CITY OF LANDER
TAYLOR DITCH REHABILITATION PROJECT
LEVEL II, FEASIBILITY STUDY
PHASE II REPORT

Submitted to:

WYOMING WATER DEVELOPMENT COMMISSION
Cheyenne, Wyoming
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November 20, 1998

Submitted to:

Wyoming Water Development Commission
Cheyenne, Wyoming

Prepared by:

GEI Consultants, Inc.
6950 South Potomac Street
Englewood, CO 80112
(303) 662-0100

Project 97384

Douglas D. Boyer, P.G.
Project Manager

Keith A. Ferguson, P.E.
Technical Reviewer
EXECUTIVE SUMMARY

The Wyoming Water Development Commission (WWDC) engaged GEI Consultants, Inc. to identify, evaluate, and perform conceptual designs of alternatives to mitigate canal deficiencies along the Taylor Ditch from Buena Vista Drive to the siphon structure at Highway 287 in Lander, Wyoming. The main objectives of the study were to perform conceptual designs and costs estimates to mitigate the following identified canal deficiencies:

1. Slope instability along the canal slope at an existing landslide at the BLM/Lee property.
2. Slope instability and seepage along the canal slope at an existing landslide near Fremont Motors.
3. Seepage along the canal within the limits of the Lander golf course.
4. Identify cause(s) of high water in the canal at the Highway 287 siphon structure.

Engineering evaluations and analyses performed to evaluate the canal deficiencies were based on reviews of existing reports, topographic surveying of the canal alignment and inverts, a canal condition survey, geologic reconnaissance, subsurface investigations and well installations, and testing of subsurface materials. The engineering evaluations and analyses indicated that the existing landslides at the BLM/Lee property and near Fremont Motors are marginally stable to unstable using historic ground water levels in the analyses.

Conceptual design alternatives were identified and evaluated to mitigate the identified canal deficiencies. Conceptual design alternatives include:

1. Placing the canal in an 84-inch-diameter CMP pipe and constructing an earthfill buttress over the pipe and slide mass or excavating and replacing the landslide material for slope restoration at the BLM/Lee property.
2. Construction of a drainage trench near the base of the slope to lower the ground water near the Fremont Motors area.
3. Construction of a compacted clay or geomembrane lining along the canal to reduce and control the seepage from the canal.

The total project cost for the preferred conceptual design alternatives (CMP pipe/earthfill buttress at the BLM/Lee property, construction of a drainage trench to lower ground water near Fremont Motors, and construction of a compacted clay lining to reduce canal seepage is approximately $1,500,000 (1999 dollars).
There do not appear to be any outstanding permitting challenges that would impact the project; however, potentially responsible parties have yet to be identified and financial obligations of these parties have yet to be quantified.
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1. INTRODUCTION

1.1 Purpose

This report summarizes the work performed for the Phase II Feasibility Study of the Taylor Ditch, Lander, Wyoming. The Phase II work was performed to develop conceptual designs and cost estimates for selected alternatives for mitigation of the canal deficiencies identified in the Phase I work for the segment of the canal from Buena Vista Drive to the siphon structure under Highway 287. A project vicinity map and project layout map are shown on Figures 1, 2 and 3, respectively. The overall length of the canal within the project area is approximately 5,200 feet.

1.2 Scope of Work

The scope of work performed for the Phase I study included the following:

1. Review of available project information and previous study results.

2. Topographic mapping of the canal invert, selected areas adjacent to the canal, and the siphon structure.

3. Subsurface explorations at two landslide/slump locations along the canal. Installation of monitoring wells to measure ground water levels in two borings.

4. Laboratory testing of selected samples obtained from the subsurface exploration program.

5. Engineering evaluations and analyses to evaluate the performance of the canal. Engineering evaluations included geological and geotechnical analyses to evaluate slope stability concerns and hydrologic/hydraulic analyses to evaluate the hydraulic characteristics of the canal and siphon structure.

6. Identification and evaluation of potential canal modification concepts to stabilize landslide/slump areas and improve canal/siphon hydraulics and preparation of comparative cost estimates for each canal modification alternative.

7. Preparation of a report summarizing the work performed for the Phase I work.

The scope of work performed for the Phase II study consisted of:

1. Expansion of the project area from the No. 8 tee box at the golf course upstream to Buena Vista Drive. This work included:
   a. Topographic mapping of the canal invert and canal condition survey.
   b. Subsurface explorations at six locations along the canal and installation of monitoring wells to measure ground water levels in three borings.
   c. Laboratory testing of selected samples obtained from the subsurface exploration program.

2. Additional engineering evaluations and further development of the selected canal repair concepts to the conceptual design-level.

3. Cost estimates for the conceptual design alternatives.

4. Permitting requirements for the project.

5. Financial analyses and stakeholder ability to pay for the project.

6. This report which summarizes the work performed for the Phase II study.

1.3 Authorization

This work was authorized by contract between the Wyoming Water Development Commission (WWDC) and GEI Consultants, Inc. (GEI), dated June 2, 1997. Amendment No. 1 was authorized by the WWDC on February 11, 1998 which included expansion of the project area from the No. 8 tee box at the golf course upstream to Buena Vista Drive.

1.4 Project Personnel

The following personnel were responsible for the work reported herein:

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Douglas D. Boyer, P.G.</td>
</tr>
<tr>
<td>In-house Consultant</td>
<td>Keith A. Ferguson, P.E.</td>
</tr>
<tr>
<td>Lead Hydraulic Engineer</td>
<td>Richard A. Westmore, P.E.</td>
</tr>
<tr>
<td>Project Engineers</td>
<td>Daniel J. Hacker, E.I.T.</td>
</tr>
<tr>
<td></td>
<td>J. Douglas Neighbors, P.E.</td>
</tr>
</tbody>
</table>
Field Geologist  Rick L. Keep  
Hydraulic Engineer  Brad W. Rastall, E.I.T.

Topographic mapping services were performed by C.E. Spurlock Jr. & Associates Inc., Lander, Wyoming, under subcontract with GEI. Drilling services were performed by Inberg-Miller Engineers, Riverton, Wyoming, under subcontract with GEI.

Mr. John W. Jackson, Wyoming Water Development Commission, was the project administrator for this work. Mr. Dave Koch, Director of Public Works, City of Lander, provided valuable input to the project.
2. BACKGROUND

During the course of this study, GEI personnel reviewed available reports and files for the project from the Wyoming Water Development Commission, City of Lander, and Popo Agie Conservation District and conducted interviews with current and former landowners whose properties abut the canal within the project area. The following is a brief summary of applicable information contained in the available documents and obtained from the interviews.

2.1 Previous Work

A number of previous engineering studies dating back to 1962 have been performed for the canal within the study area of this project. The project reports and correspondence document a long history of seepage and slope stability problems associated with the canal. In general, the project information focuses on four issues affecting the performance of the canal:

1. Seepage from the canal along the northern side of the airport/golf course area.
2. Slope instability above the Fremont Motors property.
3. Slope instability at the BLM/Lee property (since the early 1980s).
4. Questions concerning the elevation of the siphon invert (since the mid-1970s).

Very little written documentation concerning the conditions of the canal or engineering evaluations were found in the files since the mid-1980s.

2.2 Project History

The following is a brief history of the canal seepage and slope stability concerns that have been documented in the available project files.

The earliest record of concerns along the portion of the canal between the north side of the golf course and the siphon structure below Highway 287 is dated March 1962. This 1962 site visit report documents concerns about seepage losses from the canal along the north side of the golf course and instability of the slope below the canal in the area near the Fremont Motor Company.

During the summer and fall of 1976, a canal condition survey and engineering evaluations were performed to document and provide recommendations to correct numerous identified deficiencies along the canal. This 1962 site visit report documents seepage losses similar to the 1962 site visit report, as well as the slope instability concerns below the canal in the area above the Fremont
Motor Company. The slope instability was so severe that it caused structural damage to an existing house, which eventually led to the demolition of the structure. In addition, the report documents installation of a bentonite liner in the golf course dam located on the terrace above the canal.

In September 1976, the Soil Conservation Service performed a site visit, subsurface explorations, and engineering evaluation of the slope failure area along the canal above Fremont Motors. Thirteen borings were drilled along various cross sections along the slide to a depth between 13 and 49 feet below the ground surface. This evaluation of the slide concluded that the slide was occurring between the overburden soils and the top of the bedrock surface. Saturation of the overburden soils from canal seepage had contributed to the instability. Dewatering, canal lining, and toe buttressing were recommended to stabilize the slide area.

During the mid-70s the canal alignment was moved to the west of the original canal location to facilitate development along Highway 287. Part of this realignment included cuts and fills for development of an additional site west of the realigned canal known as the Bureau of Land Management (BLM) property (now owned by Lee Construction).

Two slope failures have been documented along the east-facing canal cut slope at the northeast corner of the BLM/Lee property. The first slope failure occurred in October 1981. At that time, the property was owned by the BLM. The second documented slope failure occurred in 1995 and included reactivation of the 1981 slope failure. The 1995 slope failure partially blocked the canal and included a larger area at the top (head) of the slide, which encroached closer to the northeast corner of the metal frame building on the Lee property above the canal. The material that had slid into the canal was excavated and placed on the lower portion of the slide.

During the fall of 1995, the golf course, located upslope of the canal, installed a geomembrane liner at the bottom of the golf course pond to reduce the seepage from the pond. Seepage areas were observed downslope of the pond during the summer of 1996, and repairs were made to the geomembrane liner (puncture holes and seams) during the spring of 1997.

From time to time, small seeps and wet spots have been reported, daylighting at about the mid-height of the slide mass. However, no seeps were observed during the summer of 1997.

2.3 Site Geology

The project area is located physiographically on the southwestern edge of the Wind River Basin in central Wyoming. The basin is a broad structural depression filled with sedimentary rocks. The basin is bounded by the Wind River Range on the west where Paleozoic and Mesozoic rocks dip approximately 10 to 25 degrees to the northeast.
The site is located on the north and east slopes of a small northeast/southwest trending butte. The top of the butte is capped with a thin deposit of alluvial terrace deposits consisting of subrounded sand, gravel, and cobbles. Soft clay shales of the Cody Shale underlie the terrace deposits. These clay shales dip approximately 13 to 25 degrees to the northeast. Residual soils and colluvium cover the majority of the gentle to steep slopes surrounding the butte.
3. **SUMMARY OF PHASE I EVALUATIONS**

The following is a brief summary of the Phase I evaluations. Additional information on the Phase I evaluations is included in a report entitled, "City of Lander, Taylor Ditch Rehabilitation Project, Level II, Feasibility Study," dated January 6, 1998.

3.1 **Site Investigations**

Phase I site investigations consisted of:

1. Topographic surveys
2. Canal condition survey
3. Subsurface explorations

3.1.1 **Topographic Surveys**

Topographic surveys were performed as part of Phase I and included: canal invert elevations (including siphon), topography of the slide mass at the BLM/Lee property, and two cross sections along the slide/slump area above Fremont Motors. The topographic mapping was performed by C.E. Spurlock Jr. & Associates Inc. of Lander, Wyoming.

3.1.2 **Canal Condition Survey**

A canal condition survey was performed in June 1997 by GEI's project manager. The purpose of the condition survey was to observe and document the canal and surrounding area within the study reach. Key observations from the condition survey include:

1. Seepage from the canal was observed along the northern reach of the canal (Stations 0+00 to 12+50).
2. Numerous tension cracks and signs of slope instability were observed below the canal in the vicinity of the Fremont Motors property (Stations 12+00 to 13+00).
3. Shallow slump features were observed in the steep slope behind the Sleeping Bear Campground (Stations 15+50 to 17+00).
4. The slope failure at the BLM/Lee property (Stations 24+00 to 26+00) appears to be a rotational slide encompassing the overburden soils and weathered bedrock.

3.1.3 **Subsurface Investigations**
A subsurface exploration program was performed at the site on August 13 and 14, 1997. The subsurface exploration program consisted of three borings drilled on the BLM/Lee property and two borings drilled south of Fremont Motors. The purpose of the subsurface exploration program was to identify the subsurface materials, obtain samples for laboratory testing, and measure ground water levels.

Piezometers were installed in two of the borings drilled on the BLM/Lee property to measure ground water levels.

Laboratory testing was performed on selected samples obtained from the subsurface exploration program. The results of the laboratory testing can be found in the Phase I report [1].

3.2 Summary of Engineering Analysis

Engineering analyses were performed to evaluate key areas of concern along the canal within the project area. Engineering analyses included slope stability, seepage, and hydraulic evaluations of the siphon structure.

3.2.1 Slope Stability Analyses

Slope stability analyses were performed to evaluate the stability of the existing slope failure at the BLM/Lee property and the existing slide/slump area southwest of Fremont Motors. Static slope stability analyses were performed on critical sections to evaluate the likely failure mechanism(s) for the slides, to support the basis of the selected strength parameters and phreatic surface (ground water) for the analyses, and to evaluate the feasibility of slope repair alternatives.

For the BLM/Lee property, slope stability analyses results indicated that the existing slope configuration with current ground water measurements indicate that the slope is stable, although the calculated factor of safety is slightly below the minimum recommended factor of safety of 1.5. The results of stability analyses performed for the original slope configuration (pre-failure) using historic (higher) ground water levels indicate that the original slope had a factor of safety of about 1.0. The conclusions of the slope stability analyses for the BLM/Lee property indicate that:

1. The instability of the original slope configuration was predictable, based on the assumed material properties and historic ground water levels measured at the site.
2. The initial 1981 slope failure has created a zone of weaker materials in the failure surface/slide zone. The presence of these weaker materials within the slope is continuing to affect the current stability of the slope.

3. The elevation of the ground water in the slope plays a major role in the stability of the slope.

For the Fremont Motors Area stability analyses performed for this location indicate that the slope at this location is marginally stable, i.e., factor of safety of approximately 1.0. Similar to the analyses performed for the BLM/Lee property, the analyses indicate that the presence of weaker materials in the slope, due to previous slope failures, and the elevation of the ground water in the slope plays a major role in the stability of the slope.

3.2.2 Seepage Evaluations

A number of canal seepage studies and evaluations have been performed in the past by the Natural Resources Conservation Service (formerly the Soil Conservation Service). In addition, seepage observations during the canal condition survey performed as part of this study (see Section 3.1.2) indicated that seepage losses from the canal appear to be greatest in the area between the No. 8 tee box at the golf course and the turn in the canal alignment above the Fremont Motors property (project Stations 0+00 to 12+00). Ongoing seepage in the area above Fremont Motors appears to be contributing to the slope instability in this area.

3.2.3 Hydraulic Evaluations

Preliminary hydraulic evaluations of Taylor Ditch and the siphon structure below Highway 287 were performed to evaluate the canal water surface profiles and head required for the siphon to operate under normal and maximum flow conditions. Typical canal cross sections were surveyed and assumed to be representative of the canal. The siphon and canal were evaluated at the average and maximum discharges of 47 cubic feet per second (cfs) and 97 cfs, respectively. Siphon inlet depths were estimated to be 1.1 feet and 2.1 feet for the discharges of 47 cfs and 97 cfs, respectively.

3.3 Design Modification Alternatives

Engineering evaluations and slope stability analyses were performed to evaluate potential slope repair alternatives for the existing landslide and slump areas at the BLM/Lee property and Fremont Motors area.

3.3.1 Slope Restoration Alternatives
Based on our understanding of the subsurface stratigraphy and ground water pressures in the failure areas, the engineering properties of the weathered clay shale, results of the stability analyses described in the preceding section, and experience with the rehabilitation of other failed slopes, the following slope repair alternatives were recommended for the BLM/Lee property slide area and the area south of Fremont Motors.

**BLM/Lee Area**
- Earthfill Buttress
- Pipe/Earthfill Buttress
- Concrete Pier Wall and Buttress
- Earthfill Excavation and Replacement

**Fremont Motors Area**
- Lower Ground Water
- Earthfill Buttress

### 3.3.2 Canal Lining Alternatives

Based on our understanding of the project and our experience with other canal lining projects, the following canal lining alternatives were considered:

1. Compacted Clay
2. Geomembrane (exposed and covered)
3. Concrete
4. Soil-Cement
5. Concrete Block
6. CMP Pipe

### 3.3.3 Siphon Modification Alternative

Concern had been expressed that the siphon inlet elevation allegedly causes an increased canal water depth at the landslide at the BLM/Lee area. Therefore, additional hydraulic analyses were performed to evaluate the change in the water surface profile in the canal, due to lowering the inlet and outlet elevations of the siphon 1 foot. The results of the preliminary evaluation of canal and siphon hydraulics indicate that lowering the siphon inlet and outlet does not significantly decrease water depth at the landslide. Therefore
siphon modification was no longer considered. Problems associated with increased water depth in the canal may be due to debris clogging the siphon pipe or the inlet trashrack or may be indicative of canal maintenance needs.

3.4 Evaluation of Alternatives

A preliminary evaluation of the alternatives discussed in Section 3.3 was performed. The evaluation was based on the technical feasibility, estimated cost of construction, operation and maintenance costs, visual impacts, and other factors.

3.4.1 Slope Restoration Alternatives

The following table presents the preliminary evaluation of alternatives considered to restore the slope at the BLM/Lee property.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Technical Feasibility</th>
<th>Economic Feasibility</th>
<th>Operation and Maintenance Costs</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe/Earthfill Buttress</td>
<td>Yes</td>
<td>Least Expensive</td>
<td>Low to Moderate</td>
<td>Low to Moderate Visual Impacts</td>
</tr>
<tr>
<td>Concrete Pier Wall and Earthfill Buttress</td>
<td>Yes</td>
<td>Most Expensive</td>
<td>Low to Moderate</td>
<td>Moderate Visual Impacts</td>
</tr>
<tr>
<td>Earth Excavation and Replacement</td>
<td>Yes</td>
<td>Moderately Expensive</td>
<td>Low</td>
<td>Minimal Visual Impacts</td>
</tr>
<tr>
<td>Earthfill Buttress</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

The preliminary evaluation of alternatives indicates that the pipe/earthfill buttress and the earth excavation and replacement alternatives appear to be the most viable alternatives to repair the slope along the BLM/Lee property. The concrete pier wall alternative, while technically feasible, is more costly than either of the other two alternatives and does not appear to add any additional value or other intangibles that would warrant further consideration of this alternative.
3.4.2 Canal Lining Alternatives

The following table presents the preliminary evaluation of alternatives considered to reduce canal seepage between Stations 0+00 to 12+00.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Technical Feasibility</th>
<th>Economic Feasibility</th>
<th>Operation and Maintenance Costs</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Lining</td>
<td>Yes</td>
<td>Least Expensive</td>
<td>Moderate</td>
<td>Erosion Concerns</td>
</tr>
<tr>
<td>Geomembrane Lining</td>
<td>Yes</td>
<td>Low</td>
<td>Low to Moderate</td>
<td>Erosion Concerns</td>
</tr>
<tr>
<td>Concrete Lining</td>
<td>Yes</td>
<td>Moderate</td>
<td>Low</td>
<td>No Erosion, High Durability, Increased Capacity, Visual Impacts</td>
</tr>
<tr>
<td>Soil-Cement Lining</td>
<td>Yes</td>
<td>Moderate to High</td>
<td>Low</td>
<td>No Erosion, High Durability, Increased Capacity, Visual Impacts</td>
</tr>
<tr>
<td>Concrete Block Lining</td>
<td>Yes</td>
<td>Most Expensive</td>
<td>Low</td>
<td>No Erosion, High Durability, Increased Capacity, Reduced Visual Impacts</td>
</tr>
<tr>
<td>CMP Pipe</td>
<td>Yes</td>
<td>Moderate to High</td>
<td>Low to Moderate</td>
<td>No Erosion, High Durability, Reduced Visual Impacts</td>
</tr>
</tbody>
</table>

The clay and geomembrane lining alternatives are the least expensive alternatives considered, but will likely have the highest operation and maintenance costs than any other alternative. The concrete lining alternatives and CMP pipe alternative are all considerably more expensive than the clay and geomembrane lining alternatives. However, the concrete lining and CMP pipe alternatives will likely have lower operation and maintenance costs over the life of these alternatives, as compared to the clay and geomembrane lining alternatives.
3.5 Conclusions and Recommendations

3.5.1 Conclusions

The main conclusions of the Phase I work include:

1. In general, the canal is operating satisfactorily. However, a number of deficiencies have been noted in previous reports and observed in this study.

2. The results of the slope stability analyses performed for the existing landslide located at the BLM/Lee property indicate that, assuming lower ground water levels, the existing slope is stable. However, analyses using historic ground water levels (higher ground water) indicate that the slope is marginally stable to unstable.

3. Slope stability analyses performed for the slide/slump area above Fremont Motors indicate that the slope is marginally stable to unstable.

4. The slope stability analyses for both the BLM/Lee property and the Fremont Motors area indicate that the presence of weaker materials in the slope, due to previous slope failures and the elevation of the ground water in the slopes, play a major role in the stability of the slopes.

5. Of the alternatives considered to repair the slope on the BLM/Lee property, the earthfill/pipe buttress alternative and the earthfill excavation and replacement alternative appear to be the most cost-effective solutions.

6. Of the alternatives considered to reduce canal seepage between Stations 0+00 and 12+00, the earth lining and geomembrane lining alternatives appear to be the most cost-effective solutions.

3.5.2 Recommendations

The following are recommendations from the Phase I work:

1. An alternative(s) should be selected for further evaluation to repair the slope on the BLM/Lee property. We recommend either the earthfill/pipe alternative and/or the earthfill excavation and replacement alternative.

2. An alternative(s) should be selected for further evaluation to reduce canal...
seepage between Stations 0+00 to 12+00. We recommend either the earth lining alternative and/or the geomembrane alternative.

3. Phase II conceptual design layouts should include an interceptor trench/drain along the downslope side of the canal between Stations 12+00 and 13+50 to lower the ground water level and increase the stability in this area.

4. Either as part of the Phase II work, or at some later date, a video inspection of the siphon structure below Highway 287 should be performed to observe the condition of the siphon and investigate if there is a partial obstruction of the siphon, causing water to back-up behind the inlet structure.
4. ADDITIONAL SITE INVESTIGATIONS

4.1 General

Additional site investigations were performed for the section of the canal from the No. 8 tee box upstream to Buena Vista Drive. This part of the project area was included as part of the project after the completion of the Phase I work.

4.2 Existing Canal Conditions

The existing canal in the additional Phase II project area (through the Lander golf course) consists of a earthen canal with a 6- to 7-foot bottom width and variable side slopes between approximately 2H:1V (horizontal to vertical) to nearly 1H:1V. The depth of the canal is approximately 4 feet.

Previous observations and reports have focused on seepage areas below the canal. These seepage areas have caused soft, wet areas below the canal on the golf course which have lead to ruts from equipment and golf carts and standing water. No flow has been reported or measured from these areas. Slope instability of the downslope canal slopes has not be observed or reported within the additional Phase II study area. Apparently the seepage has increased over the past few years and lead the golf course to install a geomembrane liner in the canal in the spring of 1998.

Seepage also appears at various locations on the upslope side of the canal. Much of this seepage is limited to wet spots along the canal side slope and appears related to irrigation water from upslope sources. Slope instability in the upslope canal side slopes has not be observed or reported within the additional Phase II study area.

Storm water discharge and other discharge pipes of unknown sources also discharge into the canal within the additional Phase II study area.

4.3 Topographic Surveys

Topographic surveys were performed as part of the Phase II work of this study to provide baseline information on the current configuration of the canal from the No. 8 tee box to Buena Vista Drive. The surveys included collection of invert elevations along the canal.

The results of the topographic surveys are included in Appendix A. The topographic mapping was performed by C.E. Spurlock Jr. & Associates Inc. of Lander, Wyoming.

4.4 Subsurface Explorations
A subsurface exploration program was performed at the site on May 7, 1998. The program consisted of six additional borings (B-201 through B-206) and three observation wells, which were drilled at selected locations along the canal. The locations of the six additional borings are shown on Figure 3. The locations of the borings were selected based on reported seepage areas along the canal and drill rig access considerations. The purpose of the borings and observation wells was to identify the subsurface materials, obtain samples for laboratory testing, and measure ground water levels.

The subsurface explorations were performed by Inberg-Miller Engineers, of Riverton, Wyoming. The drilling was performed using a truck-mounted Mobil Drill, Model B57. The borings were advanced using 4-1/2-inch-diameter hollow stem augers. Subsurface samples were obtained by driving a standard split spoon sampler with a 140-pound hammer, falling 30 inches.

In general, the borings encountered stiff, moist, silty clay over the Cody Shale. The borings were drilled to a depth of between 15 and 16 feet below the ground surface. Observation wells were installed in three of the borings, borings B-201, B-203, and B-204. Sand backfill was placed around the outside of the PVC wells, and a steel casing was placed at the surface to protect the wells. Cross sections of the generalized stratigraphy and logs of the borings are shown on Figure 4. A legend is provided on Figure 5. Detailed logs of the borings are included in Appendix C.

### 4.5 Ground Water

Observation wells were installed in Borings B-201, B-203, and B-204. Ground water levels were measured periodically for several months following the installation of the wells. No water has been measured in the wells since the wells were installed. It appears that the absence of water in the wells is due to the installation of a geomembrane liner in the canal.

### 4.6 Laboratory Testing

Laboratory testing was performed on selected samples obtained from the subsurface exploration program. The laboratory testing included gradation analyses and Atterberg limits. These tests were used to classify the subsurface materials.

The results of the laboratory testing are summarized in Table 1.
5. CONCEPTUAL DESIGN ALTERNATIVES

5.1 General

Several modification alternatives were evaluated and analyzed as a part of Phase I work. Based on this work, alternatives were selected for further evaluation, and are described in the following sections. The conceptual design alternatives include:

**BLM/Lee Property**

1. Pipe/Earthfill Buttress
2. Earth Excavation and Replacement

**Fremont Motors Area**

1. Lower Ground Water

**Canal Lining**

1. Compacted Clay Lining
2. Geomembrane Lining

Conceptual design drawings and cost estimates for each alternative are provided in Appendix C and Section 6, respectively.

5.2 BLM/Lee Property Slope Restoration Alternatives

5.2.1 Pipe/Earthfill Buttress

This alternative consists of placing the canal in an 84-inch-diameter CMP, and placing an earthfill buttress at the toe of the existing landslide as shown on Sheet 1 in Appendix C. The pipe allows additional earthfill to be placed over the toe of the slide mass which increases the stability of the slide mass. The earth buttress will slope at 2 horizontal to 1 vertical from the top of the slide area to a 23-foot-wide bench at elevation 5492.0, near the middle of the slide area. From this bench the earth buttress will slope at 3.25 horizontal to 1 vertical, over the pipe, to existing ground.

The upstream end of the new CMP will tie into an existing 84-inch-diameter CMP at approximately Sta. 24+15. Erosion protection will be placed at the downstream end of the new CMP at approximately Sta. 26+04 and a removable trashrack/security grid will
be placed at the downstream end of the pipe. The trashrack/security grid will prevent unauthorized entrance into the pipe and will be removable for cleaning trash off the inside of the grid.

5.2.2 Earth Excavation and Replacement

This alternative consists of excavating the entire existing landslide material, including the weak failure zone material. Earthfill and a filter/drain sand blanket will be placed in the excavated area as shown on Sheet 2 in Appendix C. The filter/drain sand blanket will control the ground water level in the earthfill material. The earthfill buttress will start at approximate elevation 5504.5, about twenty feet from the northeast corner of the metal frame building on the BLM/Lee property. The slope of the buttress will be 2.8 horizontal to 1 vertical. Because of the steep excavation slope and the proximity of the metal frame building to the excavation, the northeast corner of the metal frame building may have to be stabilized to restrain the building during the excavation, or the method of excavation may require modification to insure stability of the building. The canal bottom will be eight feet wide with 1.5 horizontal to 1 vertical side slopes. Impermeable material will be placed in the canal and the canal bottom will be regraded to a uniform 0.1 percent slope. The filter/drain sand blanket will be protected with a layer of riprap at the contact with the canal.

5.3 Fremont Motors Area

This alternative consists of constructing a drainage trench parallel to the canal from approximately Sta. 10+00 to Sta. 14+00. The drainage trench will be offset approximately 80 feet from the canal. The trench would average 12 feet deep by 3 feet wide and will contain a 9-inch-diameter slotted PVC collector pipe surrounded by filter/drain sand. The collector pipe will discharge into two 9-inch-diameter solid PVC pipes that will convey water collected in the trench to a single 12-inch-diameter PVC discharge pipe. The 12-inch-diameter pipe discharges water at a location near Highway 287. A plan view and typical section of the drainage trench are shown on Sheet 4 in Appendix C.

5.4 Canal Lining Alternatives

5.4.1 Compacted Clay Lining

This alternative consists of excavating material from the existing canal and placing a low permeability clayfill in the bottom and along the sides of the canal. The canal bottom will be 8 feet wide with 2 horizontal to 1 vertical side slopes. The clayfill will be protected by a gravel layer along the bottom and sides of the canal. Some earthfill will
be required to reshape the canal and provide stable slopes. It is anticipated that material excavated from the canal will be suitable as clay fill. A plan view of the limits of the canal lining and a typical section of the canal lining are shown on Sheets 3 and 4, respectively, in Appendix C.

5.4.2 Geomembrane Lining

This alternative consists of excavating the existing canal and placing a geomembrane liner over a sand drain in the canal. The canal bottom will be 8 feet wide with 2 horizontal to 1 vertical side slopes. The sand drain will contain a collector/discharge pipe located approximately every 500 feet along the canal. The geomembrane will be protected by a gravel layer along the bottom and sides of the canal. The purpose of the gravel layer over the geomembrane liner is to:

1. Provide additional UV protection for the liner, and

2. Protect the liner from puncture sources (e.g., golf shoe spikes, golf club divots, cross country ski poles, etc.).

Some earthfill will be required to reshape the canal and to provide stable slopes. A plan view of the limits of the canal lining and a typical section of the canal lining are shown on Sheets 3 and 4, respectively, in Appendix C.
6. OPINION OF PROBABLE CONSTRUCTION COSTS

6.1 Alternative Cost Estimates

The estimated project costs for each alternative were prepared and are summarized in Table 2. Detailed cost estimates for each alternative are provided in Tables 3 through 7.

Costs estimates were developed by preparing a schedule of bid items for each alternative to provide the cost of construction. The costs for engineering during construction were added to the cost of construction, then a 15 percent contingency was added to the combined costs for the total construction cost. Costs for preparation of final design and specifications, permitting and mitigation, legal fees and acquisition of rights-of-way are estimated as a percentage of the total construction costs.

6.2 Basis for Cost Estimates

Quantities included in the cost estimates for the BLM/Lee property alternatives are based on available topographic mapping. Quantities for the other alternatives are based on approximate typical cross sections. In some cases, more detailed mapping will be required to refine construction quantities during final design. Unit prices are based on previous work by GEI for the City of Lander, R.S. Means Heavy Construction Cost Data, and GEI's data base of similar project bid tabs. All unit prices were adjusted to reflect current local construction climate.

As shown on Tables 3 through 7, all cost estimate include the following contingencies:

- Engineering Costs During Construction @ 10 percent
- Contingencies on Constructions and Engineering @ 15 percent

Costs are estimated for 1999. If the project is extended beyond this time, some additional cost should be included for inflation.

Costs for project administration and engineering are estimated on the following percentages of the total construction cost:
6.3 Total Project Costs

The total project cost for the preferred conceptual design alternatives is:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Project Component Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLM/Lee Property</td>
<td></td>
</tr>
<tr>
<td>Pipe/Earthfill Buttress</td>
<td>$282,280</td>
</tr>
<tr>
<td>Fremont Motors Area</td>
<td></td>
</tr>
<tr>
<td>Lower Ground Water</td>
<td>$87,948</td>
</tr>
<tr>
<td>Canal Lining</td>
<td></td>
</tr>
<tr>
<td>Compacted Clay Lining</td>
<td>$1,133,958</td>
</tr>
</tbody>
</table>

The compacted clay lining alternative was selected over the slightly less expensive geomembrane lining alternative for the following reasons:

1. The compacted clay lining alternative requires no specialized equipment for installation. Therefore, more local contractors could likely do the work.

2. The geomembrane lining alternative would likely have higher operation and maintenance costs to repair possible leaks and tears in the liner.

3. The expected design life of the compacted clay liner is longer than the
geomembrane liner.
7. PERMITTING

Construction activities for the Taylor Ditch rehabilitation could be contained along a narrow corridor adjacent to the canal and within the canal right-of-way, and in small (less than 2 acres) areas away from the canal near the Fremont Motors and BLM/Lee properties.

Since the project consists of maintenance or construction of an irrigation ditch, it appears that construction activities would be exempt from U.S. Army Corps of Engineers 404 permitting due to Exemption No. 3. We recommend confirming this exemption during the final design as regulations are subject to constant revision.

We are not aware of any construction impacts to threatened or endangered species, cultural resources, or jurisdictional wetlands. Construction is limited to private property so no other Federal permits would be required.

The size of the construction area will require the contractor to obtain a NPDES stormwater permit from the Wyoming Department of Environmental Quality.

No other City, County, or other permits have been identified at this time. However, it would be good public relations practice to keep local land owners and other interested organizations informed of the status of the project and address their concerns whenever possible.
8. FINANCIAL FEASIBILITY

8.1 Background

The proposed modifications to the Taylor Ditch canal within the project boundaries would correct existing slope stability and seepage issues and increase the reliability of irrigation water supply to members of the Taylor Ditch Company. The members of the Taylor Ditch Company are diverse and include the City of Lander, the Lander Golf Course, and individual irrigators located along the ditch. In addition, there are a number of "interested parties" that could be affected by the proposed modifications to the ditch. These include various land owners and concerned individuals located along the ditch.

8.2 Ability-to-Pay

The purpose of this economic analysis for modifications to the Taylor Ditch is to develop feasibility estimates of ability-to-pay for the proposed slope stability and seepage modifications to the ditch. If ability-to-pay is too low relative to project costs, it may be prudent to terminate project planning at an early stage. If ability-to-pay appears to be reasonable relative to project costs, more detailed cost estimates and more refined ability-to-pay estimates will be needed during the next phase of study (Level III) to develop a financing plan for the project.

For the purpose of this financial feasibility analysis, we have not provided a breakdown of project costs per "responsible" party. However, we have included those parties in the cost sharing portion of the analyses that we believe could be responsible or could benefit from the proposed canal modifications. We have used this approach for the following reasons:

1. The City of Lander is the only project sponsor for this study.

2. No irrigation district or other legal entity has been formed by the Taylor Ditch Company that could receive grant and loan money from the State.

3. Other potentially responsible parties have not been identified to determine allocated project costs of the proposed slope stability and seepage modifications. Other "responsible" parties may include:

   a. Lander Golf Course
   b. Abutting property owners
   c. Previous land owners
   d. Original developers
   e. Other interested parties
Based on the above approach and the estimated total project cost in Section 7, we have prepared an ability-to-pay assuming a 50 percent grant and a 50 percent loan scenario. Based on guidelines furnished by the WWDC, we have assumed an interest rate for the loan portion of the project will be financed at the current State Lands and Investments Board interest rate of 6.0 percent (agricultural projects) for the BLM/Lee property and Fremont Motors area components and an interest rate of 7.25 percent (municipal projects) for the canal lining component. A 30-year-term was used in the analysis for both loan rates. The following table summarizes the results of the financial analyses:

<table>
<thead>
<tr>
<th>Canal Modification Component</th>
<th>Project Component Cost</th>
<th>Grant Amount</th>
<th>Loan Amount</th>
<th>Annual Payment</th>
<th>Potential Beneficiary</th>
</tr>
</thead>
<tbody>
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<td>BLM/Lee Property</td>
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<td>$141,140</td>
<td>$141,140</td>
<td>$10,254</td>
<td>Taylor Ditch Irrigation Co., City of Lander, Property Owner, Abutting Property Owners, Others?</td>
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<tr>
<td>Fremont Motors Area</td>
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<td>$43,974</td>
<td>$43,974</td>
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<td>Taylor Ditch Irrigation Co., City of Lander</td>
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<td>Canal Lining</td>
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<td>$566,979</td>
<td>$566,979</td>
<td>$46,844</td>
<td>Golf Course, City of Lander</td>
</tr>
</tbody>
</table>

8.3 Conclusions

The following are the conclusions of the financial feasibility:

1. The Taylor Ditch Company delivers water to some 2077.79 assessed acres. These acres will benefit from any canal improvements both from an increased water supply and from a more reliable delivery system. Financial obligation of Taylor Ditch Irrigation Company has not been quantified.

2. Other potentially responsible parties have yet to be identified and financial obligations of these parties have yet to be quantified. Additional economic analyses will be needed in Phase III to assess the ability-to-pay and willingness-to-pay of all potentially responsible parties.
9. CONCLUSIONS

9.1 Conceptual Designs

The following are conclusions of the Phase II study of the project:

1. In general, the subsurface samples collected as part of the Phase II investigations consisted of silty clays and clayey sands over Cody Shale and are similar to the samples collected for during the Phase I investigations.

2. Observed seepage downslope of the canal appears to be related, at least in part, to water in the canal.

2. Water level readings in wells installed as part of the Phase II investigations indicate that the wells are dry and likely reflect the influence of the geomembrane liner installed in the canal by the golf course.

3. The pipe/earthfill buttress and the earthfill excavation and replacement alternatives are viable solutions to repair the slope failure at the BLM/Lee property. However, the pipe/earthfill buttress alternative is a less expensive alternative.

4. The compacted clay and geomembrane liner alternatives are viable solutions to reduce the seepage from the canal. However, the compacted clay liner alternative is a slightly less expensive and lower maintenance solution.

5. The project should be exempt from U.S. Army Corps of Engineers 404 permit requirements under Exemption No. 3. A Wyoming NPDES stormwater permit will be required for construction. No other federal, state, or local permits should be required for the proposed construction.

6. The City of Lander is expected to have the financial resources to satisfy the estimated loan obligation. However, other potentially responsible parties have yet to be identified and financial obligations of these parties have yet to be quantified.
10. **RECOMMENDATIONS**

Based on this conceptual level study, we recommend:

1. The pipe/earthfill alternative for mitigating the landslide at the BLM/Lee property is the preferred alternative for final design. The conceptual level cost estimate indicates that this option is less expensive, and constructability issues (especially excavation near the existing building) contribute to a greater uncertainty in the cost estimate of the earth excavation alternative.

2. Final designs should include a drainage trench for controlling the landslide at the Fremont Motors area.

3. The compacted clay lining option for controlling seepage from the canal is the preferred alternative for final design. Conceptual level cost estimates indicate that the difference between options is small, however the lower operation and maintenance costs and a longer expected life make the clay liner a more attractive alternative.

4. During final designs, the proper federal agencies should be contacted in order to confirm the permitting conclusions presented in this report. In addition, local permitting requirements and landowner access permission should be confirmed.

5. Other potentially responsible parties have yet to be identified and financial obligations of these parties have yet to be quantified. Additional economic analyses will be needed in Phase III to assess the ability-to-pay and willingness-to-pay of all potentially responsible parties.

6. A video inspection of the siphon structure below Highway 287 should be performed to observe the condition of the siphon and investigate if there is a partial obstruction of the siphon, causing water to back up behind the inlet structure.
11. LIMITATIONS

This report has been prepared for the use of the Wyoming Water Development Commission, City of Lander, and Taylor Ditch water users. GEI Consultants, Inc., has endeavored to conduct the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in this geographical area and under similar conditions as this project. No other representation, expressed or implied, is included or intended in the document.

The analyses and recommendations contained in this report are based in part on data obtained from subsurface explorations. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations.

Our review of the available information referenced the Phase I report has been limited to those project components or features that apply to the proposed scope of work for the Taylor Ditch within the project study area. No review or evaluation of any other project feature or facility component of the Taylor Ditch outside the project study area has been performed as part of this work.

It is the understanding of GEI Consultants, Inc., that this report is to be used in connection with the feasibility evaluation of Taylor Ditch within the project study area. This stated purpose was a significant factor in determining the scope and level of service provided for in this work. Should the purpose of this report change, the report immediately ceases to be valid and use of it by the Wyoming Water Development Commission, City of Lander, the Taylor Ditch water users, or any other party without GEI Consultants, Inc., prior review and written authorization shall be at the sole risk of the user.
12. REFERENCES

The following references were used during the course of the work described herein:


### TABLE 1 - SUMMARY OF LABORATORY TEST RESULTS

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Sample No.</th>
<th>Depth (feet)</th>
<th>Atterberg Limits</th>
<th>Minus No. 200</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LL</td>
<td>PI</td>
</tr>
<tr>
<td>B-201</td>
<td>S-1</td>
<td>6</td>
<td>38</td>
<td>13</td>
</tr>
<tr>
<td>B-201</td>
<td>S-3</td>
<td>16</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>B-202</td>
<td>S-2</td>
<td>11</td>
<td>51</td>
<td>29</td>
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<td>S-3</td>
<td>16</td>
<td>54</td>
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<td>B-204</td>
<td>S-1</td>
<td>6</td>
<td>45</td>
<td>25</td>
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<tr>
<td>B-205</td>
<td>S-2</td>
<td>11</td>
<td>56</td>
<td>35</td>
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</table>
### TABLE 2 - SUMMARY OF OPINION OF PROBABLE PROJECT COSTS

<table>
<thead>
<tr>
<th>Construction Cost Total</th>
<th>Project Administrative and Engineering Costs</th>
<th>Acqusition of Access and Rights-of-Way</th>
<th>Project Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preparation of Final Design and Specifications</td>
<td>Permitting and Mitigation</td>
<td>Legal Fees</td>
</tr>
<tr>
<td>BLM/Lee Property</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe/Earthfill Buttress</td>
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<td>$24,546</td>
<td>$2,455</td>
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<tr>
<td>Earth Excavation and Replacement</td>
<td>$289,543</td>
<td>$28,954</td>
<td>$2,895</td>
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<td>Fremont Motors Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Ground Water</td>
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<td>$7,648</td>
<td>$765</td>
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<tr>
<td>Canal Lining</td>
<td></td>
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<tr>
<td>Compacted Clay Lining</td>
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<td>$81,727</td>
<td>$10,216</td>
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<tr>
<td>Geomembrane Lining</td>
<td>$1,018,912</td>
<td>$81,513</td>
<td>$10,189</td>
</tr>
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</table>

**TABLE 2 - SUMMARY OF OPINION OF PROBABLE PROJECT COSTS**
# TABLE 3 - OPINION OF PROBABLE FINAL PROJECT COST

BLM/Lee Property  
Pipe/Earthfill Buttress

## Project Administrative and Engineering Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Design and Specifications @ 10% of CCT</td>
<td>$24,546</td>
</tr>
<tr>
<td>Permitting and Mitigation @ 1% of CCT</td>
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<tr>
<td>Legal Fees @ 2% of CCT</td>
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<tr>
<td>Acquisition of Access and Rights-of-Way @ 2% of CCT</td>
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</tr>
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</table>

## Project Component Costs

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
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<td>L.S.</td>
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<tr>
<td>Site Clearing</td>
<td>1</td>
<td>Acre</td>
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<td>$1,300</td>
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<tr>
<td>Stripping and Stockpiling Topsoil</td>
<td>750</td>
<td>C.Y.</td>
<td>$3.50</td>
<td>$2,600</td>
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<tr>
<td>Unclassified Excavation</td>
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<td>C.Y.</td>
<td>$7.00</td>
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</tr>
<tr>
<td>Furnishing and Placing Earthfill</td>
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<td>Acre</td>
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</tbody>
</table>

Base Construction Subtotal (BCS) | $147,000 |
Mobilization @ 10% of BCS | $14,700 |
Unscheduled Items @ 20% of BCS + Mobilization | $32,340 |

Construction Cost Subtotal No.1 (CC#1) | $194,040 |

Engineering Costs During Construction @ 10% of CC#1 | $19,404 |

Construction Cost Subtotal No.2 (CC#2) | $213,444 |

Contingencies @ 15% of CC#2 | $32,017 |

Construction Cost Total (CCT) | $245,461 |

Project Total Costs | $282,280 |
### TABLE 4 - OPINION OF PROBABLE FINAL PROJECT COST

**BLM/Lee Property**

**Earth Excavation and Replacement**

#### Project Administrative and Engineering Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Design and Specifications @ 10% of CCT</td>
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#### Project Component Costs

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<th>Unit</th>
<th>Unit Price</th>
<th>Cost</th>
</tr>
</thead>
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<td>7,600</td>
<td>C.Y.</td>
<td>$8.00</td>
<td>$60,800</td>
</tr>
<tr>
<td>6 Furnishing and Placing Filter/Drain Sand</td>
<td>1,100</td>
<td>C.Y.</td>
<td>$20.00</td>
<td>$22,000</td>
</tr>
<tr>
<td>7 Furnishing and Placing Riprap and Bedding</td>
<td>110</td>
<td>C.Y.</td>
<td>$45.00</td>
<td>$5,000</td>
</tr>
<tr>
<td>8 Furnishing and Installing Chainlink Fence</td>
<td>100</td>
<td>L.F.</td>
<td>$11.50</td>
<td>$1,200</td>
</tr>
<tr>
<td>9 Provide Support for Existing Building</td>
<td>1</td>
<td>L.S.</td>
<td>$10,000.00</td>
<td>$10,000</td>
</tr>
<tr>
<td>10 Reclamation</td>
<td>1</td>
<td>Acre</td>
<td>$5,000.00</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

#### Summary Costs

- **Base Construction Subtotal (BCS)**: $173,400
- **Mobilization @ 10% of BCS**: $17,340
- ** Unscheduled Items @ 20% of BCS + Mobilization**: $38,148

**Construction Cost Subtotal No.1 (CC#1)**: $228,888

- **Engineering Costs During Construction @ 10% of CC#1**: $22,889

**Construction Cost Subtotal No.2 (CC#2)**: $251,777

- **Contingencies @ 15% of CC#2**: $37,767

**Construction Cost Total (CCT)**: $289,543

**Project Total Costs**: $332,975
TABLE 5 - OPINION OF PROBABLE FINAL PROJECT COST
Fremont Motors Area
Lower Ground Water

Project Administrative and Engineering Costs
Preparation of Final Design and Specifications @ 10% of CCT $7,648
Permitting and Mitigation @ 1% of CCT $765
Legal Fees @ 2% of CCT $1,530
Acquisition of Access and Rights-of-Way @ 2% of CCT $1,530

Project Component Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dewatering</td>
<td>1</td>
<td>L.S.</td>
<td>$2,500.00</td>
<td>$2,500</td>
</tr>
<tr>
<td>2 Site Clearing</td>
<td>1</td>
<td>Acre</td>
<td>$1,300.00</td>
<td>$1,300</td>
</tr>
<tr>
<td>3 Stripping and Stockpiling Topsoil</td>
<td>275</td>
<td>C.Y.</td>
<td>$3.50</td>
<td>$1,000</td>
</tr>
<tr>
<td>4 Unclassified Excavation</td>
<td>1,100</td>
<td>C.Y.</td>
<td>$5.00</td>
<td>$5,500</td>
</tr>
<tr>
<td>5 Furnishing and Placing Earthfill</td>
<td>560</td>
<td>C.Y.</td>
<td>$8.00</td>
<td>$4,500</td>
</tr>
<tr>
<td>6 Furnishing and Placing Filter/Drain Sand</td>
<td>550</td>
<td>C.Y.</td>
<td>$20.00</td>
<td>$11,000</td>
</tr>
<tr>
<td>7 Furnishing and Installing PVC Drain Pipe</td>
<td>1,500</td>
<td>L.F.</td>
<td>$10.00</td>
<td>$15,000</td>
</tr>
<tr>
<td>8 Reclamation</td>
<td>1</td>
<td>Acre</td>
<td>$5,000.00</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

Base Construction Subtotal (BCS) $45,800
Mobilization @ 10% of BCS $4,580
Unscheduled Items @ 20% of BCS + Mobilization $10,076

Construction Cost Subtotal No.1 (CC#1) $60,456

Engineering Costs During Construction @ 10% of CC#1 $6,046

Construction Cost Subtotal No.2 (CC#2) $66,502

Contingencies @ 15% of CC#2 $9,975

Construction Cost Total (CCT) $76,477

Project Total Costs $87,948

COST_EST.XLS
Lower_G.W.
9/2/98
GEI Consultants, Inc.
TABLE 6 - OPINION OF PROBABLE FINAL PROJECT COST
Canal Lining
Compacted Clay Lining

<table>
<thead>
<tr>
<th>Project Administrative and Engineering Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Design and Specifications @ 8% of CCT</td>
</tr>
<tr>
<td>Permitting and Mitigation @ 1% of CCT</td>
</tr>
<tr>
<td>Legal Fees @ 1% of CCT</td>
</tr>
<tr>
<td>Acquisition of Access and Rights-of-Way @ 1% of CCT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Component Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>1 Dewatering</td>
</tr>
<tr>
<td>2 Site Clearing</td>
</tr>
<tr>
<td>3 Stripping and Stockpiling Topsoil</td>
</tr>
<tr>
<td>4 Unclassified Excavation</td>
</tr>
<tr>
<td>5 Furnishing and Placing Clay Lining</td>
</tr>
<tr>
<td>6 Furnishing and Placing Erosion Protection</td>
</tr>
<tr>
<td>7 Furnishing and Placing Earthfill</td>
</tr>
<tr>
<td>8 Bridge &amp; Pipe Removal and Replacement</td>
</tr>
<tr>
<td>9 Reclamation</td>
</tr>
</tbody>
</table>

Base Construction Subtotal (BCS) | $611,800 |
Mobilization @ 10% of BCS | $61,180 |
Unscheduled Items @ 20% of BCS + Mobilization | $134,596 |

Construction Cost Subtotal No.1 (CC#1) | $807,576 |

Engineering Costs During Construction @ 10% of CC#1 | $80,758 |

Construction Cost Subtotal No.2 (CC#2) | $888,334 |

Contingencies @ 15% of CC#2 | $133,250 |

Construction Cost Total (CCT) | $1,021,584 |

Project Total Costs | $1,133,958 |
### TABLE 7 - OPINION OF PROBABLE FINAL PROJECT COST

#### Canal Lining

**Geomembrane Lining**

<table>
<thead>
<tr>
<th>Project Administrative and Engineering Costs</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Design and Specifications @ 8% of CCT</td>
<td>$81,513</td>
</tr>
<tr>
<td>Permitting and Mitigation @ 1% of CCT</td>
<td>$10,189</td>
</tr>
<tr>
<td>Legal Fees @ 1% of CCT</td>
<td>$10,189</td>
</tr>
<tr>
<td>Acquisition of Access and Rights-of-Way @ 1% of CCT</td>
<td>$10,189</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Component Costs</th>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dewatering</td>
<td>1</td>
<td>L.S.</td>
<td>$11,500.00</td>
<td>$11,500</td>
<td></td>
</tr>
<tr>
<td>2 Site Clearing</td>
<td>5</td>
<td>Acre</td>
<td>$1,300.00</td>
<td>$6,500</td>
<td></td>
</tr>
<tr>
<td>3 Stripping and Stockpiling Topsoil</td>
<td>5,700</td>
<td>C.Y.</td>
<td>$3.50</td>
<td>$20,000</td>
<td></td>
</tr>
<tr>
<td>4 Unclassified Excavation</td>
<td>12,100</td>
<td>C.Y.</td>
<td>$10.00</td>
<td>$121,000</td>
<td></td>
</tr>
<tr>
<td>5 Furnishing and Placing Earthfill</td>
<td>6,050</td>
<td>C.Y.</td>
<td>$8.00</td>
<td>$48,400</td>
<td></td>
</tr>
<tr>
<td>6 Furnishing and Placing Filter/Drain Sand</td>
<td>4,050</td>
<td>C.Y.</td>
<td>$20.00</td>
<td>$81,000</td>
<td></td>
</tr>
<tr>
<td>7 Furnishing and Placing Erosion Protection</td>
<td>3,800</td>
<td>C.Y.</td>
<td>$27.00</td>
<td>$102,600</td>
<td></td>
</tr>
<tr>
<td>8 Furnishing and Placing Geomembrane Lining</td>
<td>132,600</td>
<td>S.F.</td>
<td>$1.25</td>
<td>$165,800</td>
<td></td>
</tr>
<tr>
<td>9 Furnishing and Installing PVC Drain Pipe</td>
<td>600</td>
<td>L.F.</td>
<td>$10.00</td>
<td>$6,000</td>
<td></td>
</tr>
<tr>
<td>10 Furnishing and Installing Drain Pipe Outfalls</td>
<td>8</td>
<td>EA.</td>
<td>$300.00</td>
<td>$2,400</td>
<td></td>
</tr>
<tr>
<td>11 Bridge &amp; Pipe Removal and Replacement</td>
<td>1</td>
<td>L.S.</td>
<td>$40,000.00</td>
<td>$40,000</td>
<td></td>
</tr>
<tr>
<td>12 Reclamation</td>
<td>1</td>
<td>Acre</td>
<td>$5,000.00</td>
<td>$5,000</td>
<td></td>
</tr>
</tbody>
</table>

|                | Base Construction Subtotal (BCS) | $610,200 |
|                | Mobilization @ 10% of BCS         | $61,020  |
|                | Unscheduled Items @ 20% of BCS + Mobilization | $134,244 |

#### Construction Cost Subtotal No.1 (CC#1)

|                | $805,464 |

#### Engineering Costs During Construction @ 10% of CC#1

|                | $80,546  |

#### Construction Cost Subtotal No.2 (CC#2)

|                | $886,010  |

#### Contingencies @ 15% of CC#2

|                | $132,902  |

#### Construction Cost Total (CCT)

|                | $1,018,912 |

#### Project Total Costs

|                | $1,130,992 |

9/2/98
GEI Consultants, Inc.
NOTES:
1. SEE FIGURE 3 FOR LOCATION OF BORINGS.
2. SEE FIGURE 5 FOR LEGEND AND NOTES.
**LEGEND**

Silty Clay. Medium to high plastic fines, 0%-10% fine sand, 0%-5% gravel to 3/4”, slight reaction with HCL, gypsum crystals, medium stiff to very stiff, moist to wet, dark grey-brown. (CL, CH)

Clayey Sand with gravel. Mostly fine to coarse sand with gravel and cobbles, < 30% medium to high plastic fines, medium dense, moist, brown (SC).

Fresh Clay Shale. Mostly medium plastic fines, laminated, hard to very hard, moist to dry, grey to dark grey-brown.

Indicates that 33 blows of a 140 lb. hammer falling 30 inches were required to drive a split-spoon or modified California sampler 12”.

Indicates approximate location of material change. Exact strata change not encountered in samples.

Indicates observation well installed in boring to depth indicated. Horizontal lines indicate screened interval of observation well.

**NOTES**

1. Borings were drilled May 7, 1998.
2. Borings were drilled with 4.25-inch I.D. hollow stem augers powered by a mobile B57 truck mounted drilling rig.
3. Boring elevations and topography were surveyed by C.E. Spurlock and Associates in July 1998.
4. Borings are subject to limitations, explanations, and conclusions of this report.
5. Subsurface profiles are known only at the boring locations and may differ at other locations. Conclusions and recommendations presented in this report are based on reasonable engineering interpretation of the boring results.

Wyoming Water Development Commission

Taylor Ditch Feasibility Study

Gei Consultants, Inc.

Land, Wyoming

Project No. 97384

Sept. 1998

Figure 5

 Wyoming Water Development
Commission

Taylor Ditch
Feasibility Study

Gei Consultants, Inc.

Land, Wyoming

Project No. 97384

Sept. 1998

Figure 5
RECORD OF SOIL EORATION  
BORI: NO. 8201

Project:  Taylor Dock  
Location:  Lander, WY

Surface Elevation:  
Datum:  Client:  

Job No.: 7693RE

**SAMPLE**

<table>
<thead>
<tr>
<th>Depth</th>
<th>No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>12&quot;</td>
<td>Stiff, moist, gray-brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>14&quot;</td>
<td>Becomes frag at 10'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>SS</td>
<td>12&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GROUND WATER MEASUREMENTS

Compl. Depth 16'  ft. Cave-in depth __ ft.  
Foreman  
Inspector:  

After 1/2 Hrs. __ ft.  After __ hrs. __ ft.  
Method 4.25 HSA  

Date Begun: 5/1/74  Date Comp. 5/7/74

INBERG-MILLER ENGINEERS  
124 East Main Street  
Riverton, WY 82501
**RECORD OF SOIL LOCATION**

**Project:** Taylor Ditch  
**Location:** Lander, WY

**Surface Elevation:**  
**Datum:**  
**Client:** GEI

<table>
<thead>
<tr>
<th>Depth</th>
<th>No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td>Surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>4&quot;</td>
<td>Stiff, moist, Brown Silty Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>14&quot;</td>
<td>Grades to Hard @ ~12.5' (Coh. Shale)</td>
<td>4'6-6</td>
<td>2-4-6</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>SS</td>
<td>14&quot;</td>
<td></td>
<td>9'2-11</td>
<td>9-4-9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14'6-16</td>
<td>10-12-20</td>
</tr>
</tbody>
</table>

**GROUND WATER MEASUREMENTS**

Date Begun: 5-7-98  Date Comp. 5-29-98

Compl. Depth 16 ft. Cave-in depth 13 ft.  
Foreman TLV Inspector: ESR

After 1/4 Hrs. 9 ft. After ____ hrs. ____ ft.  
Method 4-4 HSA

INBERG-MILLER ENGINEERS  
124 East Main Street  
Riverton, WY 82501
<table>
<thead>
<tr>
<th>Depth</th>
<th>No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>16</td>
<td>Firm, Mar. to bot., Brown silt, clay</td>
<td>4½-6</td>
<td>1-2-9</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>16</td>
<td>Clay shale?</td>
<td>9½-11</td>
<td>2-4-8</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>SS</td>
<td>16</td>
<td></td>
<td>14½-16</td>
<td>1-3-5</td>
</tr>
</tbody>
</table>

GROUND WATER MEASUREMENTS

Date Begun: 5-7-98 Date Comp: 5-7-98

Compl. Depth 16 ft. Cave-in depth __ ft. Foreman __
After ½ Hrs. __ ft. After __ hrs. __ ft. Method __½' HSA
## RECORD OF SOIL LOCATION

**BORL. NO.: B264**

### Location Information
- **Project:** Taylor Ditch
- **Location:** Lander, WY
- **Surface Elevation:**
- **Datum:**
- **Client:**
- **Job No.:** 7693KE

### Sample Details

<table>
<thead>
<tr>
<th>Depth</th>
<th>No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td>Surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>1B</td>
<td>Stiff, moist, brown clay</td>
<td>4'1/2-6</td>
<td>4/5-6</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>12</td>
<td>Hard, moist, brown-grey</td>
<td>9'6-11</td>
<td>15-22-25</td>
</tr>
<tr>
<td>3</td>
<td>55</td>
<td>SS</td>
<td>1B</td>
<td>Silty clay (coarse silt)</td>
<td>14'1/6</td>
<td>12-18-20</td>
</tr>
</tbody>
</table>

### Ground Water Measurements

- **Date Begun:** 5-7-98
- **Date Comp.:** 5-7-99
- **Compl. Depth:** 15 ft.
- **Cave-in depth:** 15 ft.
- **Foreman:**
- **Inspector:**
- **After Hours:**
- **Method:** 4'4" HSA

---

**INBERG-MILLER ENGINEERS**
124 East Main Street
Riverton, WY 82501
**Record of Soil Exploration**

**Project:** Taylor Ditch  
**Location:** Lander, WY  
**Surface Elevation:**  
**Datum Client:**  
**Job No.:** 76928E

<table>
<thead>
<tr>
<th>Depth No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td>Surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>Stiff, Moist, Brown Silty Clay (Weathered Silt)</td>
<td>4½ - 6</td>
<td>8-10-11</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>Graded to unweathered below 5'</td>
<td>9½ - 4</td>
<td>6-11-13</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>SS</td>
<td>Becomes hard at 15'</td>
<td>14½ - 16</td>
<td>9-12-18</td>
</tr>
</tbody>
</table>

**Ground Water Measurements**

<table>
<thead>
<tr>
<th>Compl. Depth</th>
<th>ft. Cave-in depth</th>
<th>ft.</th>
<th>Foreman</th>
<th>Inspector</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td></td>
<td></td>
<td>TW</td>
<td>Goz</td>
</tr>
</tbody>
</table>

**Drilling & Sampling Notes**

**Inberg-Miller Engineers**

124 East Main Street  
Riverton, WY 82501
<table>
<thead>
<tr>
<th>Depth</th>
<th>No.</th>
<th>Type</th>
<th>Rec.</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>Sample Depth</th>
<th>DRILLING &amp; SAMPLING NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td>Surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moist, Brown Clay, Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>with gravel and cobbles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>SS</td>
<td>12&quot;</td>
<td>Still, moist, grey-brown</td>
<td>4½-10</td>
<td>6-12-16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Silt, Clay (Cody Shale)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>SS</td>
<td>12&quot;</td>
<td></td>
<td>9½-11</td>
<td>6-10-18</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>SS</td>
<td>12&quot;</td>
<td></td>
<td>14½-16</td>
<td>6-15-20</td>
</tr>
</tbody>
</table>

GROUND WATER MEASUREMENTS

Date Begun: 5-2-90 Date Comp. 5-7-91

Compl. Depth 16 ft. Cave-in depth 11 ft.
Foreman T.L.V. Inspector: L.C.

After 1½ Hrs. 3½ ft. After ___ hrs. ___ ft.
Method 4½" HSA

INBERG-MILLER ENGINEERS
124 East Main Street
Riverton, WY 82501
ITOR WELL SCHEMATIC - FIELD DATA

PROJECT: Taylor Oaks
LOCATION: [Location Details]
CLIENT: [Client Information]
MONITOR WELL NO.: [Monitor Well Number]

LOCKING (STEEL) (PVC) (FLUSH-MOUNTED) - CAP

CASING
DIAMETER: (2.0) (4.0) in
MATERIAL: PVC
GAUGE: 40 SCH
FROM (A): [Depth]
TO (J): [Depth]

BLANK CASING
FROM (A): [Depth]
TO (G): [Depth]

FACTORY SLOTTED CASING (SCREEN)
SLOT SIZE: 0.02 (0.01) in
FROM (G): [Depth]
TO (H): [Depth]

BLANK CASING
FROM (H): [Depth]
TO (J): [Depth]

PACKING:
Concrete:
FROM (B): [Depth]
TO (C): [Depth]

Bentonite Plug:
FROM (C): [Depth]
TO (D): [Depth]

(Natural Soil)(Grout) Backfill:
FROM (D): [Depth]
TO (E): [Depth]

Bentonite Plug:
FROM (E): [Depth]
TO (F): [Depth]

Sand: washed, silica, fine, medium to coarse
Gravel: fine to coarse,
FROM (F): [Depth]
TO (I): [Depth]

Natural Cave-in:
FROM (I): [Depth]
TO (K): [Depth]

TOTAL COMPLETED CASING DEPTH (J): [Depth]
TOTAL COMPLETED TEST BORING DEPTH (K): [Depth]

ELEVATIONS
DATE:
SURFACE E1.: [Depth] ft
CASING E1.: [Depth] ft
STATIC GROUNDWATER SURFACE E1.: [Depth] ft

Note: All depths measured from existing ground surface
ITOR WELL SCHEMATIC - FIELD DA

PROJECT: Taylor Ditch JOB NO. 761286
LOCATION: La Jolla, CA CLIENT: GFL
BORING NO. B202 MONITOR WELL NO. MW34

LOCKING (STEEL) (PVC) (FLUSH-MOUNTED) - CAP

Casing
Diameter: (2.0) (4.0) in
Material: PVC
Gauge: 40 SCH
From (A): 50 ft
To (J): 14 ft

Blank casing
From (A): 0 ft
To (G): 4 ft

Factory slotted casing (screen)
Slot size: 0.02" (0.01) in
From (G): 13 3/4 ft
To (E): 13 3/4 ft

Blank casing
From (H): 13 3/4 ft
To (J): 14 ft

Packing:
Concrete:
From (B): 0 ft
To (C): 1 ft

Bentonite Plug:
From (C): 1 ft
To (D): 2 1/2 ft

(Natural Soil)(Grout) Backfill:
From (D): ___ ft
To (E): ___ ft

Bentonite Plug:
From (E): ___ ft
To (F): ___ ft

Sand: washed, silica, fine, medium to coarse
Gravel: fine to coarse,
From (F): 3 1/2 ft
To (I): 14 ft

Natural Cave-in:
From (I): 14 1/4 ft
To (K): 14 1/4 ft

Total completed casing depth (J): 14 ft
Total completed test boring depth (K): 14 1/2 ft

Note: All depths measured from existing ground surface.

INBERG - MILLER ENGINEERS
PROJECT: Taylor DR
LOCATION: Cote
CLIENT: ECI
BORING NO. B264
MONITOR WELL NO. M14

LOCKING (STEEL) (PVC) (FLUSH-MOUNTED) - CAP

CASING
DIAMETER: (2.0) (4.0) in
MATERIAL: PVC
GAUGE: 40 SCH
FROM (A): 0 ft
TO (J): 14 ft

BLANK CASING
FROM (A): 0 ft
TO (G): 4 ft

FACTORY SLOTTED CASING (SCREEN)
SLOT SIZE: 0.02 (0.01) in
FROM (G): 4 ft
TO (H): 13 4/8 ft

BLANK CASING
FROM (H): 13 4/8 ft
TO (J): 14 ft

PACKING:
Concrete:
FROM (B): 0 ft
TO (C): 1 ft

Bentonite Plug:
FROM (C): 1 1/2 ft
TO (D): 3 1/2 ft

(Natural Soil)(Grout) Backfill:
FROM (D): 1 1/2 ft
TO (E): 1 1/2 ft

Bentonite Plug:
FROM (E): 1 1/2 ft
TO (F): 1 1/2 ft

Sand: washed, silica, fine, medium to coarse
Gravel: fine to coarse,
FROM (F): 2 ft
TO (I): 14 1/2 ft

Natural Cave-in:
FROM (F): 14 ft
TO (K): 18 1/2 ft

TOTAL COMPLETED CASING DEPTH (J): 14 ft
TOTAL COMPLETED TEST BORING DEPTH (K): 19 1/2 ft

ELEVATIONS
DATE:
SURFACE EL.: _______ ft
CASING EL.: _______ ft
STATIC GROUNDWATER SURFACE EL.: _______ ft

INBERG - MILLER ENGINEERS
PLAN VIEW

PROFILE ALONG PROPOSED CANAL

SECTION

EXCAVATION AND REPLACEMENT CONFIGURATION LOOKING DOWNSTREAM STA. 24+97