse FRS

Dam Safety Program Activities

- Recurrent Dam Safety
- Structures Assessment
- Dam Rehabilitation

Recurrent Dam Safety Activities

Dam Safety Inspections

- Annual Inspections
- Quarterly Inspections
- Event Inspections
- Outlet Inspections

Recurrent Dam Safety Activities

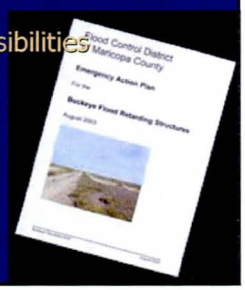
Dam Surveys

- GPS Surveys
- Physical Changes
  - Land Subsidence
  - Embankment and Foundation Settlement
- Evaluate Trends
- Actions

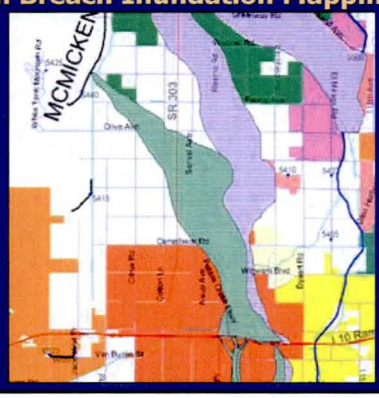
Recurrent Dam Safety Activities

Emergency Action Plans

- Significant Flood Events and Related Emergency Conditions
- Define Agency Responsibilities
- Inundation Mapping
- Required by ADWR
- Updating All EAPs



Dam Breach Inundation Mapping



Dam Breach Inundation Mapping

Unauthorized Utilities At Guadalupe FRS

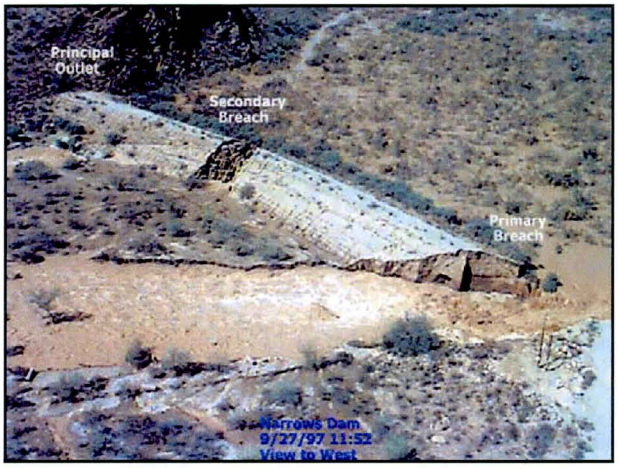
Electrical Lines
Dam #2

Trench for Irrigation Line at Dam No.1

Unauthorized Utilities At Guadalupe FRS

Fiber Optics Line
Dam No.2

Irrigation Lines
Dam No. 1



Structures Assessment

Phase I

- Individual Structures Assessment
  - Data Review, Dam Inspections, Failure Modes Analysis
- Conceptual Alternatives
  - Structural and Non-Structural

Structures Assessment

Phase II

- Site Specific Field Investigations, Analysis and Repairs at Dams
- Special Studies - Overall Technical Evaluation of Issues Common to Many District Dams

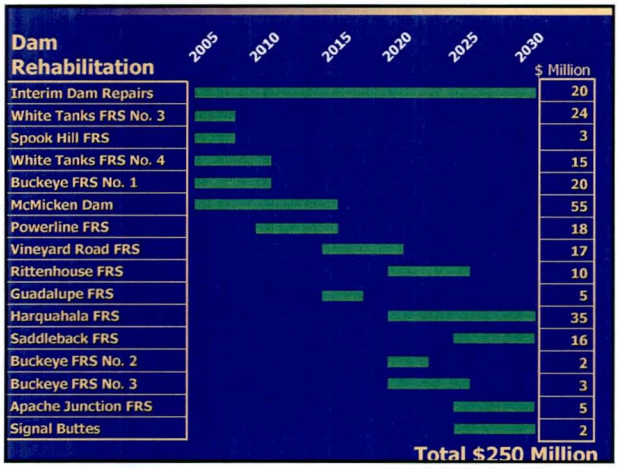
Buckeye FRS # 1

2004 Transverse Cracks Investigation and Repair

Dam Rehabilitation

Dams Status

- Overall Dams are Well Maintained
- Recurrent Dam Safety Activities and Structures Assessment are Keeping the Dams Safe to Operate for the Short Term and Interim Term
- 15 Dams Identified for Rehabilitation or Replacement
  - 14 NRCS Dams, 1 Corps of Engineers
- Total Length of Dams 60 miles
- $230 Million – 25 Years



QUESTIONS

Tom Renckly, P.E.
Structures Management Branch Manager
Planning and Project Manager Division

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP

Presented by

Brett Howey, P.E.

Embankment Dam Utility Penetration Workshop

June 1, 2005
Flood Control District of Maricopa County

Brett Howey, P.E.
Dam Safety Engineer
Structures Management Branch

Working to Improve Our Services

Dam Crossing Requests

- Urbanization has Increased Right-of-Way Requests to Cross District Dams with Utilities
- Dam Crossings have Greater than Typical Technical Design Requirements
- Currently Each Applicant is Individually Informed of Technical Dam Safety Complexities

Working to Improve Our Services

Need for Standard Guidance

- Applicants Tend to be Unacquainted with District Dam Locations & Dam Safety Concerns
- Multiple Submittals Result to Address Dam Safety Concerns
- Schedules & Budgets Often Impacted
- Multiple Agency Involvements

Working to Improve Our Services

Solution

Development of Design Guidelines Will.....

- Provide Navigation through Permit Process
- Detail Restricted Locations & Techniques
- List Required Submittals & Fees
- Provide Design Requirements Based on Industry Accepted Procedures
- Provide Example Submittals

Working to Improve Our Services

"Win – Win"

Right-of-Way Applicants
- Saves Time & Resources
- Better Understanding of District Expectations

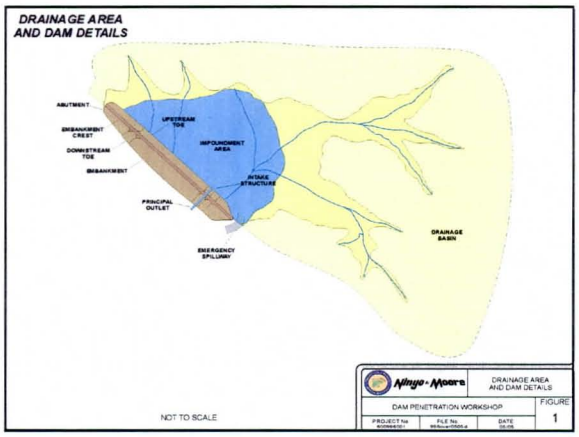
District
- Insures Continued Safe Operation of Dams
- Improves Review Efficiency & Approval

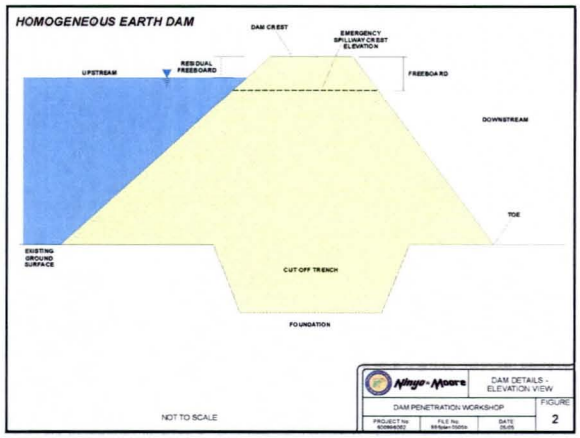
Workshop Goals

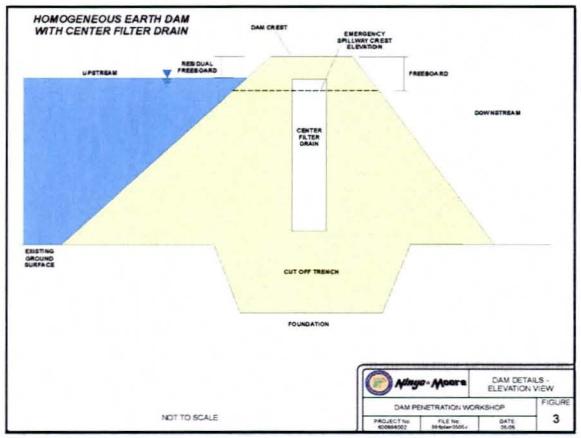
Education

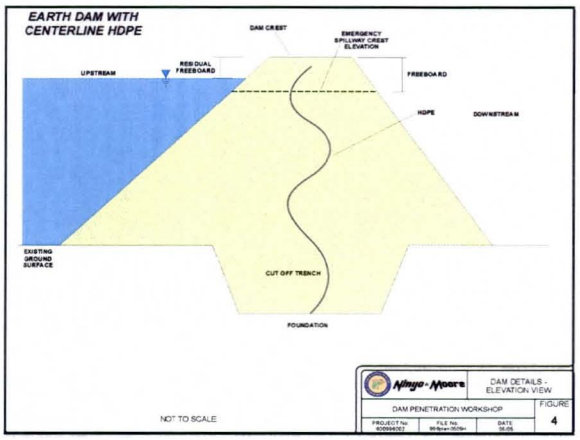
Increase Understanding of:
- Dam Safety Concerns & Risks Related to Utility Penetrations
- Location & Operation of District Dams
- Utility Industry
- Utility Planning, Design, & Construction
- Mechanisms of Dam Failure Resulting from Penetrations

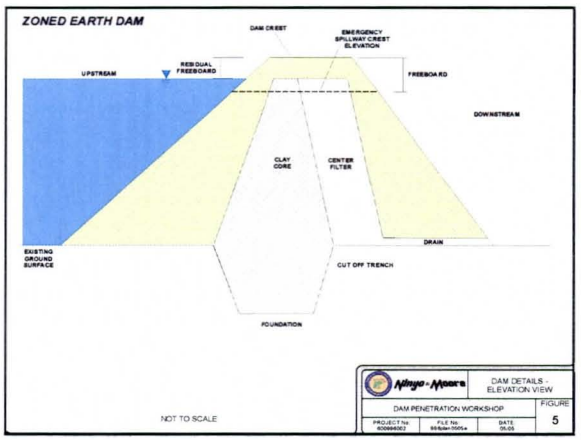
Dam Terminology

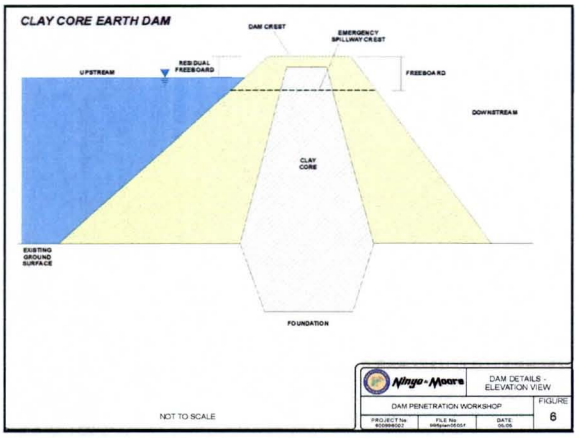




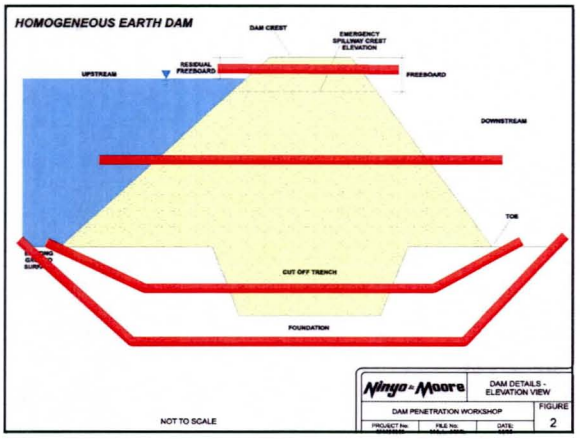


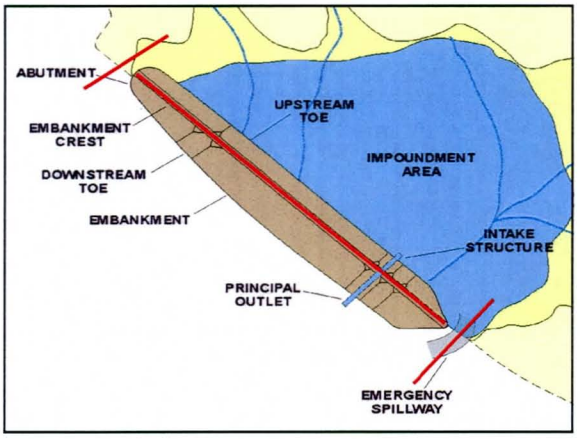






What is Considered a Penetration?





Questions

Brett Howey, P.E.
Dam Safety Engineer
Structures Management Branch

RIGHT-OF-WAY PERMITTING

Presented by

Brett Howey, P.E.

Right-of-Way Permitting

Embankment Dam Utility Penetration Workshop
June 1, 2005
Flood Control District of Maricopa County

Brett Howey, P.E.
Dam Safety Engineer
Structures Management Branch

Right-of-Way Authority

Resolution FCD 2002R002

- Authority to Regulate and Control District Real Property
- Authority to Issue and Enforce Permits to Maintain Safe Flood Control Operation
- Authority to Inspect
- Authority to Collect Permit Fees
- Authority to Collect After-the-Fact Fees

Permit Types

- Ingress/Egress
- Utility in District Right-of-Way
- Recreational Use Permit
- Storm Water Runoff/Drainage

Permit Application Process

(1) Meet with District Early to Discuss Conceptual Plans
(2) Complete Application Form
(3) Submit Completed Form, Application Fee, Full-size Plans and/or Drainage/Engineering Reports to District Right-of-Way Permit Specialist
(4) Payment of Review Fee
(5) ADWR and NRCS or USACE Heads-up
(6) District Review & Comment (back & forth)
(7) State/Federal Review & Permitting
(8) Final Plan Approval Letter Issued by District
(9) Right-Way-Permit Issued After Contractor Submits:
- Certificate of Insurance
- Performance Bond
- Payment of Any Outstanding Fees

Permit Closeout Process

(1) District Inspector Verifies Construction was in Accordance with Approved Plans
(2) As-built Plans are Requested from Permitee
(3) If Applicable, an Easement is Prepared and Finalized
(4) Performance Bond is Released
(5) Permit is Closed by the District

Insurance/Bonding Requirements

Commercial & General Liability
$2,000,000 General Aggregate
$2,000,000 Products/Completed Operation Aggregate
$1,000,000 Each Occurrence
The District is to be Named as Additional Insured

Performance Bond
$10,000 Minimum
$25,000 Minimum when Impacting a Dam

Permit Fees

Permit Filing	$250 /application
Temporary Access	$325 plus Rent
Permanent Installation Review	$650 /application $325 /review and each thereafter
Inspections	$70 to $90 depending on distance
Rent (if applicable)	$600 min. or appraised value
Easement	$600 min. or appraised value
Appraisal Fee	$250 in-house review or actual cost incurred for outside review
Extensions	$50 plus rent and extensions
After-the-Fact Permit	$1,500 plus standard fees

Permit Review

Permit Specialist Acts as District Point of Contact and Liaison Between District and Permitee

Permit Specialist Routes Plans for Review & Comment to:

- Lands Division
- Engineering Division
- Regulatory Division
- O&M Division
- Structures Management Branch
- Any Other Related Project Managers

Permit Specialists

West Valley
Angie Hardesty
(602) 506-5476
alh@mail.maricopa.gov

East Valley
Shelby Brown
(602) 506-4583
sjb@mail.maricopa.gov

Questions

Brett Howey, P.E.
Dam Safety Engineer
Structures Management Branch

ROUTE SELECTION AND PLANNING PROCESS

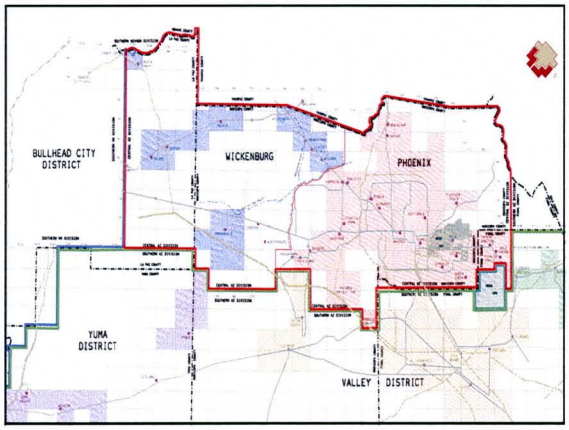
Presented by

Claudia Fisher

SOUTHWEST GAS CORPORATION

Route Selection and Planning Process

Presented by
Claudia Fisher
Distribution Engineer
Southwest Gas Corporation
June 1, 2005



Central Arizona Division

- **36 permitting agencies**
- **2,400 permits processed in 2004**
- **Pipeline covers 24,000 square miles**
- **24,000 miles of distribution main and 461 miles of transmission main**
  - **9,578 miles of main in Central Arizona**
- **Install an average of 35 miles of main/year**
- **Serve 780,000 customers in Arizona**

Route Selection

- Customer Requirements
- Timeline
- Available Right of Way (ROW)
- Cost
- Constructability
- Limitations

Customer Requirements

- Location and layout of development
  - Serve model phase first
- Anticipated capacity requirements
  - Dictates pipe size and pressure
- Timeframe

Timeline Dictated by:

- Municipalities
  - Capital Improvement Projects
  - Events (Festivals, Sports Events, etc.)
- Developer
- Weather
  - Monsoon Season
  - Heating Season
- Agencies permit approval time

Available ROW

- Prefer to locate facilities within ROW
  - Generally shorter permitting timeframe
  - Less costly than acquiring easements from private land owners
- Restrictions while in the ROW
  - Congested with other utilities
  - Working hours
  - Lane closures
  - Pavement repair issues
  - Installation methods

Cost

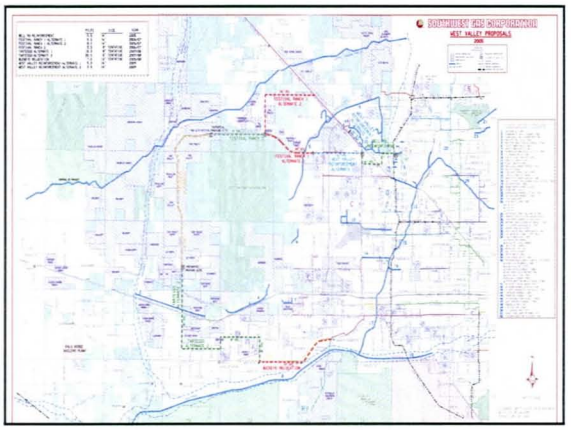
- Attempt to determine the shortest possible route to minimize labor and material costs
- Allow longest possible timeframe for construction
- Avoid purchasing private easements
- Select most constructible route

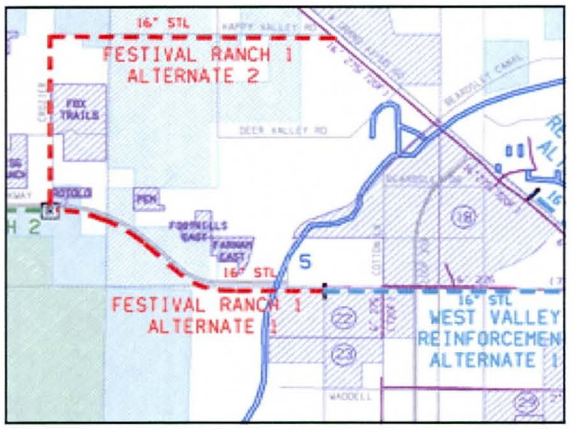
Constructability

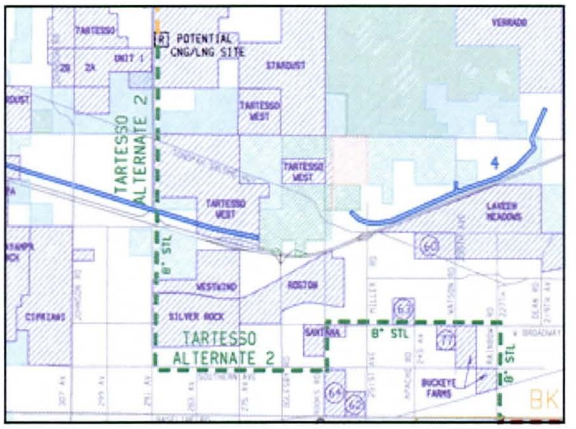
- Best case scenario:
  - Open cut straight trench in dirt
- Avoid installing elbows
- Limitations on pipe installed via bore
- Work space requirements for large equipment
- Major obstacles
  - Rail Roads, Rivers, Freeways and…Dams

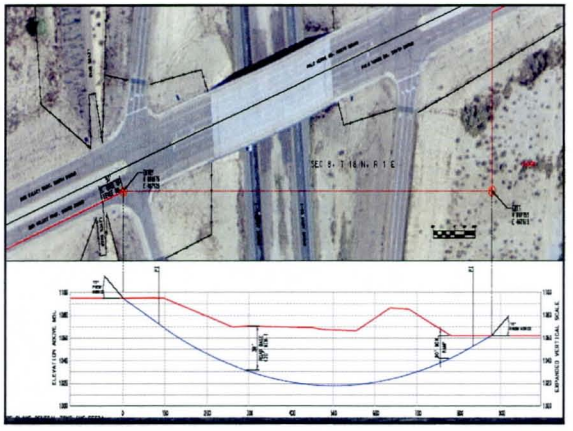
Limitations to Consider

- Growth dictates expansion
- Source of Gas
  - El Paso Natural Gas
- Pressure, Pipe Size and Materials
  - DOT Requirements (49 CFR Parts191-192)
- ROW
  - Time and Cost limitations







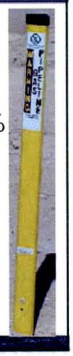


Hurdles when crossing FCD structures

- Identifying Flood Control District Structures
- Design Requirements
- Construction Requirements
- Permitting Process

Safety and Maintenance

- Valves and blowdown assemblies are installed to isolate major structures
- Hydrostatic pressure testing to 90% of SMYS
- Corrosion control
- Biannual patrols of pipelines
- Annual leak survey of pipelines
- Gas line markers



SOUTHWEST GAS CORPORATION

Questions?

- 36 permitting agencies
- 2,400 permits processed in 2004
- Pipeline covers 24,000 square miles
- 24,000 miles of distribution main and 461 miles of transmission main
- 9,578 miles of main in Central Arizona
- Install an average of 35 miles of main/year
- Serve 780,000 customers in Arizona

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP

CASE HISTORIES - DESIGN TECHNIQUES

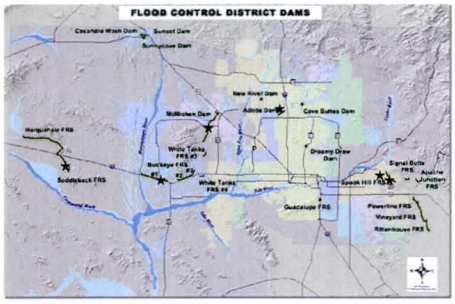
Presented by

J. David Deatherage, P.E.

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP

Case Histories - Design Techniques

J. David Deatherage, P.E.
Copper State Engineering, Inc.



Historical Dam Failure Review Facts:
60% of failures in earth dams greater than 50 feet in height in the western US are the result of piping failures, as compared with 20% in the eastern US.
Source: USBR-Technical Services Center

Causes of increased piping failures in arid region dams:
•Many dams are dry for decades. Plastic embankment soils desiccate, yielding cracks susceptible to piping.
•Moisture sensitive foundation soils "collapse" causing differential settlement cracks susceptible to piping.
•Dispersive soils are sometimes encountered that are very susceptible to piping.

Utility penetrations through arid western dams must not increase the potential for piping failures. Govt. agencies note the following:

•USBR - The use of conduits through embankments should be avoided when safe and cost-effective alternatives are available.
•Corps of Engineers - In future designs, cutoff collars for seepage control are not to be provided for conduits through earth and rockfill dams.
•USBR - Seepage along the conduit will be controlled by installation of a properly graded filter around the conduit at the downstream slope of the impervious zone.

Concerns with buried utility crossings of dam crests:

•Corrosion of metal utility components
•Lack of construction monitoring
•Piping of dam materials into conduit
•Piping of dam materials around conduit
•Erosive flow out of conduit

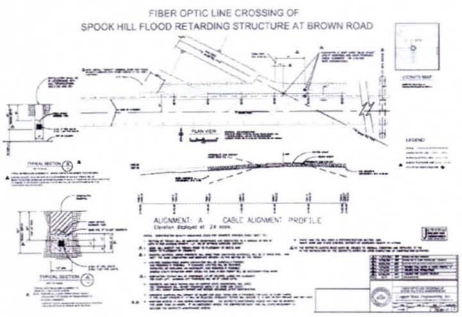
EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

Dam Utility Crossing Design References Sources:

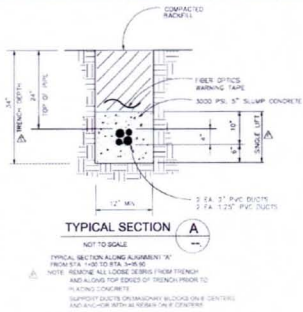
- Design of Small Dams - USDI-Bureau of Reclamation
- Seepage Drainage and Flow Nets - Cedergren
- Advanced Dam Engineering - Jansen
- Protective Filters - Standard No. 13 -USDI Bureau of Rec.
- Basic Properties of Sand and Gravel Filters - ASCE - JGED
- Filters for Silts and Clays - ASCE - JGED

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE



EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE



EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

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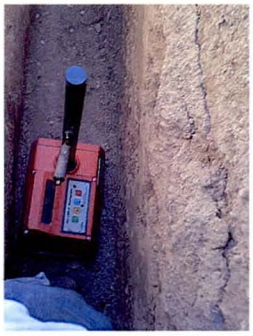

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

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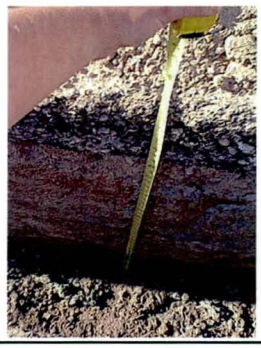

EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

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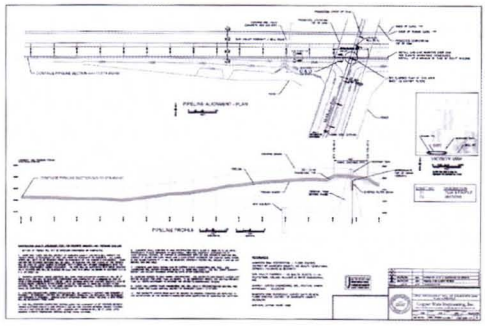

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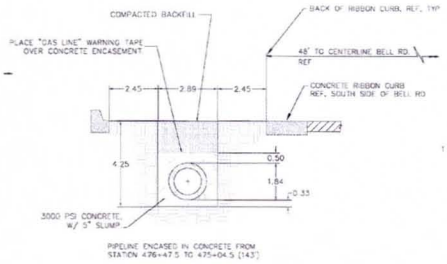

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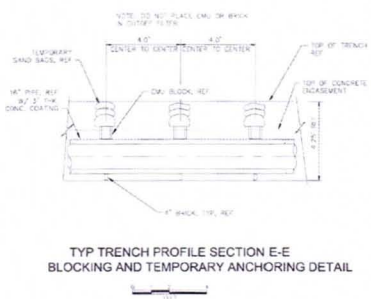

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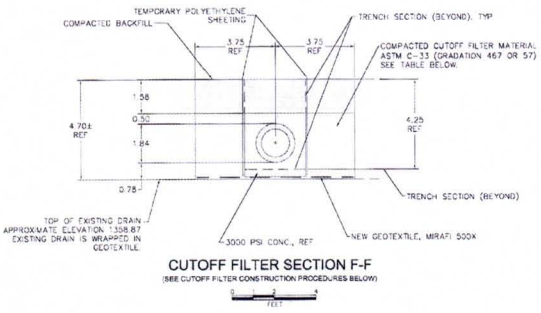

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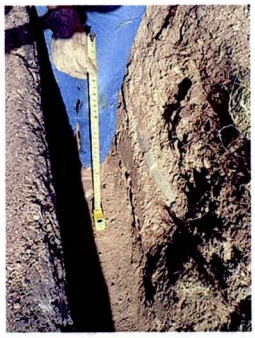


EMBANKMENT DAM UTILITY PENETRATION WORKSHOP - CSE

Based on our experience, Copper State Engineering suggests that certain buried utilities can cross through the crest of earth fill dams in Maricopa County utilizing a simplified design and permitting procedure, providing the following criteria is met:

- the crossing does not penetrate an impervious core or filter zone in the dam
- the crossing is within the freeboard of the dam, above the designed maximum water surface elevation
- the utility is a dry (electric or telecommunication) or a pressurized gas (natural gas), and does not contain a possibly erosive liquid (water or gasoline)
- the crossing occurs in a roadway crossing the dam that is built up to the same or higher elevation as the crest of the dam
- the original design information for the dam is reviewed as part of the crossing design and permitting
- the crossing in in a portion of a dam not significantly compromised by loss of freeboard due to ground water subsidence
- the dam crest soils are not significantly dispersive

ADOBE DAM SEWER CROSSING:

A CASE HISTORY IN PIPE PENETRATION USING PIPE RAMMING

Presented by

Eric Laurin

EMBANKMENT DAM UTILITY PENETRATIONS

Flood Control District of Maricopa County
June 1, 2005

ADOBE DAM SEWER CROSSING:
A Case History in Pipe Penetration Using Pipe Ramming
1999 - 2000

Adobe Dam

- Flood Control (Skunk Creek)
- Earthen Dam Structure
- Located in North Phoenix from 30th Avenue to 43rd Avenue Crossing Deer Valley Alignment

Why Was Penetration Necessary?

- Adobe Highlands
- 200 Acre Residential Development
- Sewer Service Required
- City of Phoenix Stipulated Gravity Service
- Sewer Outfall Just East of 35th Avenue

Regulatory Interface & Approvals

- ACOE, FCDMC, ADWR Dam Safety Division
- City of Phoenix Water Services
- City of Phoenix DSD

Project Requirements

- Don't Disturb Core
- Don't Create a Path for Water
- Do Monitor Real Time Impacts
- Do Provide For Permanent Inspection Opportunity
- Meet ALL Sewer Design/As-Built Criteria

Penetration Techniques

- No Dig Alternatives Only
- Pipe Ramming Selected
  - Meets Criteria
  - Used By ADOT
  - Local Experience

VIDEO

CONCLUSIONS

- Long Distance = Decreasing Rates of Advancement
  = Increased Chance of Deflection
- Thorough Knowledge of Soil Conditions and Dam Construction Needed.
- Vigilance During Operation
- End Result: No Impact to Dam

THANK YOU!!!!

ANY QUESTIONS??

Supplemental Notes

for Presentation by

Eric Laurin

ADOBE DAM SEWER JACK/BORE

GENERAL SEWER NOTES

ALL CONSTRUCTION TO CONFORM TO M.A.G. SPECIFICATIONS AND DETAILS AND TO CITY OF PHOENIX SUPPLEMENTS TO M.A.G. SPECIFICATIONS AND DETAILS, UNLESS MODIFIED ON THE PLANS.
1.0 INSPECTION (SEE CITY OF PHOENIX SUPPLEMENT TO M.A.G. SPECIFICATION SECTION 615.8.1). 100% OF PIPE.
THE FOLLOWING M.A.G. DETAILS ARE SPECIFICALLY NOT APPROVED:
425 24" ALUMINUM MANHOLE FRAME AND COVER.

ALL COMPACTION TO BE TYPE 1 COMPACTION PER SEC. 601.

ENGINEER'S NOTES/SEWER

THESE PLANS ARE NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS THE APPROVAL BLOCK HAS BEEN SIGNED BY THE APPROPRIATE AGENCIES. ALL WORK SHALL CONFORM TO THE CURRENT M.A.G. SPECIFICATIONS AND STANDARD DETAILS TOGETHER WITH THE SUPPLEMENT OF THE APPROPRIATE AGENCY.

THE CONTRACTOR SHALL MAKE NO CLAIM AGAINST THE OWNER OR THE ENGINEER REGARDING ALLEGED INACCURACY OF CONSTRUCTION STAKES SET BY THE ENGINEER UNLESS ALL SURVEY STAKES SET BY THE ENGINEER ARE MAINTAINED INTACT AND CAN BE VERIFIED AS TO THEIR ORIGIN. IF IN THE OPINION OF THE ENGINEER, THE STAKES ARE NOT MAINTAINED INTACT AND CANNOT BE VERIFIED AS TO THEIR ORIGIN, ANY REMEDIAL WORK REQUIRED TO CORRECT ANY ITEM OF IMPROPER CONSTRUCTION WORK IN THIS DEVELOPMENT SHALL BE PERFORMED AT THE SOLE EXPENSE OF THE RESPONSIBLE CONTRACTOR OR SUBCONTRACTOR.

NOTHING CONTAINED IN THE CONTRACT DOCUMENTS SHALL CREATE, NOR SHALL BE CONTRUED TO CREATE, ANY CONTRACTUAL RELATIONSHIP BETWEEN THE ENGINEER AND THE CONTRACTOR OR ANY SUBCONTRACTOR.

THE ENGINEER AND/OR OWNER ARE NOT RESPONSIBLE FOR CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES OR FOR SAFETY PRECAUTIONS OR PROGRAMS UTILIZED IN CONNECTION WITH THE WORK. THE ENGINEER AND/OR OWNER ARE NOT RESPONSIBLE FOR THE CONTRACTOR'S FAILURE TO CARRY OUT THE WORK IN ACCORDANCE WITH THE CONTRACT DOCUMENTS NOR ANY COSTS INCURRED, WHETHER INITIAL OR ADDITIONAL, TO CORRECT, MODIFY, OR ALTER ANY CONSTRUCTION COMPLETED CONTRARY TO THE CONTRACT DOCUMENTS.

THE CONTRACTOR SHALL IN ALL CASES, BEGIN SEWER LINE CONSTRUCTION FROM THE DOWNSTREAM MANHOLE OR SEWER STUB WHETHER EXISTING OR PROPOSED. PRIOR TO INSTALLATION OF ANY SEWER LINE, THE CONTRACTOR SHALL EXCAVATE AND EXPOSE THE POINT OF CONNECTION OF NEW SEWER LINE TO THE EXISTING STUB OR MANHOLE AND VERIFY THE ELEVATION AND LOCATION. SHOULD THE EXISTING CONDITION VARY FROM THE DETAIL ON THE PLANS, THE CONTRACTOR SHALL NOTIFY THE ENGINEER PRIOR TO CONTINUING WORK.

DEVELOPMENT SERVICES DEPARTMENT'S FIELD INSPECTION GROUP SHALL BE NOTIFIED 48 HOURS BEFORE ANY CONSTRUCTION BEGINS. TELEPHONE (602) 262-7811

THE ENGINEER WILL MAKE FIELD RECORD DRAWING MEASUREMENTS OF THE WORK UPON NOTIFICATION BY THE WATER/SEWER CONTRACTOR THAT THE PIPE WORK IS COMPLETE AND READY FOR RECORD DRAWING SURVEY. IF THE CONTRACTOR DOES NOT LEAVE THE TRENCHES OPEN SO THAT THE ACTUAL PIPE LINE AND SERVICES CAN BE OBSERVED, THE RECORD DRAWING MEASUREMENTS WILL REFLECT THE TRENCH LOCATION ONLY. IF THE TRENCHES ARE BACKFILLED AND OBSCURED TO THE POINT THAT RECORD DRAWING MEASUREMENTS CANNOT BE PERFORMED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING ACCURATE RECORD DRAWING MEASUREMENTS AND SECURING THE ACCEPTANCE OF THE RECORD DRAWINGS BY THE JURISDICTIONAL AGENCY.

THE CONTRACTOR SHALL NOTIFY THE ENGINEER BEFORE THE FITTINGS ARE COVERED SO RECORD DRAWING MEASUREMENTS MAY BE TAKEN. FITTINGS SHALL NOT BE COVERED UNTIL SURVEYS HAVE BEEN COMPLETED.

A THOROUGH ATTEMPT HAS BEEN MADE TO SHOW THE LOCATIONS OF ALL UNDERGROUND OBSTRUCTIONS AND UTILITY LINES IN THE WORK AREA. HOWEVER, THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGE TO OBSTRUCTIONS AND UTILITY LINES ENCOUNTERED DURING CONSTRUCTION AND SHALL DETERMINE THE EXACT LOCATION OF UTILITIES IN THE AREA.

ALL EARTHWORK CONSTRUCTION SHALL CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS STANDARD DETAILS AND/OR SPECIFICATIONS INCLUDING ANY SUPPLEMENTS THERETO AND THE SOILS REPORT PREPARED BY:

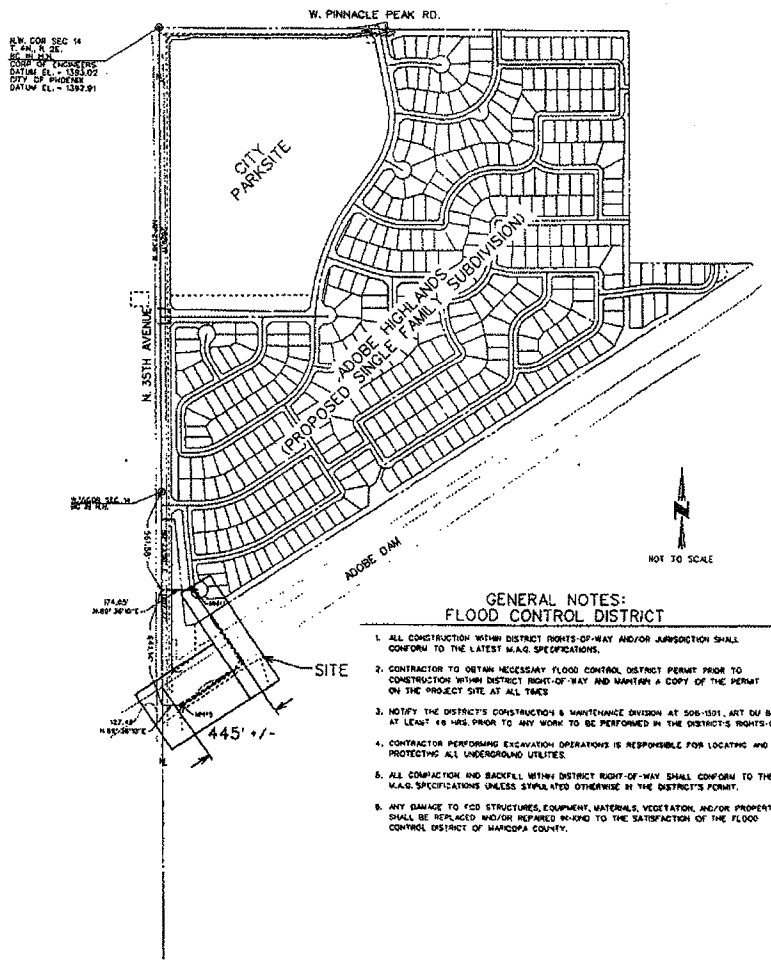
CONSTRUCTION INSPECTION & TESTING CO.

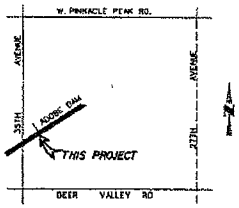
DATA FOR EARTHWORK CALCULATIONS IS PROVIDED IN THE SOILS REPORT AND (IF APPLICABLE) ANY SUPPLEMENTS THERETO.

THE QUANTITIES SHOWN ARE AN ESTIMATE ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING ALL QUANTITIES BEFORE BIDDING.

ESTIMATED QUANTITIES

DESCRIPTION	UNIT	QUANTITY
10" V.C.P. SEWER LINE	LF	369
10" VCP SEWER LINE	LF	288
30" D.I.P. SEWER LINE	LF	242
24" CASING PIPE - PIPE RAMMING	LF	210
5' DIA. SANITARY MANHOLE	EA	1
LAUNCH & RECEIVING PIT BACKFILL	CY	430
16" DOUBLE SWING GATE	EA	1
BENTONITE FILL	CY	28
PRECAST VAULT	EA	1
30 MIL PVC GEOMEMBRANE	SF	400
GEOGRID	SF	27
GEOTEXTILE	SF	400
7' AL GRATING	SF	27





VICINITY MAP
(NOT TO SCALE)

DEVELOPER

CONTINENTAL HOMES, INC.
7001 N. SCOTTSDALE RD., # 2050
SCOTTSDALE, AZ 85253
(602) 483-0006
(602) 951-7199 (FAX)
CONTACT: DAVE MAGUIRE

ENGINEER

COE & VAN LOO CONSULTANTS, INC.
4550 N. 12TH STREET
PHOENIX, ARIZONA 85014
(602) 264-6831
(602) 200-0203 (FAX)
CONTACT: ERIC LAURIN

BENCHMARK

BRASSCAP IN HANDHOLE AT
31ST AVENUE AND DEER VALLEY ROAD
EL. = 1377.19 (CITY OF PHX. DATUM)
(CORP OF ENGINEERS DATUM = CITY OF PHX. DATUM + 0.09')

GENERAL NOTES: FLOOD CONTROL DISTRICT

1. ALL CONSTRUCTION WITHIN DISTRICT RIGHTS-OF-WAY AND/OR JURISDICTION SHALL CONFORM TO THE LATEST M.A.G. SPECIFICATIONS.
2. CONTRACTOR TO OBTAIN NECESSARY FLOOD CONTROL DISTRICT PERMIT PRIOR TO CONSTRUCTION WITHIN DISTRICT RIGHT-OF-WAY AND MAINTAIN A COPY OF THE PERMIT ON THE PROJECT SITE AT ALL TIMES
3. NOTIFY THE DISTRICT'S CONSTRUCTION & MAINTENANCE DIVISION AT 506-1501, ART DU BOIS, AT LEAST 48 HRS. PRIOR TO ANY WORK TO BE PERFORMED IN THE DISTRICT'S RIGHTS-OF-WAY.
4. CONTRACTOR PERFORMING EXCAVATION OPERATIONS IS RESPONSIBLE FOR LOCATING AND PROTECTING ALL UNDERGROUND UTILITIES.
5. ALL COMPACTION AND BACKFILL WITHIN DISTRICT RIGHT-OF-WAY SHALL CONFORM TO THE LATEST M.A.G. SPECIFICATIONS UNLESS STIPULATED OTHERWISE IN THE DISTRICT'S PERMIT.
6. ANY DAMAGE TO FCD STRUCTURES, EQUIPMENT, MATERIALS, VEGETATION, AND/OR PROPERTY SHALL BE REPLACED AND/OR REPAIRED IN-KIND TO THE SATISFACTION OF THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.

SHEET INDEX

1.....COVER SHEET
2.....ADOBE DAM CROSSING
3.....CONNECTING SEWER
4.....DETAIL SHEET

APPROVAL OF THESE PLANS SHALL NOT PREVENT THE CITY FROM REQUIRING CORRECTION OF ERROR IN THE PLANS WHERE SUCH ERRORS ARE SUBSEQUENTLY FOUND TO BE IN VIOLATION OF ANY LAW, ORDINANCE, OR OTHER HEALTH/SAFTEY ISSUE.

"THIS PLAN IS APPROVED SUBJECT TO COMPLETION OF THOSE LINES LABELED "EXISTING" WHICH HAVE BEEN PROPOSED AS A PART OF ANOTHER DEVELOPMENT. THE DEVELOPER OF THIS PROJECT MAY BE REQUIRED TO CONSTRUCT THOSE LINES PER CITY REQUIREMENTS PRIOR TO RECEIVING SERVICE FOR THIS PROJECT."

AS-BUILT CERTIFICATION

I HEREBY CERTIFY THAT THE "RECORD DRAWING" MEASUREMENTS AS SHOWN HEREON WERE MADE UNDER MY SUPERVISION OR AS NOTED AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

REGISTERED LAND SURVEYOR/ENGINEER — DATE

REGISTRATION NUMBER

APPROVED FOR:

THE CITY OF PHOENIX

WATER SERVICES DIRECTOR — DATE
CITY OF PHOENIX

Brian M. Moore P.E. (by approval letter) — 8 Jan. 99
U.S. ARMY CORPS OF ENGINEERS — DATE
LOS ANGELES DISTRICT
OPERATIONS DIVISION

Shelly Power (by approval letter) — 6 Apr. '99
MARICOPA COUNTY FLOOD — DATE
CONTROL DISTRICT

ADWR Dam Safety Section Approval Stamp — 24 MAR '99
Application No. 07.57

ADOBE HIGHLANDS

COE & VAN LOO
PLANNING • ENGINEERING • LANDSCAPE ARCHITECTURE
4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

COVER SHEET

REVISIONS		DATE	BY
1	MOST CHANGE	1/19/99	ETC

DESIGNED RBW
DRAWN ETC
CHECKED ETC
DATE 01/29/99

SHEET 1 OF 4

980013

D.I.S. # 987073 P# 98242 Q.S. # 43-21

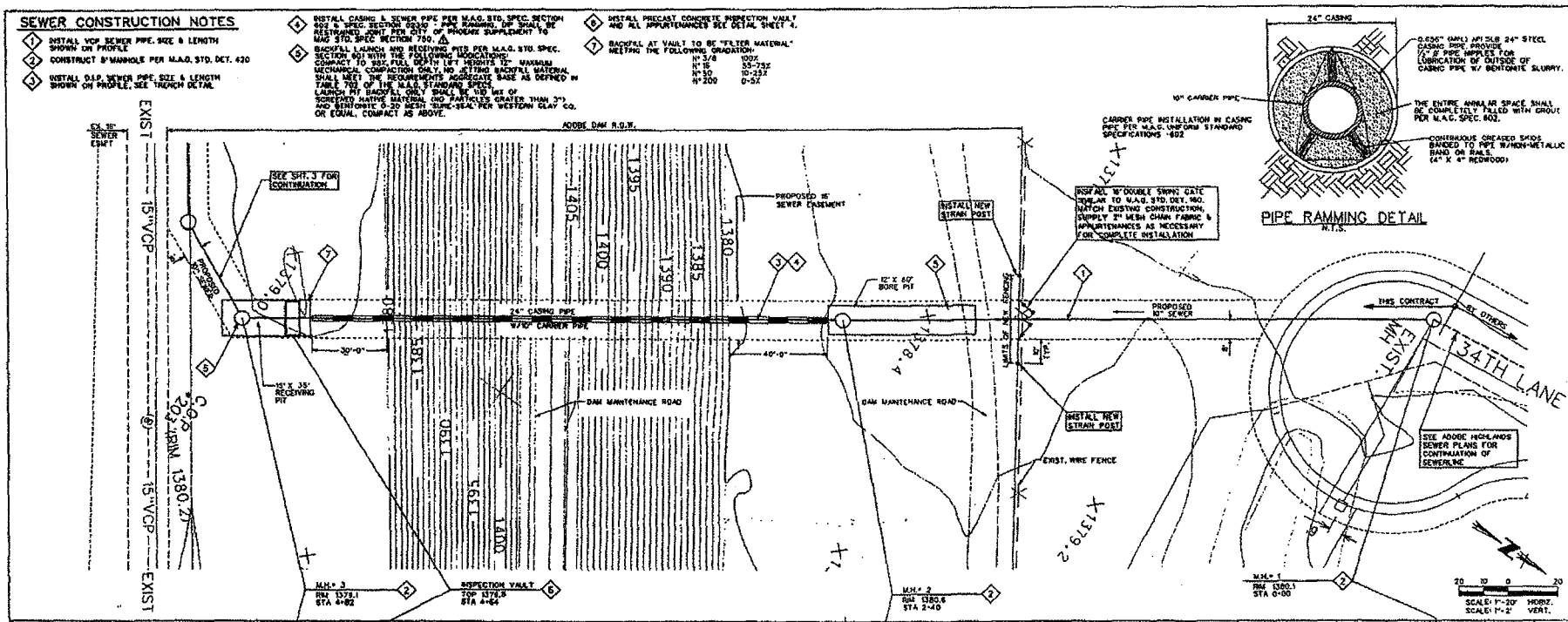
02097P04-001001.tif

DATE: Feb 04, 1999
TIME: 10:11:32
FILE: n:\980013\dwg\adobe.dgn

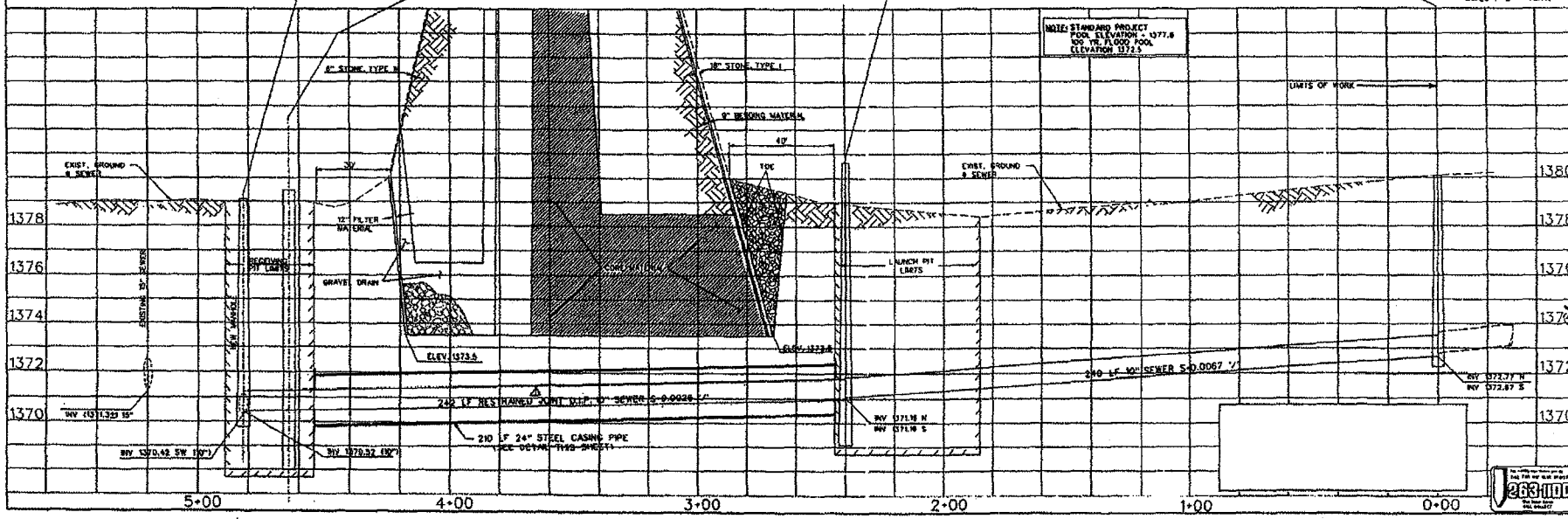
SEWER CONSTRUCTION NOTES

1. INSTALL VCP SEWER PIPE, SIZE & LENGTH SHOWN ON PROFILE
2. CONSTRUCT 8' MANHOLE PER M.A.G. STD. DET. 420
3. INSTALL D.I.P. SEWER PIPE, SIZE & LENGTH SHOWN ON PROFILE, SEE TRENCH DETAIL
4. INSTALL CASING & SEWER PIPE PER M.A.G. STD. SPEC. SECTION 601 & SPEC. SECTION 602 - PIPE RAMMING. DIP SHALL BE RESTRAINED JOINT PER CITY OF PHOENIX SUPPLEMENT TO MAG STD. SPEC SECTION 780. △
5. BACKFILL LAUNCH AND RECEIVING PITS PER M.A.G. STD. SPEC. SECTION 601 WITH THE FOLLOWING MODICATIONS: COMPACT TO 95% FULL DEPTH LEFT HEIGHTS 12" MAXIMUM MECHANICAL COMPACTION ONLY, NO JETTING. BACKFILL MATERIAL SHALL MEET THE REQUIREMENTS AGGREGATE BASE AS DEFINED IN TABLE 702 OF THE M.A.G. STANDARD SPECS. LAUNCH PIT BACKFILL ONLY SHALL BE 100 MIX OF SCREENED NATIVE MATERIAL (NO PARTICLES GRATER THAN 3") AND BENTONITIC 0-20 MESH "SUNC-SEAL" FOR WESTERN CLAY CO. OR EQUAL, COMPACT AS ABOVE.
6. INSTALL PRECAST CONCRETE INSPECTION VAULT AND ALL APPURTENANCES SEE DETAIL SHEET 4.
7. BACKFILL AT VAULT TO BE "FILTER MATERIAL" MEETING THE FOLLOWING GRADATION:

N° 3/4	100%
N° 16	55-75%
N° 50	10-25%
N° 200	0-5%



PIPE RAMMING DETAIL
N.T.S.



ADOBE HIGHLANDS

COE & VAN LOO
PLANNING • ENGINEERING • LANDSCAPE ARCHITECTURE
4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

REVISIONS	DATE	BY
△ RESTRAINED JOINTS	12 APR '99	SEW

DESIGNED SEW
DRAWN BEC
CHECKED BEL
DATE 01/29/99

ADOBE DAM CROSSING

SHEET 2 OF 4

980013

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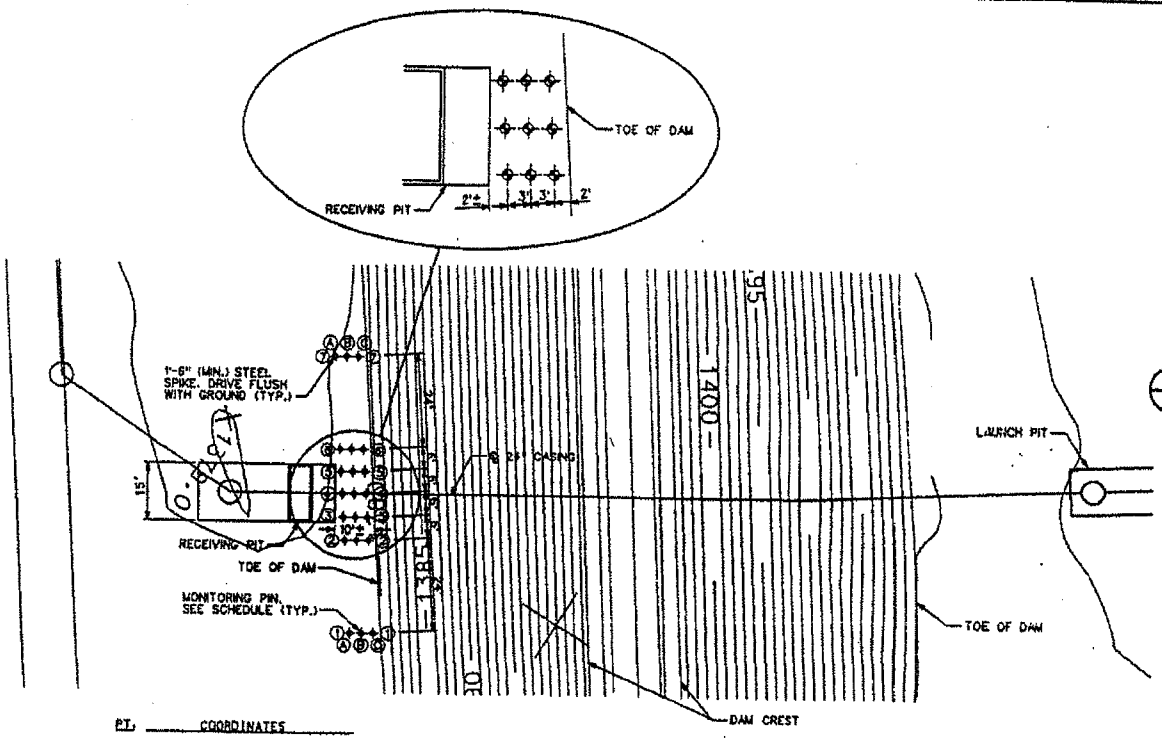
D.I.S. # 98707 P.# 98242 Q.S. # 43-21



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A2	N 11742.3975.	E 10410.8025
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A6	N 11728.5207.	E 10391.2210
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B1	N 11758.8238.	E 10428.8027
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B3	N 11741.4778.	E 10404.3259
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B6	N 11731.0702.	E 10389.6398
B7	N 11717.1934.	E 10370.0583
C1	N 11761.3733.	E 10427.2215
C2	N 11747.4964.	E 10407.6400
C3	N 11744.0272.	E 10402.7447.
C4	N 11740.5580.	E 10397.8493
C5	N 11737.0888.	E 10392.9539
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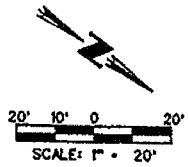
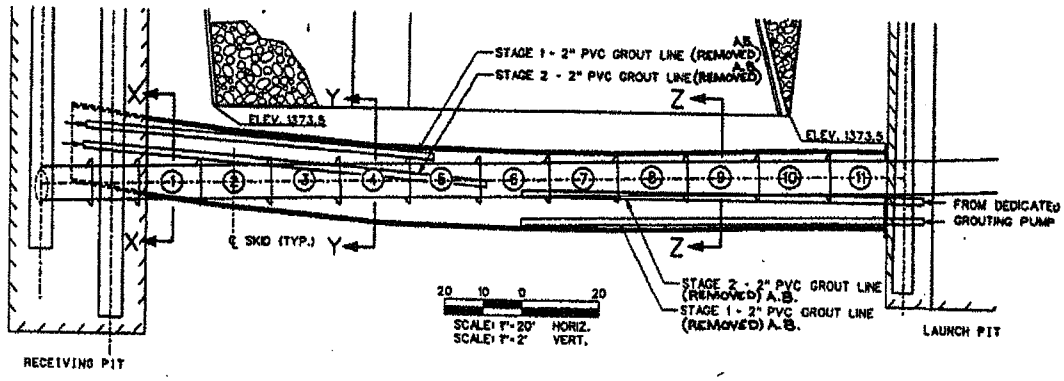


1 MONITORING PIN LOCATIONS



2 CARRIER PIPE GROUTING DETAIL

DATE:- Nov. 23, 1998
TIME:- 09:19:25
FILE:- e:\980013\land\sh05wrcr.dgn

02123P04-001005.tif

ADOBE DAM (07.57)

ADOBE DAM SEWER JACK/BORE
FOR
ADOBE HIGHLANDS DEVELOPMENT
CVL PROJECT NO. 98-0013-11

PROJECT SPECIFICATIONS

ARIZONA DEPARTMENT OF WATER RESOURCES
DAM SAFETY SECTION

APPROVED
FOR CONSTRUCTION

APPLICATION NO. 07-57 DATE: MAR 24, 1999

Prepared by:

Coe & Van Loo Consultants, Inc.
4550 N. 12th Street
Phoenix, Arizona 85014
(tel.: 602-264-6831)

Prepared for:

Continental Homes, Inc.

Date Issued: 26 March 1999

Registered Professional Engineer (Civil)
CERTIFICATE NO.
14478
ERIC
LAURIN
Date Signed 25 1999
ARIZONA, U.S.A.

ADOBE DAM (07.57)

ADOBE DAM SEWER CROSSING
FOR
ADOBE HIGHLANDS DEVELOPMENT
CVL PROJECT NO. 98-0013-11

CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

Prepared by:

Coe & Van Loo Consultants, Inc.

Prepared for:

Arizona Department
of
Water Resources

Dam Safety

ARIZONA DEPARTMENT OF WATER RESOURCES
DAM SAFETY SECTION

APPROVED
FOR CONSTRUCTION

APPLICATION NO. 07 - 57 DATE: MAR 24, 1999

RECEIVED
MAR 29 1999
DAM SAFETY SECTION

January 29, 1999

ADOBE DAM (07.57)

Registered Professional Engineer (Civil)
CERTIFICATE NO.
14478
ERIC
LAURIN
Date Signed 1/29/99
ARIZONA, U.S.A.

ADOBE DAM SEWER CROSSING
FOR
ADOBE HIGHLANDS DEVELOPMENT
CVL PROJECT NO. 98-0013-11

SURFACE WATER DIVERSION (SWD) PLAN

Prepared by:

Coe & Van Loo Consultants, Inc.

Prepared for:

Arizona Department
of
Water Resources

Dam Safety

ARIZONA DEPARTMENT OF WATER RESOURCES
DAM SAFETY SECTION

APPROVED
FOR CONSTRUCTION

APPLICATION 07 - 57 DATE: MAR 24, 1999

January 29, 1999

Registered Professional Engineer (Civil)
CERTIFICATE NO.
14478
ERIC
LAURIN
Date Signed 3-26-99
ARIZONA, U.S.A.

SECTION 01400

QUALITY CONTROL PLAN

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

It is the responsibility of the Contractor to ensure that material, equipment, and workmanship conform to the requirements and level of quality as established by these specifications and contract drawings. Quality control by the Contractor includes review of shop drawings prior to submission to the Engineer, inspection of materials and equipment at the time of delivery, protection of the work from surface runoff, sheeting/shoring of excavations as necessary, and worker safety.

The Contractor shall participate in the Construction Quality Assurance (CQA) Plan and provide the necessary assistance to the Engineer-of-Record or Engineer in their facilitation of this plan.

1.2 FIELD TESTS AND INSPECTIONS

A. All tests which require the services of a laboratory to determine compliance with the Contract Document shall be performed by an independent commercial testing laboratory acceptable to Engineer.

B. Testing Laboratory Services Furnished by Owner - Unless otherwise specified, Owner shall pay all charges of testing laboratories for quality control tests made in the field or laboratory on relative density tests on embedment, fill, and backfill materials, in-place field density tests on embedments and fills during and after their incorporation in the Work. Field sampling and testing will be performed by testing-laboratory personnel. Engineer shall determine the exact time and location of field sampling and testing.

C. Arrangements for delivery of samples and test specimens to the testing laboratory will be made by Engineer.

D. The Contractor shall furnish all sample materials and cooperate in the sampling and field testing activities, interrupting the Work when necessary.

E. The Contractor shall perform field tests as specified by the Engineer and provide labor, equipment, and incidentals required for testing. The testing shall be overseen and certified by the Engineer.

F. See Specification Section 02310.1.6-A for additional information.

SECTION 02310

PIPE RAMMING

Registered Professional Engineer (Civil) CERTIFICATE NO. 14478 ERIC LAURIN Date Signed 3-5-99 ARIZONA, U.S.A.

PART 1 GENERAL

1.1 SUMMARY

A. The work includes furnishing and installing a cased tunnel by pipe ramming beneath Adobe Dam without open excavation, and installation of carrier pipe with specified appurtenances as shown on the drawings and as specified in these Special Provisions.

B. For the purpose of this Section, pipe ramming is defined as the trenchless installation of a pipe by pushing the pipe using a pneumatically driven device. During the ramming process, the pipe may be unloaded using a screw auger or screw conveyor system. The contractor shall provide a minimum 5 foot soil plug at the end of the pipe at all times under normal soil removal procedures.

C. Set-up of pipe ramming machine of suitable capacity to drive home entire length of casing.

D. The Contractor shall have the option to select the necessary steps for casing pipe installation, subject to approval by the Engineer.

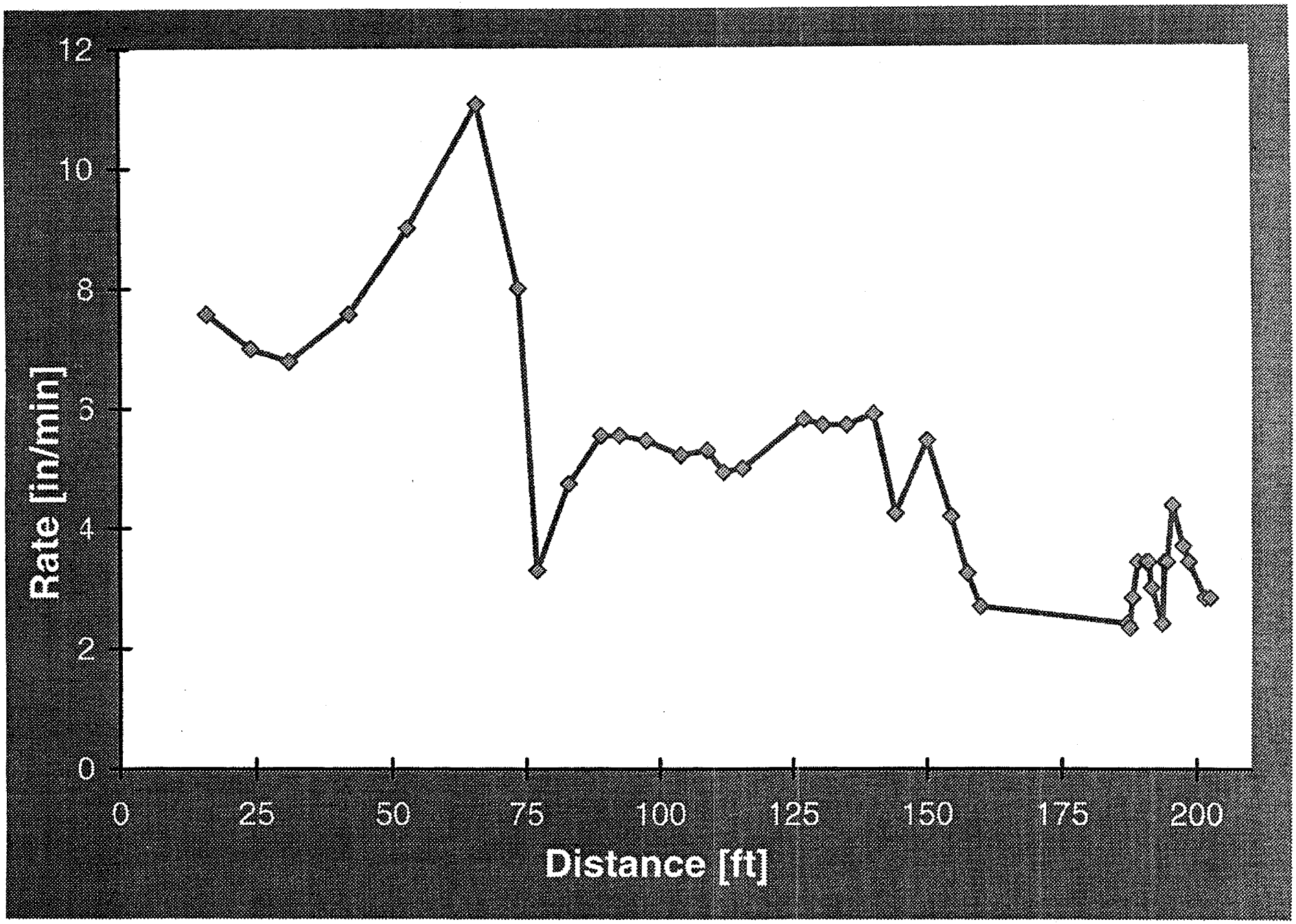
E. The specifications supersede MAG Standard Specification Section 602 unless otherwise noted or shown.

F. These specifications are complimentary to the contract drawings.

1.2 DEFINITIONS

A. Pipe Ramming: A non-steerable system of forming a bore by driving an open-ended casing using a percussive hammer from a pit and only displacing the wall thickness of the casing. The soil will remain in the casing until the bore has been completed and then may be removed by water, augering, jet-cutting or compressed air.

B. Launch/Drive Pit: A pit used for "launching" a trenchless technology excavation tool.



Coe Van Loo Consultants, Inc
Phoenix, Arizona

Dam Movement Monitoring

Vertical Elev.

Change in Vertical Elevation from Day 1 to Current Day

Delta t's

Controls

Date [day]	A-1 [ft]	B-1 [ft]	C-1 [ft]	A-2 [ft]	B-2 [ft]	C-2 [ft]	A-3 [ft]	B-3 [ft]	C-3 [ft]	A-4 [ft]	B-4 [ft]
14-Dec	0	0	0	0	0	0	0	0	0	0	0
17-Dec	0	0	0	0	0	0.02	0.02	0.01	0.01	0.01	0.01
20-Dec	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0.01
21-Dec	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0
28-Dec	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0.01
3-Jan	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0.01	0.01
20-Jan	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0.01	0.01
28-Jan	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0	0	0	0.01
11-Feb	0.01	0.05	0.02	0	0.01	0.01	0.01	0	0	0	0.01
10-Mar	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0	-0.01	0.01	0
Average	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01
STD Dev	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00

Delta t = Day1 - Current Day
Day1 = December 14,1999

Dam Movement Monitoring

Vertical Elev.

Change in Vertical Elevation from Day 1 to Current Day

Delta t's

Date [day]	C-4 [ft]	A-5 [ft]	B-5 [ft]	C-5 [ft]	A-6 [ft]	B-6 [ft]	C-6 [ft]	A-7 [ft]	B-7 [ft]	C-7 [ft]
14-Dec	0	0	0	0	0	0	0	0	0	0
17-Dec	0.06	0.01	0.06	0.01	0	0.01	0.01	0	0	0
20-Dec	0.05	0.01	0.05	0.01	0	0.01	0.01	0.01	0	0
21-Dec	0.05	1	0.04	0.01	-0.01	0.01	0	0	-0.01	-0.01
28-Dec	0.05	0.01	0.04	0.01	0	0.01	0.01	0.01	0	0
3-Jan	0.05	0	0.05	0.01	0	0.01	0.01	0	0	0
20-Jan	0.05	0.01	0.05	0.01	0	0.01	0.01	0.01	0	0
28-Jan	0.05	0.01	0.05	conc. lid	0	conc. lid	conc. lid	0.01	0	0
11-Feb	0.05	0	0.05	conc. lid	0	conc. lid	conc. lid	0	0	0
10-Mar	0.04	0.01	0.04	-0.01	-0.01	-0.01	0	0.01	0	0
Average	0.04	0.11	0.04	0.01	0.00	0.01	0.01	0.01	0.00	0.00
STD Dev	0.02	0.31	0.02	0.01	0.00	0.01	0.01	0.01	0.00	0.00

Overall Average	0.01
Overall Standard Deviation	0.07

Delta t = Day1 - Current Day
Day1 = December 14,1999

Dam Movement Monitoring

Horizontal Distances

Change in Discrete Points from Day 3

Delta t's

Date [day]	$t_{,A\ 1\text{-}2}$ [ft]	Control $t_{,B\ 1\text{-}2}$ [ft]	$t_{,C\ 1\text{-}2}$ [ft]	$t_{,A\ 2\text{-}3}$ [ft]	$t_{,B\ 2\text{-}3}$ [ft]	$t_{,C\ 2\text{-}3}$ [ft]	$t_{,A\ 3\text{-}4}$ [ft]	$t_{,B\ 3\text{-}4}$ [ft]	$t_{,C\ 3\text{-}4}$ [ft]
14-Dec	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17-Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Dec	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
21-Dec	0.00	-0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01
28-Dec	0.00	-0.01	0.00	0.02	0.00	0.01	-0.01	0.00	0.01
3-Jan	0.00	-0.01	0.00	0.01	-0.01	-0.01	0.01	0.01	-0.01
20-Jan	0.00	-0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01
28-Jan	-0.01	0.16	-0.01	0.01	0.00	0.01	0.00	c.lid	c.lid
11-Feb	-0.01	0.16	-0.01	0.01	0.00	0.01	0.00	c.lid	c.lid
10-Mar	-0.01	0.16	0.00	0.01	-0.01	0.01	0.00	0.01	0.02
Average	0.00	0.05	0.00	0.01	0.00	0.00	0.00	0.00	0.01
StdDev	0.00	0.08	0.00	0.01	0.00	0.01	0.00	0.00	0.01

Delta t = Day1 - Current Day
Day1 = December 17,1999
Due to no available data for 12-14-99

Dam Movement Monitoring

Horizontal Distances

Change in Discrete Points from Day 3

Delta t's

Date [day]	$t_{,A\ 4\text{-}5}$ [ft]	$t_{,B\ 4\text{-}5}$ [ft]	$t_{,C\ 4\text{-}5}$ [ft]	$t_{,A\ 5\text{-}6}$ [ft]	$t_{,B\ 5\text{-}6}$ [ft]	$t_{,C\ 5\text{-}6}$ [ft]	$t_{,A\ 6\text{-}7}$ [ft]	**Control** $t_{,B\ 6\text{-}7}$ [ft]	$t_{,C\ 6\text{-}7}$ [ft]
14-Dec	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17-Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Dec	0.00	0.01	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00
21-Dec	0.00	0.02	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00
28-Dec	0.00	0.01	-0.02	0.00	0.00	0.00	-0.01	0.00	0.00
3-Jan	0.01	0.01	-0.01	0.00	0.00	0.00	-0.01	-0.02	-0.01
20-Jan	0.00	0.02	c. lid	0.01	c. lid	c. lid	-0.01	c. lid	c. lid
28-Jan	0.00	0.01	c. lid	0.01	c. lid	c. lid	-0.01	c. lid	c. lid
11-Feb	0.00	0.01	c. lid	0.01	c. lid	c. lid	-0.01	c. lid	c. lid
10-Mar	-0.01	0.01	-0.03	0.01	-0.01	0.00	-0.01	0.00	0.00
Average	0.00	0.01	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00
StdDev	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00

Overall Average	0.004
Overall Standard Deviation	0.024

Delta t = Day1 - Current Day
Day1 = December 17,1999
Due to no available data for 12-14-99

INSTALLATION METHODS FOR UNDERGROUND UTILITIES

Presented by

Brett Gillespie

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Presentation Overview

- Methods
- Benefits & Disadvantages
- Constraints
- Constructability
- Construction Controls

HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Methods

- Directional Drilling
- Jack & Bore
- Open Cut

HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Directional Drilling

Advantages:

- Requires No Bore Pit
- Construction Time
- Environmentally Responsible
- Directional Capabilities

Disadvantages:

- Ineffective in Unconsolidated Soils
- Very Difficult to Maintain Sewer Alignment

HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Jack & Bore

Advantages:

- Large & Small Diameter Pipe Capabilities
- Grade Control for Sanitary Sewer
- Environmental Impact Control
- Seal Voids
- Below Dam Structure

Disadvantages:

- Unsuitable Material Can Stop Production
  - Must Redesign
  - Select Alternate Method
  - Time & Material Loss

HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Open Cut

Advantages:

- Cost Savings
- Construction Time
- Scheduling

Disadvantages:

- Environmental Impact
- Dam Integrity
- Liability
- Aesthetics

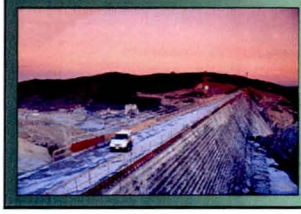
HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Owner Constraints

- Right of Way Issues
- Adequate Work Area
- Coordinating Facility Owner's Activities



HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Regulators & Inspectors

- Riparian Zone Restraints
- Environmental Impact Issues
- Inspectors Involved in Total Process

HAYDON BUILDING CORP

FCDMC
Dam Penetrations Workshop

Installation Methods for Underground Utilities

Constructability

- Methods & Engineering Tolerances Must Balance
- Use of Alternative Bid Methods

HAYDON BUILDING CORP

CASE HISTORIES OF SEEPAGE PROBLEMS IN DAMS FROM PENETRATIONS

Presented by

James R. Talbot, P.E.

CASE HISTORIES OF SEEPAGE PROBLEMS IN DAMS FROM PENETRATIONS

By Jim Talbot

Conduit Seepage Failure

- Most seepage failures in dams occur around conduits
- The conduit or other penetrations are locations vulnerable to seepage problems

Conduit Seepage Failure

Note:

- Concrete pipe
- Cradle under pipe
- Structural Anti-seep collars

RALEIGH AIRPORT STORM WATER POND

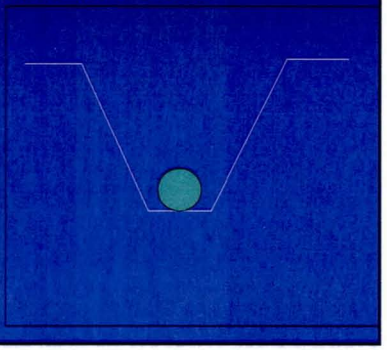
- Small pond – 15-foot high dam
- CMP outlet
- Had been in operation about 20 years
- CMP had deteriorated – bottom gone

RALEIGH AIRPORT STORM WATER POND

- Airport had consultant design repair
- Excavation to remove and replace pipe
- New CMP installed

RALEIGH AIRPORT STORM WATER POND

- Excavation had steep sides
- Pipe placed on flat surface
- No compaction under pipe
- Placement of fill likely not complete under pipe



RALEIGH AIRPORT STORM WATER POND

- Trench filled and pond put into operation
- Storm 2 weeks later
- Pond filled and failed at outlet pipe

RALEIGH AIRPORT STORM WATER POND

- Failure along edge of pipe
- Inlet on left side of pipe
- Outlet on right side of pipe
- Airport Auth. wanted orig. consultant to design repair

RALEIGH AIRPORT STORM WATER POND

- Another excavation made similar to first
- Backfill more carefully
- Storm 1 week later – failed again.

RALEIGH AIRPORT STORM WATER POND

- 2nd failure on both sides of pipe
- Airport Auth. wanted orig. consultant to design repair
- Another similar excavation with careful backfill

RALEIGH AIRPORT STORM WATER POND

- Dam failed 3 times before they called me to help them
- Each time the failure was along the sides of the pipe – may have started under haunches of pipe

RALEIGH AIRPORT STORM WATER POND

- Filter diaphragm (collar) put around pipe
- Filter is sand graded to prevent soil of dam from passing through it

RALEIGH AIRPORT STORM WATER POND

- Filter collar extended into side slopes
- Side slopes are flattened to 1.5:1
- Filter collar intercepts all areas of possible seepage along pipe and excavation lines

RALEIGH AIRPORT STORM WATER POND

- Placement of filter to make sure it has no voids under pipe
- This repair was successful – no more failures

RALEIGH AIRPORT STORM WATER POND

- Placement and compaction of soil at flatter sloping excavation slopes allows mixing and compaction of interface

A Small Dam with CMP

- A common failure location for flexible pipe with no cradle or seepage control measures
- Note this failure above the pipe

Deteriorated CMP

- Conduit failures can start as a leak through holes in old pipes

Piping Failure at Conduit, WY

- Area around conduits are vulnerable to poor placement & compaction, & to cracking

Piping Failure at Conduit, WY

- Note flexible pipe, no cradle
- Anti-seep collar in background
- Pipe deflections will create voids

Seepage Failure, WY

- Failure underway
- Started with seepage at conduit

Seepage Failure, WY

- Results of seepage failure at conduit
- Dam had been in service 20 years

Seepage Failure, WY

- No one was killed in this failure
- Many animals were killed
- Property damage was very high

Small Dam Failure at Conduit

Anti-Seep Collars –vs- Filter Diaphragm

- We know of and have pictures of 100's, perhaps 1000's of failures where anti-seep collars were used
- We know of and have no pictures of failures where filter diaphragms were installed correctly (to height and width recommended)
- We believe filter diaphragms can mitigate most problems associated with installation of penetrations through dams

NRCS EXPERIENCE WITH FAILURE RELATED TO CONDUITS IN EMBANKMENT DAMS

Presented by

Danny McCook, P.E.

NRCS Experience with Failures Related to Conduits in Embankment Dams

by Danny McCook, Geotechnical Engineer, P.E., National Design, Construction, and Soil Mechanics Center, Fort Worth, Texas

SCS Case Histories that Illustrate Conditions Causing Failures

- Most case histories from Sherard Study
- Common factors in case histories emphasized
- Study of failures has contributed to basic understanding of causes of many failures

STUDY OF PIPING FAILURES
AND EROSION DAMAGE FROM RAIN IN
CLAY DAMS IN OKLAHOMA AND MISSISSIPPI

A report prepared for the
United States Department of Agriculture
SOIL CONSERVATION SERVICE

by

JAMES L. SHERARD
Consulting Engineer
March 1972

Sherard Study of NRCS Dams

- Eleven Oklahoma dams failures studied
- Ten of the 11 failures occurred on first filling during construction or shortly after
- Three failures had eyewitness accounts
- All but one failure occurred where foundation materials changed abruptly in thickness and character near the failure

Sherard Study of NRCS Dams

- At several sites, multiple tunnels developed, and a total of 15 tunnels were documented in the 11 dams
- 7 of the 15 tunnels occurred near conduits through the dams
- At several failures, a muddy leak was observed in the embankment considerably above the location of the conduit as the first sign of distress.

Sherard Study of NRCS Dams

- At other sites, leaks occur near conduits and followed the alignment of the conduit
- Dispersive clays were predominant in all of the failed dams in the study.

Case History # 1

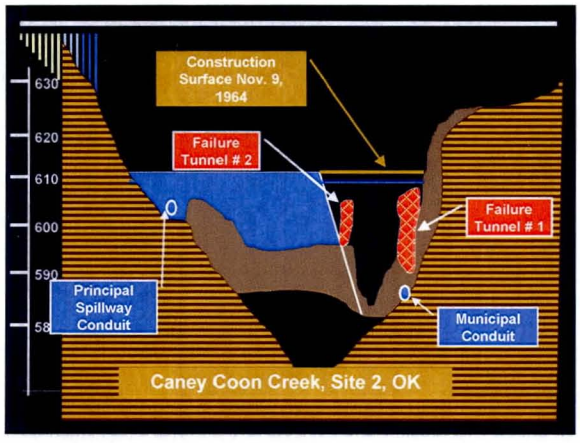
Caney Coon Creek Site 2

Caney Coon Creek Site 2

- Eyewitness account – two separate failure tunnels
- Tunnel # 1 first observed November 19, 1964 at 10 AM small leak emerging from 6 inch diameter area. Travelling between contact of dam and abutment
- Followed alignment of municipal water supply line

Caney Coon Creek Site 2

- By Morning of following day, Tunnel # 1 had increased in diameter to 15 feet with q of 50-75 cfs
- Tunnel # 2 appeared at 1:30 pm on 2nd day and grew into tunnel 10 feet in diameter over next 2 days
- Tunnel # 1 had increased in size to 19 inches by 5 PM, carrying estimated q of 25 cfs



Caney Coon Creek 2 Causes of Failure

- Embankment compacted dry of optimum
- Steep abutment and differential strains in embankment
- Tunnel # 1 conduit and trench contributed to differential settlement
- Highly dispersive clay soils

Case History # 2

Little Wewoka, Site 17, Oklahoma

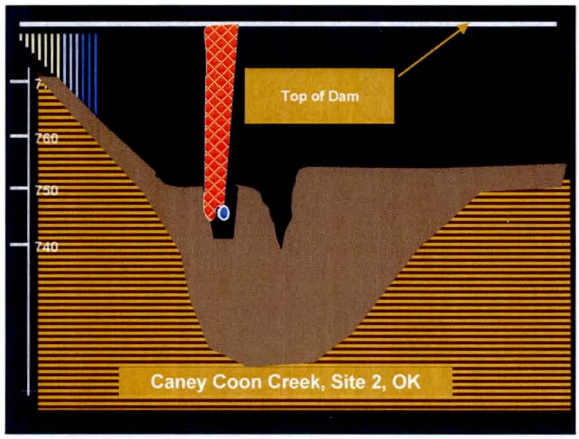
Little Wewoka, Site 17, OK

Little Wewoka, Site 17, OK

- Eyewitness account
- Initial leak about 6 inches in diameter with a trickle of water observed at 8 AM
- Leak emerged on downstream slope about 15 feet vertically above conduit.
- Sudden first filling of reservoir probably no more than 5 feet above initial leak

Little Wewoka, Site 17, OK

- By midday, leak had eroded tunnel 10-feet in diameter.
- By evening, reservoir was emptied and dam had eroded downward until the conduit was exposed.
- The top of the tunnel collapsed leaving a breach 47 feet wide at the crest.



Factors in Failure of Little Wewoka, Site 17, OK

- Highly dispersive clays
- Conduit installed in excavated trench
- Steep bedrock profile

Case History # 3

Potacocawa Site 2, Mississippi

Potacocowa Site 2, MS

Potacocowa Site 3, MS

- Failure occurred following sudden increase in pool level during construction
- Reservoir level was only about 4 feet above invert of conduit at failure
- Highly dispersive clay soils

Potacocowa Site 2, MS

Factors in Failure of Potacocowa Site 3, MS

- Highly dispersive clays
- Conduit installed in excavated trench

Case History # 4

Upper Red Rock, Site 48, Oklahoma

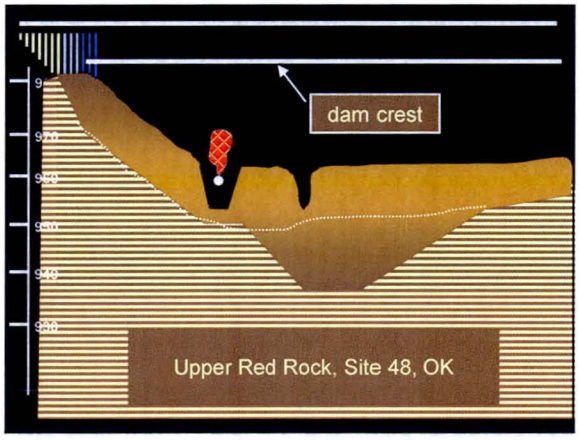
Upper Red Rock, Site 48

- No eyewitness, but reservoir emptied about 24 hours following rise in reservoir.
- Failure tunnel about 10 feet in diameter.
- Conduit exposed and washed clean at both upstream and downstream ends

Upper Red Rock, Site 48

- Excavation for repair showed that conduit was completely surrounded by intact earth fill over the central 50 feet of its length (tunnel did not follow conduit continuously

Upper Red Rock, Site 48



Upper Red Rock 48 Causes of Failure

- Embankment compacted dry of optimum
- Highly dispersive clays
- Conduit installed on highly compacted trench backfill

Case History # 5

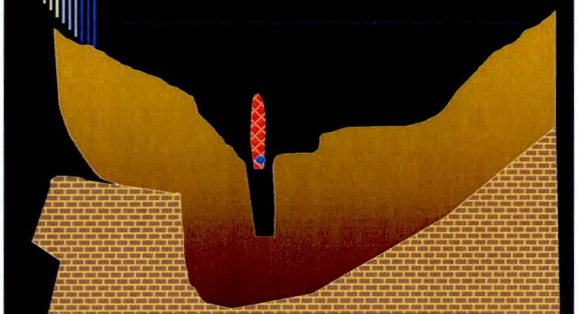
Owl Creek, Site 13, Oklahoma

Owl Creek 13, OK

- No eyewitness
- Failure tunnel along right side of conduit
- Failure tunnel about 18 feet in diameter with bottom near bottom of conduit

Example Failures – Owl Creek, Site 13

Example Failures – Owl Creek, Site 13



Example Failures – Owl Creek, Site 13

Owl Creek 13 Causes of Failure

- Embankment compacted dry of optimum
- Highly dispersive clays
- Conduit installed on highly compacted trench backfill
- Near sharp bedrock profile under dam

Case History # 6

Upper Clear Boggy 53, Oklahoma

Upper Clear Boggy 53, OK

- Failure on first filling
- Tunnel followed conduit closely – but at center of dam was about 8 feet laterally away from conduit
- Highly dispersive clay soils

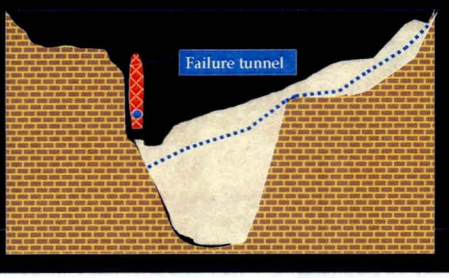
Upper Clear Boggy, Site 53

Viewed Downstream

Example Failures - Upper Clear Boggy, Site 53

Viewed Upstream

Example Failures - Upper Clear Boggy, Site 53



Upper Clear Boggy 53, OK – Causes of Failure

- Sharp bedrock profile under failure area
- Highly dispersive clay embankment
- Embankment compacted dry of optimum
- Drying cracks during fill placement interruptions
- Poor bonding between lifts

Case History # 7

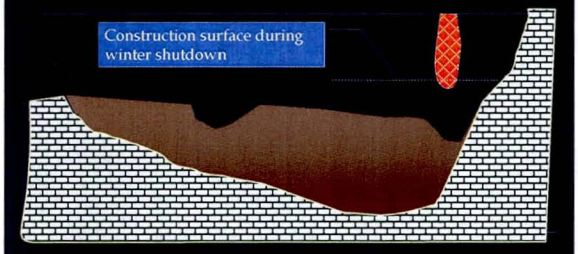
Upper Clear Boggy 50, Oklahoma

Upper Clear Boggy Site 50

- Failure not in vicinity of conduit
- Steep bedrock abutment
- Winter shutdown could have caused poorly bonded lift
- Highly dispersive clays

Example Failures - Upper Clear Boggy, Site 50 (looking upstream)

Example Failures - Upper Clear Boggy, Site 50 (looking downstream)



Upper Clear Boggy 50, OK – Causes of Failure

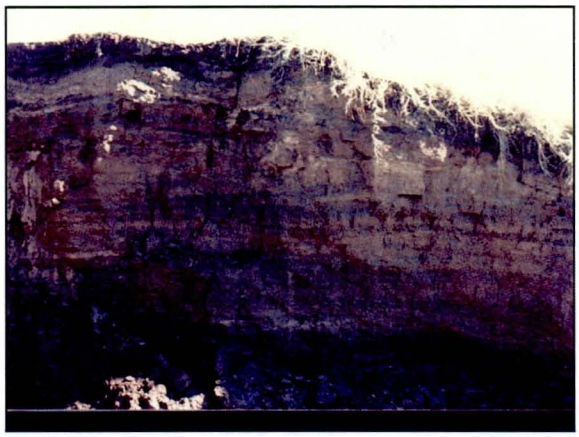
- Sharp bedrock profile probably caused differential settlement and hydraulic fracture of embankment – 25 feet difference in thickness of alluvium near failure
- Conduit not in vicinity of failure
- Highly dispersive clays

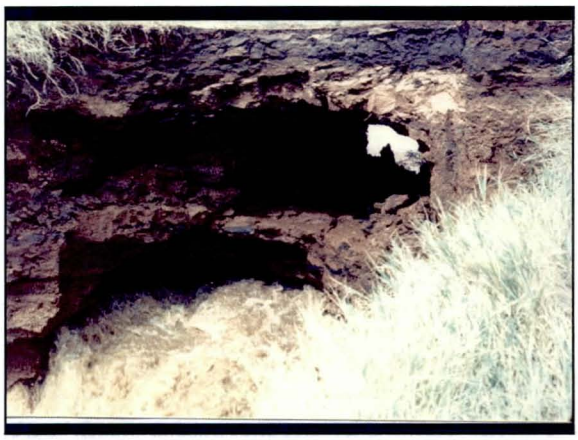
Case History # 8

Upper Red Rock Site 20, Oklahoma

Upper Red Rock Site 20, Oklahoma

- Failure on Second First Filling
- Site Built in 1973
- Impounded pool of water until 1986 with no problems
- Unprecedented pool level reached that was 4 feet below dam crest
- Failure tunnel 40 feet to side of conduit



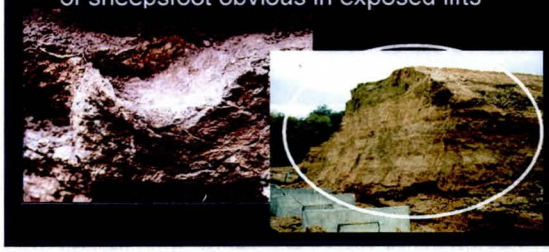


Upper Red Rock, Site 20, OK – Causes of Failure

- Lack of bonding of lifts in embankment – discing not required
- Embankment highly compacted – imprints of sheepsfoot obvious in exposed lifts
- Highly dispersive clays

Upper Red Rock, Site 20, OK – Causes of Failure

- Embankment highly compacted – imprints of sheepsfoot obvious in exposed lifts



Case History # 9

Jackson Mill Creek, Site 1, SC

Jackson Mill Creek, Site 1, SC

- Failure occurred in partially completed embankment during construction
- Sudden first filling following large rainfall

Upper Red Rock, Site 20, OK – Causes of Failure

- Lack of bonding of lifts in embankment – discing not required
- Embankment highly compacted – imprints of sheepsfoot obvious in exposed lifts
- Highly dispersive clays

Common Factors in Failures

- Ten of 11 OK dams failed on first filling, usually shortly after construction during a large rainfall event that filled reservoir rapidly
- Failures begin with an initial leak that gradually eroded a tunnel. If the tunnel became large enough, the roof collapsed forming a breach

Conditions Common in Problems/Failures

- Excavations made to install conduits (transverse to the embankment) with too steep side slopes
- Variable foundation materials and thicknesses of materials along alignment of embankment

Conditions Common in Problems/Failures

- Difficulty in compacting under haunches of circular conduits.
- Interruptions in fill placement and lack of bonding of lifts
- Dispersive clays –almost universal factor

Conditions Common in Problems/Failures

- Embankments constructed at overly high density and low water contents (brittle fill)
- Absence of chimney filter or filter diaphragm in design – no failures since inception of filter diaphragms in mid 1980's
- Differential settlement associated with conduit

Common Factors in Failures

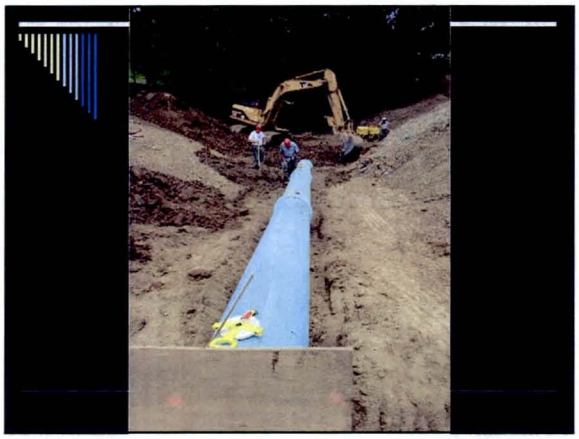
- One eyewitness account showed initial leak started through embankment at about mid-height and gradually eroded downward. It was clear that the leak was not immediately next to the conduit
- At all but one site, soils were low to medium plasticity, highly dispersive CL soils

Other observations

- Hundreds of dams built of similar soils and the same quality of construction did not fail
- Speed of filling and conditions conducive to hydraulic fracturing are thought to have been less severe at the non-failed dams.
- Differential settlement is thought to be a prime contributor to hydraulic fracturing

Installation of Filter Diaphragm at Rehab Site, Ohio

- Following slides show typical installation of rehab site where conduit is replaced and a filter diaphragm is added.
- Slides show parallel foundation trench drain as well as filter diaphragm



HYDRAULIC FRACTURING IN DAMS

Presented by

James R. Talbot, P.E.

Hydraulic Fracturing of Dams

James R. Talbot, P.E

Zones within the dam vulnerable to hydraulic fracturing are those where differential settlement causes lateral stress release

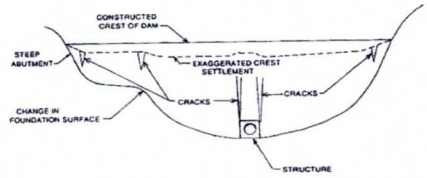
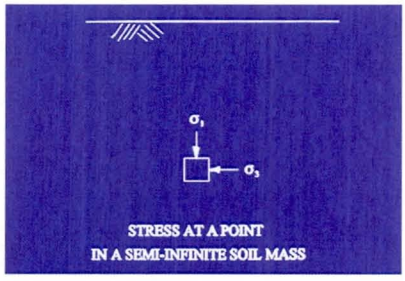


FIG. 1 COMMON ZONES OF EMBANKMENT CRACKING

Many dams have failed where fracturing of the dam as water pressure penetrates through the dam on first filling is indicated

This dam failed the first time water was stored – only 4-feet deep

To explain lateral stress release, consider stresses at a point in the ground – lateral stress about 0.6 vertical stress



The Mohr plot of stresses at-rest shows the vertical stress larger than the lateral stress (σ_3 about 0.6 to 0.7 σ_1)

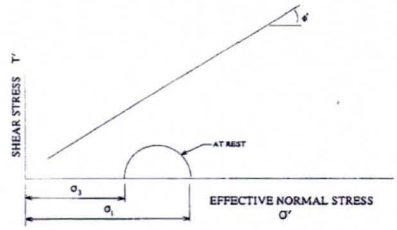
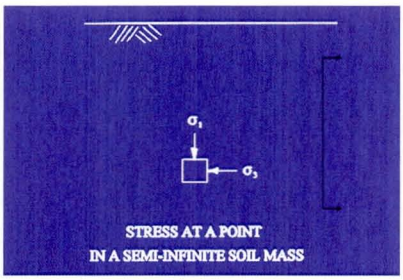


FIG. 1 STATE OF STRESS, AT-REST CONDITION

If we could insert a sheet pile along side of the cube, and pull it away



Lateral stress (σ_3) will get smaller and smaller making the circle larger and larger

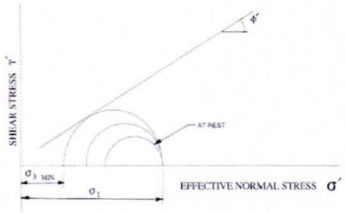


FIG. 2 STATE OF STRESS AT A POINT - MOHR PLOT

Considering a point in a dam over a steep abutment. As settlement occurs, there is some stretching of the soil in the dam causing some release of stress in the lateral direction

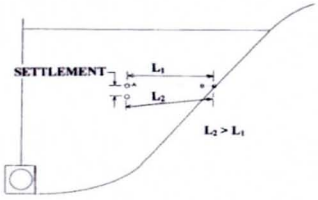
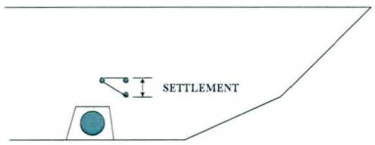


FIG 3 SETTLEMENT OVER ABUTMENT

Considering a point in a dam over a conduit or other structure. The settlement occurs over a short distance. Lateral stretching and stress release are severe above the structure



Many lateral stress release conditions will be between the at-rest and active conditions (σ_3 = 0.3 to 0.6 σ_1)

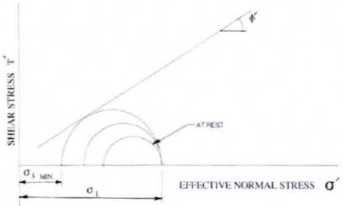
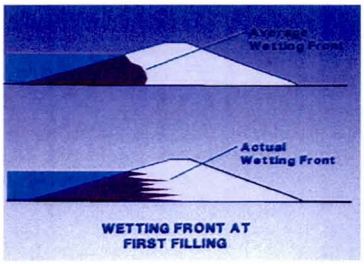
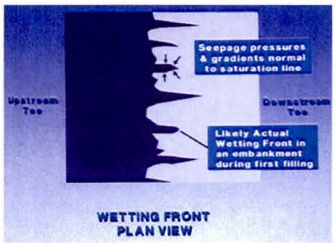


FIG. 2 STATE OF STRESS AT A POINT - MOHR PLOT

On the first filling (when hydraulic fracturing occurs) a high hydraulic gradient exists in the dam as a wetting front moves through the dam



The wetting front will not be smooth, but have projections due to the different permeability of the embankment soil. The water pressure pushing against the soil can easily be greater than the lateral stress



This condition is easily seen by using a borehole analogy. The lateral pressure in the borehole full of water can be greater than the at rest pressure even at a K value of 0.5

Soil $\gamma_T = 110$ lb/ft^3

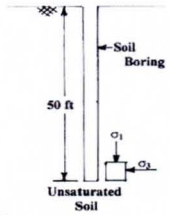
$\sigma_1 = 110\ (50) = 5500$ lb/ft^2

Say $K_o = 0.50$

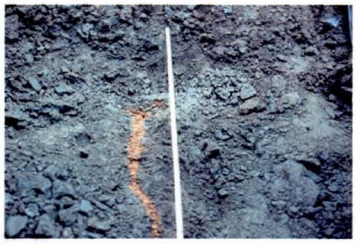
$\sigma_3 = 5500\ (0.50) = 2750$ lb/ft^2

Boring full of water
Pressure at bottom =
62.4 lb/ft^3 (50 ft) = 3120 lb/ft^2

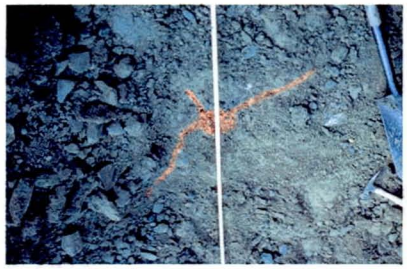
Compare with σ_3 3120 > 2750



A dam was investigated in New York State using water to wash cuttings from boreholes drilled over a steep embankment. All water was lost. Serious problems were assumed, but excavations showed cracks at the borehole.

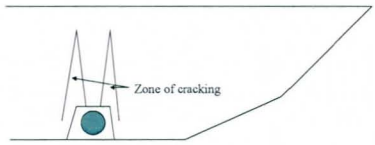


A second borehole showed the same condition

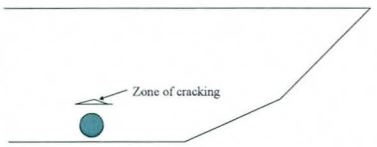


Water and air should not be used to remove cuttings when drilling in dams

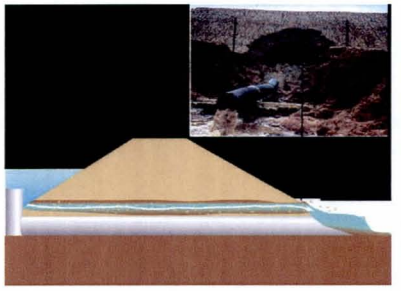
The zone of cracking is commonly above the pipe or other penetration through the dam



For flexible pipe, the pipe may deform under the load and leave a void or area of vertical stress release above the pipe where hydraulic fracturing can occur



Failures above the penetration are common because the zone of cracking is usually often above



Hydraulic Fracturing of Dams

Summary

- Hydraulic fracturing occurs when the dam is not saturated and the reservoir fills rapidly, creating high gradients on the wetting front in the dam such that the water pressure exceeds the lateral stress in the soil of the dam (can also be the vertical stress)
- All dams have conditions that cause some stress release. Certain conditions that produce large differential settlement over a short distance creates larger stress release
- Stress release is likely at or below the potential water pressure in most dams where the reservoir can fill rapidly
- Cracks from hydraulic fracturing may be small in width and may not cause failure if the soil is resistant to erosion. Concentrated leaks are likely for erosive soils unless the dam is protected with a filter/drainage system
- Hydraulic pressure in borings drilled into dams has been known to cause cracking and water loss from the boring. Drilling into dams is not recommended especially using water or air to remove cuttings

THE CAUSE OF SEEPAGE PROBLEMS ASSOCIATED WITH PENETRATIONS

Presented by

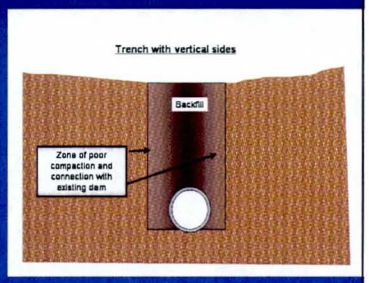
James R. Talbot, P.E.

The Cause of Seepage Problems Associated with Penetrations

By Jim Talbot

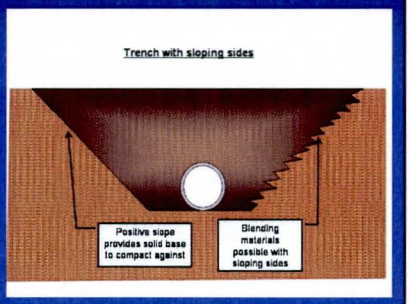
Excavations into Embankment Dams

- Excavations may be made with vertical or near vertical sides
- Compaction is poor at sides of trench
- Soil mixing and connection poor



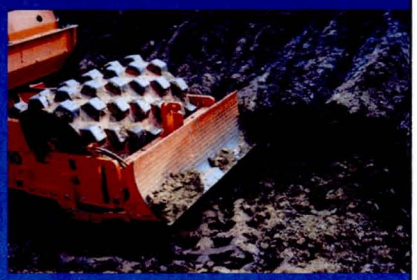
Excavations into Embankment Dams

- Slopping trench sides provide for better compaction and blending of materials



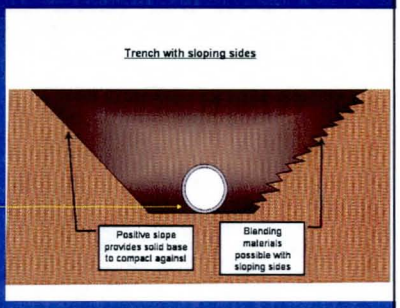
Excavations into Embankment Dams

- Small compactor compacting and mixing material on slopping side of trench in dam



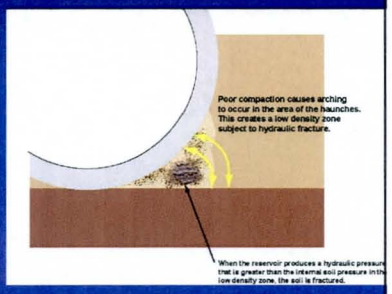
Excavations into Embankment Dams

- Circular pipe placed on level surface creates compaction problems under the haunches of the pipe

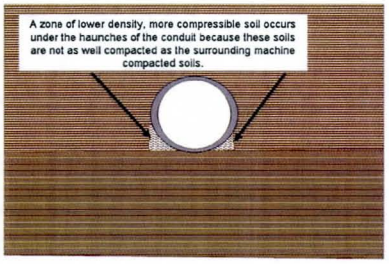


Placement & Compaction Difficult Around Circular Pipes

- It is difficult to place backfill soil under haunches of pipe
- Compaction of backfill soil is very difficult under haunches of pipe

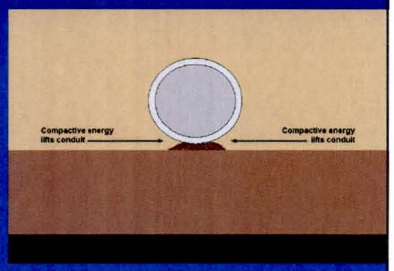


Placement & Compaction Difficult Around Circular Pipes



Placement & Compaction Difficult Around Circular Pipes

- Placement and compaction can lift pipe leaving voids
- Pipe deflections during compaction can leave voids around pipe

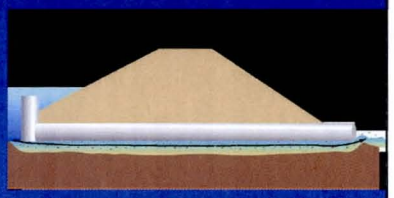


Placement & Compaction Difficult Around Circular Pipes

- Pictures of failure from internal erosion around conduits
- We can show 100's, perhaps 1000's of these

Placement & Compaction Difficult Around Circular Pipes

- The results of these placement & compaction problems is water finding its way through the dam along the penetration causing internal erosion



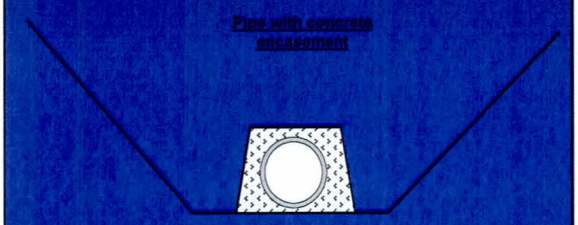
Placement & Compaction Difficult Around Circular Pipes

- Concrete cradle can be constructed under haunches of pipe to improve conditions for backfill and compaction

Placement & Compaction Difficult Around Circular Pipes

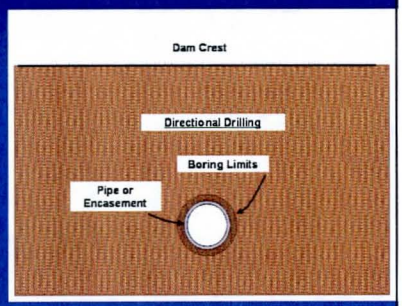
- With cradle, compaction can be accomplished using small compactors

Placement and compaction problems can be improved by using a full concrete encasement. This solution can also improve the strength and other potential for breakage or leakage of penetrations carrying liquids



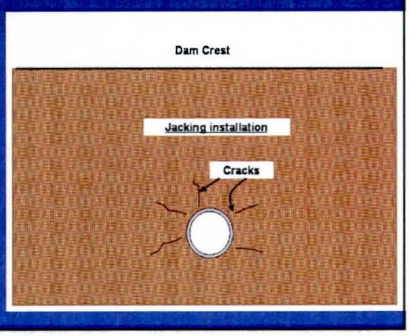
Considerations for Alternative Installation Methods

- Directional drilling and jacking can cause void space around penetration



Considerations for Alternative Installation Methods

- If jacking is done in boring smaller than pipe, there is a possibility of cracking around the pipe



POSSIBLE SOLUTIONS FOR PENETRATIONS THROUGH DAMS

Presented by

James R. Talbot, P.E.

Possible Solutions for Penetrations Through Dams

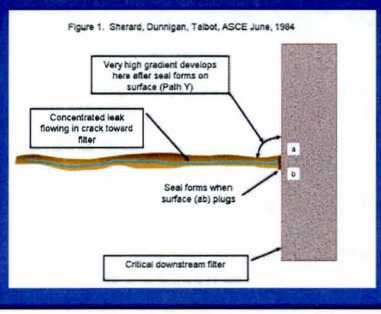
Jim Talbot

SCS (NRCS) Performed A Study on Filters

The late James L. Sherard worked with SCS to study filters for protection of embankment dams from concentrated leak development caused by erosion in cracks

- Performing test for basic properties of filter
- High velocity water running through base soil (sand) and filter – sieve used to catch particles that get through filter and test for size of these particles

- Water under high pressure passes through the simulated crack & the filter
- Eroded particles of the base soil collect at the filter face and stop flow in the crack



The No Erosion Test setup

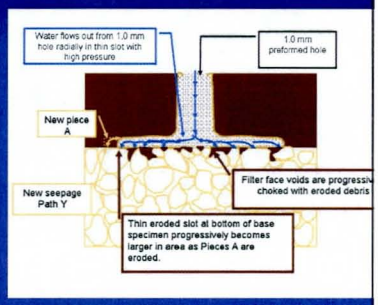
Successful filters seal the opening quickly to a drip or no flow

Filter failure in the large test

Successful filter test for gravelly clay soil in large test

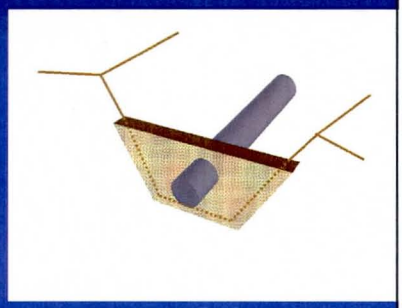
NRCS Filter Study

- Eroding soil catches at the face of the filter and seals it
- The filter face seals at the opening and some distance to each side
- The remaining filter is open to receive seepage



Filter Diaphragm Placement

- The Filter is placed where it will intercept any areas of poor compaction, cracking, or potential for concentrated leak development



Filter Diaphragm Placement

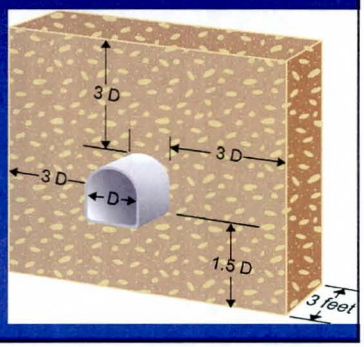
- Filter placement on existing dam
- Filter diaphragm is placed under, over and to the sides of the pipe

Filter Diaphragm Placement

- The filter is compacted
- The filter extends beyond the limits of the excavation

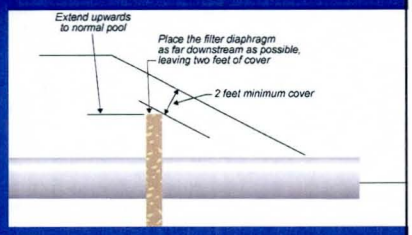
Filter Diaphragm Placement

- NRCS has set some dimensions for filter diaphragms on conduits through embankment dams



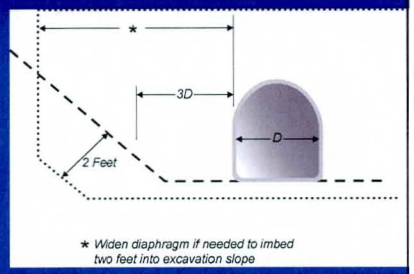
Filter Diaphragm Placement

- Additional NRCS dimensions for filter diaphragms



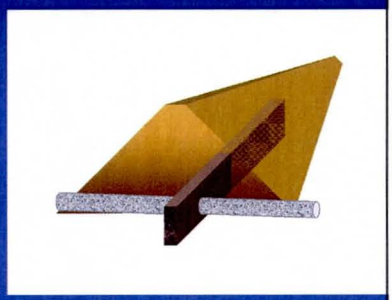
Filter Diaphragm Placement

- Filter extends beyond the limits of the excavation made to install the penetration



Filter Diaphragm Placement

- Sketch of filter diaphragm in dam
- Can tie into drainage system of dam if it has one



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APPENDIX E

PRELIMINARY RECOMMENDATIONS FOR THE OUTLINE OF THE EMBANKMENT DAM UTILITY PENETRATION GUIDELINES DOCUMENT

1. Introduction
   1.1. Purpose and Scope
   1.2. Dam Safety Background
   1.3. Overview of Permit Process and General Checklist of minimum Documents Required to Submit a ROW Application
   1.4. Definitions
   1.5. Dam & Flood Retarding Structure Locations and Identification of Corresponding Federal Sponsor
2. Planning Requirements
   2.1. Prohibited Penetrations
   2.2. Prohibited Structures.
   2.3. District and Agency Review Schedules
   2.4. General District Requirements
   2.5. Alignment Justification
   2.6. Design Concept
   2.7. Project Plan and Schedule
   2.8. Pre-submittal Meeting
3. Submittal Requirements
   3.1. Alternatives Analysis
   3.2. Right-of Way Application

3.3. Completed Checklist of Items Required for a Complete Submittal

3.4. Design Report

3.5. Construction Plans and Specifications

3.6. Proposed Construction Schedule

3.7. QA/QC Plan

3.8. Operations and Maintenance Liability Agreement

3.9. Resume of Qualified Dam Safety Engineer

3.10. Temporary Emergency Action Plan

3.11. Operations and Maintenance Plan

3.12. Operations and Maintenance Liability Agreement

3.13. Insurance and Bonding Requirements

3.14. Proof of Meeting ADWR Application Requirements

3.15. Application Fees

4. Construction Inspection and Testing and Requirements

4.1. Notification of Pre-Construction Meeting & Construction Start

4.1.1.Submittal of Draft Safety Plan for District Review and Comment

4.2. Scheduled Inspections

4.3. Issue\Incident Reporting During Construction

4.4. Post Construction QA/QC Report and Certificate of Special Inspection

4.5. As-built Drawing Requirements

5. Operation, Maintenance, and Agreement Requirements

6. Appendices

6.1. Alternatives Analysis Guidelines

6.2. Failure Modes and Effects Analysis Guidelines

6.3. Geotechnical Evaluation Example

6.4. Design Report Example

6.5. Construction Plan Example

6.6. QA/QC Example

6.7. Construction Observation and Testing Example

6.8. Reference Document List

6.8.1.CD-ROM with Full Reference Documents