GEI Consultants, Inc.

FORENSIC INVESTIGATION
MEADOW POND DAM
ALTON, NEW HAMPSHIRE

Submitted to

New Hampshire Department of Environmental Services

Concord, New Hampshire

Gonzalo Castro, Ph.D., P.E.
Principal-In-Charge

Craig F. Ward, P.E.
Senior Project Manager

53 Regional Drive
Concord, New Hampshire
(603) 224-7979

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EXECUTIVE SUMMARY

GEI Consultants, Inc. (GEI) was retained by the State of New Hampshire Department of Environmental Services (NHDES) Water Resources Division (WRD) to conduct a forensic investigation of the failure of the Meadow Pond Dam in Alton, New Hampshire. This report provides the results of GEI's forensic investigation.

The dam is located on private property owned by Mr. and Mrs. Robert Bergeron located north of Route 140 in Alton, New Hampshire. The earthen dam was approximately 30 feet tall, with an approximately 44-acre impoundment.

The dam was designed by Rivers Engineering Corp. (Rivers) in 1992. The December 17, 1992 revision of the design drawings were approved by the WRD.

The dam was constructed between November 1993, and July 1994. The owner hired Connie's Septic Service, Inc. (CSSI) to perform the earthwork construction and Putnam Concrete (Putnam) for the concrete work. The owner contracted Varney Engineering (Varney) to provide quality control services, which included materials testing and construction observation.

The dam failed in the evening of March 13, 1996. The resulting flood waters flowed along the path of the existing stream until reaching Route 140. The flood waters then traveled northeast along a residential section of Route 140 where it joined the Merrymeeting River. Extensive property damage occurred along Route 140. One life was lost during flooding.

The purpose of GEI's forensic evaluation was to determine the mechanism of failure, review the design for adequacy and to determine if the dam was constructed in accordance with the design approved by the NHDES. Work conducted by GEI as part of the forensic evaluation included field investigations, geotechnical laboratory testing of soil samples obtained from the dam, and interviews with parties involved in the design, construction and maintenance of the dam.

Based on the observations of the failure made by the Bergerons (the owners of the dam) and our own observations of the dam during the field investigations, it is our opinion that the failure took place as a result of erosion and piping immediately beneath the spillway slab. Erosion and piping resulted in the development of an open channel under the spillway slab which caused rapidly accelerating erosion and the breach of the dam. The piping failure appears to have started about 15 to 20 feet right (looking downstream) of the left end of the horizontal portion of the spillway.

GEI's review of the design relative to the standard of practice is summarized in Section 7. As-built conditions that deviate from the design are identified in Section 8. The design features and as-built deviations from the design that, in our opinion, contributed to the failure are summarized in Section 9. These contributing factors, which are related to inadequate control of seepage beneath the spillway, are listed below:

- The lateral extent of the seepage cutoff beneath the spillway into the embankments on both sides of the spillway was approximately 11 feet shorter than designed.

- Cracks in the cutoff wall and in the spillway slab and the horizontal construction joint between the spillway slab and cutoff wall provided a direct hydraulic connection to the gravel blanket downstream of the cutoff wall. These cracks were probably caused by a combination of factors, including: the lack of longitudinal steel reinforcement in the cutoff wall, which was required in the design; settlement of the embankment core material, which was not compacted sufficiently to meet the specifications; and heaving of the spillway slab and cutoff wall due to the formation of ice lenses in the gravel blanket and the underlying core material. The specified gradation for the gravel blanket material did not adequately limit the fines to avoid frost susceptibility. The frost susceptibility of the gravel blanket was further increased by the use of material containing more fines than allowed in the specifications and the presence of zones of contamination with silty core materials. Also, the gravel blanket was not thick enough to avoid frost penetration into the underlying frost susceptible core materials.

- The seepage path from the open water in the reservoir to the bottom of the cutoff wall was too short as designed, and even shorter as built.

- The gravel blanket specified in the design allowed placement of materials that were not sufficiently permeable to safely drain seepage passing the cutoff wall. The permeability of the as-built gravel blanket was even lower than that of the specified material since it contained more fine grained soils than allowed in the specifications and was contaminated with zones of silty core materials.

- The formation of ice lenses in the frost susceptible gravel blanket material and underlying core material probably caused heaving which led to the development of voids at the interfaces of the spillway, cutoff wall and grouted riprap with adjacent soils. Thawing of the ice lenses also may have left voids within the gravel blanket.

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1. INTRODUCTION

GEI Consultants, Inc. (GEI) was retained by the State of New Hampshire Department of Environmental Services (NHDES) to conduct a forensic investigation of the failure of the Meadow Pond Dam in Alton, New Hampshire, which occurred on March 13, 1996. GEI's contract for these services is dated March 19, 1996. This report provides the results of GEI's forensic investigation.

The dam is located on private property owned by Mr. and Mrs. Robert Bergeron located north of Route 140 in Alton, New Hampshire. The earthen dam was approximately 30 feet tall, with an approximately 44-acre impoundment. The dam was constructed in 1994 to replace a smaller dam located approximately 500 feet upstream, which was reported to be in poor condition. Figure 1 shows the site area in 1989, prior to the construction of the dam.

The dam was designed by Rivers Engineering Corp. (Rivers) in 1992. Rivers subcontracted Jaworski Geotech, Inc. (Jaworski) to provide geotechnical recommendations for the design. Several revisions were submitted to the NHDES Water Resources Division (WRD) for review. The December 17, 1992 revision of the design drawings were approved by the WRD. The design drawings and other documents considered part of the design are provided in Appendix A.

The design drawings show a homogeneous earthen embankment dam, approximately 470 feet long with a 12-foot-wide crest. Significant design features of the dam include the following:

- The upper portion of the upstream face of the embankment was to have a 2.5H:1V slope protected with riprap. The lower portion of the upstream face was to have a 3H:1V slope.

- The downstream face of the embankment was to have a 2.25H:1V slope.

- The embankment core fill in the dam was to be a low permeability glacial till.

- Seepage control was to be provided by a 3-foot-wide chimney drain located beneath the crest of the dam, which was to connect to a blanket drain placed on the foundation of the downstream section of the dam. A toe drain was to be located at the downstream end of the blanket drain.

- A low level outlet was designed to penetrate the dam at the base of the embankment. An antiseep collar was to be located just upstream of the chimney drain.

- The spillway was designed as an overflow embankment section with a horizontal concrete slab over the crest and a grouted riprap channel over the downstream slope of the embankment. A portion of the riprap on the upstream slope in front of the spillway was also to be grouted. The design drawings show concrete slabs on each end of the horizontal spillway slab that slope upwards from the horizontal spillway slab to the crest of the embankment. Concrete abutment walls were also required on both ends of the horizontal spillway slab.

- The design required a continuous seepage cutoff consisting of a concrete cutoff wall beneath the horizontal spillway slab and the footings for the concrete abutment walls. The footings for the abutment walls were to extend the seepage cutoff into the embankment a distance of 27 feet from the horizontal portion of the spillway slab. The cutoff wall was to extend to a depth of about 5 feet below the top of the horizontal spillway slab. The required depth of the abutment wall footings ranged from 4 to 5 feet.

- The channel downstream of the spillway was to be protected with riprap retained by a low baffle wall located 30 feet downstream of the toe of the dam.

The dam was constructed between November 1993, and July 1994. The owner hired Connie's Septic Service, Inc. (CSSI) to perform the earthwork construction and Putnam Concrete (Putnam) for the concrete construction. The owner contracted Varney Engineering (Varney) to provide quality control services, which included materials testing and construction observation.

At about 6:40 p.m. on March 13, 1996, the dam owners noticed an increase in flow in the stream leading from the dam and observed a plume of water approximately 3 feet in diameter flowing from the grouted riprap on the downstream side of the dam. The majority of the spillway and a portion of the embankment were eroded away by 7:00 pm leaving a portion of the dam foundation exposed.

The flood waters that were released flowed along the path of the existing stream until reaching Route 140. The flood waters then traveled northeast along a residential section of Route 140 where it joined the Merrymeeting River. Extensive property damage occurred along Route 140. Mrs. Lynda Sinclaire's life was lost during the flooding caused by the failure.

The post failure condition of the dam is shown on a topographic plan prepared by Eastern Topographics and survey drawings prepared by Civil Consultants. These drawings are provided in Appendices B and C, respectively.

2. SCOPE OF WORK

The purpose of this investigation was to document the condition of the site subsequent to the dam failure, to identify the failure mechanism and to evaluate the adequacy of the dam design and construction. Data collected during the investigation included: visual observations; measurements; photographs; material samples; interviews with parties involved in the design, construction and maintenance of the dam; and geotechnical laboratory testing results. GEI also reviewed design and construction documentation.

Sections 3 and 4 of this report detail specific field investigations and laboratory testing conducted for this project. Section 5 describes the various interviews with the project participants undertaken by GEI. GEI's opinion concerning the mechanism of failure is presented in Section 6. The review of the design, with GEI's opinion as to the design features that contributed to the failure, is presented in Section 7. A comparison of the as-built conditions with the design requirements is presented in Section 8, including a discussion of the deviations from the design that, in our opinion, contributed to the failure. In Section 9, the design features and deviations from the design that, in our opinion, contributed to the failure are summarized.

3. FIELD INVESTIGATIONS

Field investigations and site visits were conducted between March 19 and April 5, 1996. GEI participated in the six days of field investigations and performed two additional site visits. Field observation reports presented in Appendix D provide a record of the observations made during the site visits and field investigations.

3.1 Field Investigations

Field investigations were conducted on March 20 and April 1 through 5, 1996, as a cooperative effort of several engineering organizations. The engineers represented the interests of parties involved in the design and construction of the dam, parties impacted by the failure, and the owner, are listed below.

Interested Party	Engineering Representative(s)
Site Owner	Hydro Environmental Technologies, Inc. GeoTesting Express Simpson Gumpertz & Heger Inc.
NHDES, WRD	GEI Consultants, Inc.
Rivers Engineering	Rivers Engineering Haley & Aldrich
Jaworski Geotech, Inc.	Jaworski Geotech, Inc. William Zoino Heynen Teale Engineers, Inc.
Varney Engineering	Varney Engineering
CSSI	P.B. Aldinger & Associates Douglas G. Peterson & Associates
Putnam Concrete	Failure Analysis
The Estate of Mrs. Sinclair	GeoInsight

Initial field investigations were conducted on March 20, 1996 to obtain data which may have been destroyed by impending precipitation. The scope of the initial investigations had been planned in advance by GeoTesting Express. This investigation involved excavation and data gathering primarily on the left side of the breach.

After the initial investigation, a scope of work for additional field investigations was developed by GEI and circulated to each of the interested parties for comment (GEI memorandum dated March 22, 1996). Modifications were made to the original scope of work based on comments received from the interested parties during a telephone conference call on March 28, 1996.

The field investigations included the following:

- Careful cutting and removal of portions of the spillway slab and cutoff wall that remained on the right side of the breach after the failure to expose a void observed at the right end of the cutoff wall and to look for other possible signs of erosion;

- Excavation of the embankment to the right of the breach in a series of benches to allow soil sampling, field density testing, and observation/measurement of exposed components of the dam;

- Concrete coring to obtain samples of the cutoff wall and spillway slab for strength testing.

- Measurement and examination of debris from the concrete spillway and cutoff wall located downstream of dam. This information was used to determine as much as possible about the original configuration of the spillway and cutoff wall prior to the failure.

- Test pit excavation along the alignment of the baffle wall to determine if the wall was founded on bedrock, as shown on the design drawings;

- Test pit excavation adjacent to the stream in the base of the breach to check for presence of open gravel/cobbles in the foundation soils that could lead to internal erosion.

Additional activities performed for the investigation of the dam included professional photography, topographic mapping by aerial photogrammetry, and surveying.

Field density testing of the embankment soils was conducted by GEI and Haley & Aldrich (H&A). The majority of field density testing was conducted by H&A using a nuclear density gauge. Additional testing was conducted by H&A using sand cone methods and by GEI using a nuclear density gauge to check the accuracy of H&A's nuclear density gauge. Comparison of the density measurements obtained at three locations using the GEI nuclear gauge, the H&A nuclear gauge, and the H&A sand cone indicated a maximum variation of approximately 1.1%. The results of the field density testing are presented in the field observation reports (Appendix D). The results of field density testing using the nuclear density gauges are summarized in Table 2.

Soil samples obtained during the field investigations were transported to GEI's geotechnical laboratory for testing as described in Section 4.

3.2 Significant Observations

A list of significant observations made during the field investigation is provided below:

- A void was observed at the right end of the spillway cutoff wall. During the removal of the spillway slab, the void was observed to continue along the downstream side of the cutoff wall, near the intersection of the cutoff wall and the spillway slab. Based on observations of the soil along the bottom of the void, it appears that the void was caused by erosion and piping. Evidence of erosion was also observed on the subgrade for the sloping portion of the spillway slab, downstream of the cutoff wall. The approximate extent of the void and apparent subgrade erosion is shown on Figure 2.

- Heavily rusted steel reinforcing bars and staining of the concrete were observed on the underside of a portion of the concrete slab from the left side of the spillway (in debris pile). The approximate area of the staining and heavily rusted reinforcing bars is shown on Figure 2.

- Ice lenses were observed in the core material beneath portions of the spillway slab.

- A water mark on an existing staff gauge surveyed by Civil Consultants indicates that the maximum water level in the pond was slightly above the top of the flashboards. The elevations of ice along the upstream side of the embankment indicate that the water level in the pond immediately prior to failure was probably just below the top of the flashboards.

- A slope failure appeared to have occurred on the upstream slope of the embankment due to rapid drawdown conditions that occurred during the breach.

- Cracks were observed in the portions of the spillway slab and cutoff wall that remained intact on the right side of the breach. Caulking observed in some of the cracks indicates that the cracks occurred prior to the failure.

- Based on measurements of the intact portions of the spillway and cutoff wall and debris from the spillway and cutoff wall located downstream of the dam, the as-built dimensions of the spillway and cutoff wall differed from those shown on the design drawings.

- A cold joint appeared to be located at the junction of the spillway slab and the cutoff wall. The design drawings indicate that the spillway slabs and cutoff wall were to be cast monolithically.

- Although required in the design, no longitudinal reinforcing steel was observed at the ends of broken sections of the concrete cutoff wall.

- Reinforcing steel in the spillway slabs were observed on the bottom surfaces of the slabs, with little or no concrete cover.

- The grouted riprap downstream of the spillway slab was not as thick as required in the design.

- Along the left side of the breach, the upper portion of the chimney drain was observed to be offset about 2.2 feet upstream of the lower portion of the chimney drain.

- The chimney drain was not extended deep enough to connect to the blanket drain in the area of the low level outlet. Portions of the chimney drain in this area were contaminated with core materials.

- The baffle wall was not founded on bedrock, as required in the design.

- The as-built dimensions of the blanket drain were different from those shown on the design drawings.

- The flashboards installed on the spillway were measured to be 13⅞ inches in height in lieu of the 12-inch height required in the design.

- The gravel blanket material beneath the spillway slab was contaminated with fine grained soil.

- Examination of the foundation soil in a test pit and on an eroded face within the breach, indicated that the foundation soils consisted of sand and gravel with cobbles. No openwork cobbles or boulders were observed.

4. LABORATORY TESTING

4.1 Geotechnical Laboratory Testing

Geotechnical laboratory testing was conducted on selected soil samples collected from the site during field investigations. Testing included compaction tests, grain size analyses, hydrometer analyses, triaxial permeability tests, and water content determinations. Testing was performed in general accordance with ASTM methods. The specific test methods used are indicated on the laboratory testing report forms provided in Appendix E. A summary of samples collected and geotechnical laboratory testing conducted is provided in Table 1. The results of the compaction testing are summarized in Table 2, with the field density measurements. Gradation curves from the grain size analyses are presented in Figures 3 through 6.

The design drawings specify compaction requirements relative to maximum dry density determined by compaction testing in accordance with ASTM D 1557. Therefore, GEI performed compaction testing on soil samples obtained during the field investigation using methods described in ASTM D 1557, and related gravel corrections in accordance with ASTM D 4718. However, these methods are intended for use only with soils containing no more than 30% gravel greater than 3/4-inch. Although several of the soils samples obtained during the field investigation contained more than 30% gravel greater than 3/4-inch, ASTM D 1557 and ASTM D 4718 methods were used to be consistent with the design.

4.2 Concrete Strength Testing

Six concrete core samples obtained from the spillway slab and cutoff wall were submitted by Simpson, Gumpertz & Heger, Inc. to the Thompson & Lichtner Company, Inc. for compressive strength testing. The results of the compressive strength testing are provided in Appendix E.

5. INTERVIEWS

GEI conducted interviews with several of the interested parties to obtain additional information concerning the design, construction and maintenance of the dam. Interviews were conducted with the owners and personnel from Rivers, NHDES, CSSI, Varney Engineering, and Putnam Concrete. Memoranda prepared by GEI to summarize the interviews are presented in Appendix F.

6. FAILURE MECHANISM

Based on the observations of the failure made by the Bergerons and our own observations of the dam after the failure, it is our opinion that the Meadow Pond Dam failure took place as a result of erosion and piping of the soils beneath the spillway slab. Erosion and piping led to the development of an open channel under the spillway slab which caused rapidly accelerating erosion and the breach of the dam. According to Mr. and Mrs. Bergeron (see interview in Appendix F), the initial breach occurred about 15 to 20 feet right of the left end of the horizontal portion of the spillway.

A brief description of the piping mechanism is presented below in Subsection 6.1. This is followed by a description of the measures used to prevent piping in embankments (Subsection 6.2) as a preamble to the design and construction review presented in Sections 7 and 8. Finally in Section 9, we present our opinion relative to the factors that contributed to the piping failure and how they relate to the design and construction issues discussed in Section 7 and 8.

6.1 Piping Mechanism

Piping is the internal erosion of soils caused by seepage. As seepage passes through an embankment, frictional forces act on the soil particles in the direction of the seepage flow. These frictional forces are referred to as seepage forces and are directly proportional to the rate at which seepage pressures are dissipated as seepage flows through the embankment. Where seepage discharges, or breaks out, on a surface, such as the downstream face of an embankment, the seepage forces can carry soil particles out of the embankment, leaving a void at the face. Once a void is formed, the seepage path through the embankment is shortened, causing seepage to concentrate at the void and increasing the flow rate and seepage pressures in the soil immediately upstream of the void. The increased flow rate and pressure in turn increase the rate at which soil particles are eroded out of the embankment. Thus, the erosion of soil from the embankment proceeds upstream through the embankment from the discharge point towards the reservoir, creating a channel. The channel formed by this internal erosion is commonly referred to as a "pipe". The process of internal erosion is commonly referred to as "piping".

Voids within the embankment soils or between the embankment soils and structures also can create initiation points for piping. Since voids effectively shorten the seepage path, seepage tends to concentrate at the voids and cause localized increases in pressures and flow rates that can lead to piping. Also, soil on the upstream side of a void is poorly confined and can be eroded into the void, initiating the formation of a soil pipe.

Piping also can be caused by the erosion of soil particles from a finer grained soil into the pores (interstitial spaces between soil particles) of a coarser grained soil.

6.2 Measures to Prevent Piping

An objective of proper embankment design is to control seepage to avoid piping. To inhibit piping, it is important to minimize the seepage forces at the discharge face where the soil is not confined and thus can be removed by the seepage forces. Since seepage forces are directly proportional to the rate at which seepage pressures are dissipated, it is desirable to cause the dissipation of seepage pressures in the upstream portions of the embankment, where the soil is confined. This is accomplished by placing low permeability soils in the upstream section of the embankment. Seepage barriers are also used in the upstream portion of the embankment to dissipate seepage pressures by increasing the length of the seepage path. The low permeability soils and/or seepage barriers in the upstream section also act as the main barrier against flow, reducing the rate of seepage. Near the discharge face of the embankment where the soils are not well confined, it is desirable to minimize seepage forces. This is accomplished by placing pervious soils that allow the seepage to freely drain without the development of seepage forces. To inhibit the movement of finer grained soils into the pores of coarser grained soils, soil filters are placed between materials of widely differing particle size distributions.

In summary, specific features incorporated into the design and construction of embankment dams to inhibit piping are as follows:

- Seepage Reduction: The reduction of seepage flow and pressure should be accomplished in the upstream portions of the embankment where soils are well confined and not easily eroded. Seepage reduction is accomplished by the placement of low permeability soils and seepage barriers, such as cutoff walls, that increase the length of the seepage path.

- Drainage: Proper drainage should be provided in downstream portions of the embankment where soils are not well confined and are easily eroded. Proper drainage is accomplished by the placement of pervious soils that allow the seepage to freely drain without the development of erosive seepage forces.

- Avoidance of the Potential for the Formation of Voids: Embankments should be designed and constructed to avoid the potential for the formation of voids or spaces between the embankment soils and structures that can shorten seepage paths, cause seepage concentrations, and leave zones of unconfined soils.

- Filtration: Soil filters should be placed, when needed, to separate materials of widely varying particle size distributions to inhibit the movement of the finer grained particles.

7. DESIGN REVIEW

The design that was reviewed by GEI is presented in three drawings provided to us by WRD from their files. The three drawings are numbered C1 through C3, revision 4, dated December 17, 1992, and were prepared by Rivers Engineering Corp. (Rivers) of Manchester, New Hampshire. Copies of these drawings are provided in Appendix A. Note that the drawings are stamped "NOT FOR CONSTRUCTION". Our understanding is that there are no subsequent versions of the design drawings nor an "as-built" set of drawings.

In our review, we have considered the following documents to also be part of the design:

- Geotechnical Report "Meadow's Pond Dam, Alton, New Hampshire" by Jaworski Geotech, Inc., dated October 22, 1992.

- WRD files for the project.

The geotechnical report and key correspondence from the WRD files are included in Appendix A.

A review of WRD files indicates that there was a design change made during construction that was approved by WRD. The change consisted of the replacement of the corrugated metal pipe (CMP) low level outlet shown in the drawings with a polyethylene pipe with smooth interior and corrugated exterior of the same diameter (12 inches) as the original CMP pipe. The change also replaced the cast-in-place concrete seepage collar with a Ripley's Dam seepage collar.

Our review of the design addresses geotechnical and structural issues. Hydraulic and hydrological aspects of the design are not addressed because the failure was not related to overtopping or excessive flow over the spillway.

The design was reviewed for adequacy and, whenever possible, was checked against recommendations in the two references given in the regulations for dams issued by the NHDES. These regulations are presented in the New Hampshire Code of Administrative Rules, Chapters Env-Wr 100 - 800, under Section 307.08 titled "Earth Embankment Design Criteria". The effective date of this section is February 22, 1991. The references are the Soil Conservation Service Technical Release No. 60 of October 1985, entitled "Earth Dams and Reservoirs" [1, 2][1], and "Design of Small Dams" published by The U.S. Bureau of Reclamation in 1987 [3].

Design features not meeting the current standard of practice are noted in this section of the report. These features, which are related to the general configuration of the dam and the

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[1] Numbers in brackets correspond to references listed in Section 10.

specified soil materials, and our opinions on their possible contributions to the failure are discussed in Subsections 7.1 and 7.2, respectively. Design features that, in our opinion, contributed to the failure are summarized in Subsection 7.3.

7.1 General Configuration

The earth embankment of the Meadow Pond Dam was designed as an homogeneous embankment with chimney and blanket drains, generally in accordance with current practice.

The spillway was designed as an overflow embankment section with a concrete slab over the crest and a grouted riprap channel over the downstream slope of the embankment. The channel downstream of the dam was protected with riprap and a low baffle wall to act as an energy dissipator located 30 feet downstream of the toe of the dam. The riprap upstream of the spillway slab also was to be grouted.

The Bureau of Reclamation "Design of Small Dams" publication comments (Section 4.16) that

> "The practice of building overflow concrete spillways on earth or rock embankments has generally been discouraged because of the more conservative design assumptions and added care needed to forestall failures".
>
> More conservative construction details suggested by the Bureau are "arbitrarily increased liner thickness, increased reinforcement steel, cutoffs, joint treatment, drainage and preloading".

We interpret the terminology "arbitrarily increased" to indicate more conservatism in the design of these features than would be considered adequate for a spillway constructed on natural ground.

Seepage control beneath the spillway of Meadow Pond Dam, as designed, would be accomplished as follows: The piezometric head would be dissipated as the water flows through the core material upstream of the cutoff wall and under or around the ends of the wall and to a lesser degree through the upstream grouted riprap and the underlying gravel blanket. Downstream of the cutoff wall the seepage would enter the gravel blanket that should be a pervious (free draining) material. Note that the chimney and blanket drains, if properly designed and built, would control seepage through the embankment itself, but would have little effect on controlling seepage beneath the spillway.

The design of the spillway required a cutoff wall connected to the concrete slab at its upstream end. The lateral extent of the cutoff wall is not clear in the drawings. However, sketches by Rivers in the NHDES files dated December 11, 1992 appear to indicate that the cutoff wall was intended to be continuous with the footing for the concrete abutment wall, in effect extending the cutoff wall 27 feet beyond the edge of the horizontal section of the spillway slab. With this assumption, it is our opinion that the lateral extent of the cutoff wall would be adequate.

It is our opinion that the distance between the bottom of the cutoff wall and the open water in the reservoir was too short to provide an adequate barrier against seepage beneath the cutoff wall. The cutoff wall penetrated about 2 feet into the low permeability material in the dam. Thus, the seepage path through the core materials from the reservoir to the bottom of the cutoff wall was only about 2 feet long in the vertical direction and about 8 feet long in the horizontal direction. Note that the grouted riprap is unlikely to be a reliable seepage barrier as it would be expected to crack as the embankment settles.

In our opinion, the short seepage path between the reservoir and the bottom of the cutoff wall could have contributed to the failure.

7.2 Soils

7.2.1 Core Material

The specifications for the core material are adequate both in terms of gradation and permeability.

7.2.2 Filter Sand and Sand and Gravel

The specifications for the "filter sand" and the "sand and gravel" to be used in the chimney and blanket drains allow the presence of too many fines. The Soil Conservation Service requirement [2] for drains and filters is a maximum of 5% passing the No. 200 sieve. The U. S. Bureau of Reclamation's recommendation in "Design of Small Dams" [3] is also a maximum of 5% fines and their standard specifications in the same reference has zero percent fines. The specifications for the drain materials for the Meadow Pond Dam does not include a requirement for the percentage passing the No. 200 sieve as it is conventionally done. The specifications permit a range of 0 to 10% to pass the No. 100 sieve (0.199 mm), which would allow soils with fines percentages in excess of 5% passing the No. 200 sieve.

For both materials, the specifications also require a permeability greater than "10 E-3 cm/sec" (Note that the terminology for the number is somewhat ambiguous. We interpret it to mean 0.001 or 10^{-3} cm/sec based on the computations in the geotechnical report). In our opinion the target permeabilities are too low for the blanket drain. A seepage analysis presented in the geotechnical report indicates that the blanket drain with a permeability of 10^{-3} cm/sec would be sufficient to carry the flow through the dam computed with the assumption that the core material has a permeability of 10^{-5} cm/sec. However, it is common practice to design drains with a substantially higher permeability than indicated by the computations (typically by a factor of 10) to allow for increased seepage from unidentified sources such as more pervious zones in the embankment, such as those caused by more pervious soils or by minor cracks in the embankment or in the foundation. A permeability test performed by GEI on a sample of "sand and gravel" obtained from the dam, which did meet the gradation specifications, resulted in a permeability of 10^{-3} cm/sec. Thus, this soil barely met the permeability specification. Note that it is not common practice for a dam of this size to require permeability tests for construction control. Common practice is to specify a gradation that will ensure that the permeability would be adequate by a wide margin.

In our opinion, the allowance of soils with high fines contents and borderline permeabilities in the chimney and blanket drains did not contribute to the failure. However, in the long term, the use of soils with borderline permeabilities in the chimney and blanket drains could have resulted in seepage outbreaks on the downstream slope, potentially leading to piping of the lower embankment core materials. Note that the actual failure was caused by piping of the soils immediately beneath the spillway slab and grouted riprap, rather than through the embankment core materials.

7.2.3 Gravel Blanket

The gravel blanket material was designed to be used under the upstream grouted riprap, under the spillway slab and under the grouted riprap in the downstream spillway channel. For its use under the spillway slab downstream of the cutoff wall and under the grouted riprap, the material as specified allows a percentage of fines that is too high (up to 10%) to ensure free drainage. A permeability test on a sample of the gravel blanket that approximately complies with the gradation specification had a permeability of 10^{-4} cm/sec, which is too low to provide appropriate drainage. As discussed above, materials designed to provide drainage within the dam are generally specified to have a percentage of fines of 5% or less.

Furthermore, the material with a percentage of fines of 10% is likely to have a percentage passing 0.02 mm larger than 3%, which makes it frost susceptible [4]. The three samples of the gravel blanket that we tested exceed 3% passing 0.02 mm. The gravel blanket, which is overlain by the 8-inch-thick concrete slab or by the 18-inch-thick grouted riprap layer, would be well within the expected depth of frost penetration in Alton, New Hampshire. Upon freezing, the soil can develop ice lenses and heaving, resulting in cracking of the overlying slab, the cutoff wall, or the grouted riprap. Heaving of these structures can also lead to the formation of voids between the structures and the adjacent soils. Upon thawing, voids can develop in the gravel blanket, or at its contact with the slab or grouted riprap, as the ice lenses melt. In order to avoid frost susceptibility of the gravel blanket material, the percentage of fines should have been specified to be 3% or less.

In our opinion, the poor drainage characteristics and frost susceptibility of the gravel blanket contributed to the failure of the dam.

The combined thicknesses of the gravel blanket and spillway slab or grouted riprap were not sufficient to prevent frost penetration into the underlying core material. Since the core material is also frost susceptible, heaving and ice lenses formation would also develop. Note that ice lenses in the core material were observed during our field investigations. In our opinion, inadequate protection of the frost susceptible core materials beneath the spillway from frost penetration could have contributed to the failure.

7.3 Summary of Design Features Contributing to the Failure

In this section, we summarize those design features discussed in Subsections 7.1 and 7.2 that, in our opinion, contributed to the failure.

- The specified gravel blanket material designed to be placed under the spillway slab and the grouted riprap allowed for soils of insufficient permeability to provide proper drainage downstream of the cutoff wall.

- The specified gravel blanket material allowed for soils that are frost susceptible, which would lead to the development of ice lenses that could heave the spillway slab, cutoff wall, and grouted riprap, causing cracking of these structures and the formation of voids between these structures and the underlying soils. Thawing of the ice lenses also would cause voids in the gravel blanket or at its contact with the spillway slab. Voids would have facilitated the initiation of piping.

  Temperature data obtained from a nearby meteorological station located in New Durham, New Hampshire, indicate that partial thawing of ice lenses in the soils beneath the grouted riprap and spillway slab may have contributed to the onset of piping. The date of the failure followed three days of unseasonably warm weather during which maximum temperatures climbed above freezing. On the day of the failure, the maximum temperature had reached 52°F.

- The seepage path between the reservoir and the cutoff wall was too short to provide sufficient head loss to inhibit the initiation of piping in the gravel blanket.

- The thickness of the gravel blanket was not sufficient to protect the frost susceptible core materials beneath the spillway from frost penetration. The resulting formation of ice lenses and heaving could have damaged the spillway structures and caused the formation of voids as described above for the gravel blanket.

8. CONSTRUCTION REVIEW

The as-built conditions were observed only in the sections of the dam adjacent to the breach and thus any comparison with the design documents is limited to the observed areas. As-built conditions not in compliance with the design documents are noted in this section of the report. These conditions, which are related to geometric configuration, concrete and reinforcement, and soil materials, and our opinions on their possible contributions to the failure, are discussed in Subsections 8.1, 8.2, and 8.3, respectively. These opinions are summarized in Subsection 8.4. The observed as-built conditions are compared with the design documents in the NHDES files, which included the drawings by Rivers dated December 17, 1992. The Contractor may have had a different issue of the drawings (see interview with CSSI in Appendix F).

8.1 Geometric Configuration

The as-built configuration of the spillway and embankment was compared with that indicated in the design drawings and the sketches prepared by Rivers on December 11, 1992 (NHDES files). The as-built conditions of the right end of the spillway and portions of the embankment on either side of the breach are shown on Figure 2 and on Civil Consultants' survey drawings provided in Appendix C. Figure 2 also shows the inferred configuration of the portions of the spillway and embankment that were destroyed during failure. Differences between the design and as-built configuration of the spillway and embankment are discussed below:

- The design documents indicate that the cutoff wall and the footings for the abutment walls should form a continuous seepage cutoff beneath the horizontal and sloping portions of the spillway slab, and extending into the embankment on both sides of the spillway. As shown on Figure 3, the cutoff wall was to form the portion of the seepage cutoff beneath the horizontal portion of the spillway. On both sides of the spillway, the footings for the abutment walls were to extend the seepage cutoff into the embankment to a distance of 27 feet beyond the horizontal portion of the spillway (11.5 feet beyond the upslope end of the sloping spillway slab). The cutoff wall was to extend to a depth of 5 feet below the top of the horizontal spillway slab. The required depth of the concrete abutment wall footing varied from 5 feet, at its intersection with the cutoff wall, to 4 feet below the crest of the embankment.

  Measurements of the portions of the spillway remaining on the right side of the breach indicate that the cutoff wall extended beneath the full length of the horizontal portion of the spillway and continued approximately 16 feet right of the horizontal portion of the spillway, where it ended at the right end of the sloping slab (Figure 3). Based on observations of the debris from the spillway and cutoff wall located downstream of the dam, we conclude that the configuration of the left end of the cutoff wall and spillway were similar to that observed on the right end.

About a year after the dam was built, the dam owner added concrete wingwalls at both ends of spillway (see interview with the Bergerons in Appendix F). The wingwalls were about 4-feet-long, and were flush with the tops of the concrete abutment walls. The footings for the wingwalls were about 2 feet below the crest of the embankment. The intent of the wingwalls was to protect the embankment from splashing. The wingwalls were not deep enough to act as a continuation of the seepage cutoff wall.

In summary, the cutoff extended about 16 feet beyond the edge of the level part of the spillway instead of 27 feet, as required in the design. This condition represents a significant deviation from the design that, in our opinion, contributed to the failure of the dam.

- The design documents show the concrete abutment walls were to start at either end of the horizontal portion of the spillway, continue along the upstream side of the sloping slab, and into the embankment (see drawing C2 in Appendix A).

  The abutment wall along the right side of the breach was observed to begin about 5.6 feet right of the horizontal portion of the spillway. In other words, the abutment wall started within the sloping slab (see Figure 2).

  Except as it relates to the length of the seepage cutoff, as discussed above, the deviation in the plan location of the abutment wall did not contribute to the failure.

- The configuration of the slope just upstream of the spillway slab included a horizontal bench approximately 5-feet-wide (scaled dimension). Based on construction photographs in the NHDES files, it appears that the bench was not constructed. Thus, the as-built condition results in a reduction of the horizontal seepage path through the core material from the reservoir to the bottom of the cutoff wall. This seepage path was reduced from 8 feet (see Subsection 6.1) to 3 feet. In our opinion, this deviation may have contributed to the failure.

- Elevations of the horizontal portion of the spillway and the crest of the embankment shown on the Civil Consultants survey drawings (Appendix C) indicate that the dam was built about 1.7 to 1.9 feet higher than specified in the design. Although unlikely, it is possible that this discrepancy is due to the use of an existing control point (one of a few control points established during construction) with an erroneous benchmark elevation. Other control points could not be located by Civil Consultants for cross checking the benchmark elevation.

In our opinion, the apparent increase in the height of the dam would have little or no impact on its stability or seepage conditions. The increased height would, however, result in a significant increase in the volume of the reservoir.

The difference in elevation between the embankment crest and the horizontal portion of the spillway was about 0.2 feet higher than that specified in the design (3.09 feet). The effect of the increased height on spillway capacity is not significant.

- The height of the flashboards measured during the investigation was 13⅞-inches, instead of the 12-inch height required in the design. In our opinion, this deviation did not contribute to the failure.

- The design documents required that the concrete spillway slab (downstream of the cutoff wall) be 8-inches-thick. The measured slab thickness ranged from about 6 inches, in the level portion of the spillway, to about 14 inches, where the spillway slab slopes upward toward the embankment. In our opinion, this deviation did not contribute to the failure.

- The design documents specified a downstream slope of 2.25H:1V and an upstream slope of 3H:1V and 2.5H:1V in the lower and upper parts of the slope, respectively. Undisturbed sections of the downstream slope surveyed by Civil Consultants were less steep than specified. In our opinion, this deviation did not contribute to the failure. The upstream slopes were disturbed by the slope failure that occurred as a result of rapid drawdown following the breach, and thus, the as-built slope could not be surveyed.

- The design documents required the 3-foot-wide chimney drain consisting of filter sand to extend vertically from 2 feet below the crest of the embankment (or below the gravel blanket under the spillway slab) to the base of the embankment and connect with the blanket drain.

  Where exposed by excavation along the left side of the breach (about baseline station 1+30), the upper approximately 13 feet of the chimney drain was offset upstream from the lower portions of the chimney drain by about 2.2 feet, such that the two sections overlapped horizontally by only about 0.8 feet. The bottom of the upper section and the top of the lower section overlapped vertically by about 2 feet.

Excavation along the right side of the breach exposed a roughly 30-foot-long section of the chimney drain (about baseline station 2+30 to 2+60) in the vicinity of the low level outlet pipe (about baseline station 2+50) that did not connect with the blanket drain.

Portions of the chimney drain exposed by excavation along the right side of the breach were found to be contaminated with occasional zones of silty sand with gravel core material and boulders.

In our opinion, the deviations from the designed chimney drain did not contribute to the failure. However, in the long term, these deviations could have resulted in outbreaks of seepage on the downstream slope, potentially leading to piping of the core materials in the lower embankment. Note that the actual failure was caused by piping of the soils immediately below the spillway slab and grouted riprap, rather than through the embankment core materials.

- The design documents required the blanket drain to consist of a 3-foot-thick layer of sand and gravel sandwiched between two 1-foot-thick layers of filter sand. The base of the blanket drain was to be placed on the glacial till foundation soil.

  Where exposed by excavation along the left and right sides of the breach, the sand and gravel layer typically ranged in thickness from about 1 to 2 feet, with a maximum observed thickness of about 2.7 feet. The sand filter layers typically ranged in thickness from about 0.7 to 1.0 feet. On the left side of the breach (about baseline station 1+30), the upper filter sand layer was not placed from the chimney drain to a distance of about 18 feet downstream of the chimney drain. On the right side of the breach (about baseline station 2+26), the upper filter sand layer was not placed from the chimney drain to a distance of about 9 feet downstream of the chimney drain.

  In our opinion, the deviations from the designed blanket drain did not contribute to the failure. However, these deviations could have long-term effects similar to those discussed above for the chimney drain.

- The design drawings indicate that the baffle wall that retained the riprap in the energy dissipator was required to be founded on bedrock. The baffle wall footing was to be anchored by dowels (#6 steel reinforcing bars) grouted into bedrock.

  During the breach, most of the baffle wall was displaced, leaving only about 7 or 8 feet of the wall intact. A test pit excavated at the end of the intact portion of the wall, beneath the former location of the footing of the displaced portion of the wall, indicated that the wall in this area had been founded on an approximately

3.5-foot-thick layer of gray silty sand with gravel. The upper approximately 2 feet of the layer contained 10- to 12-inch-diameter boulders. Bedrock was encountered in the test pit at a depth of about 3.5 feet below the base of the footing. In our opinion, this deviation did not contribute to the failure.

- According to the design drawings, the required thickness of the gravel blanket beneath the grouted riprap was 1.0 foot. The required thickness of the gravel blanket beneath the spillway was approximately 2.25 feet (scaled dimension).

  The thickness of the gravel blanket measured at several locations beneath the edge of the grouted riprap exposed along the right side of the breach typically ranged from approximately 1.0 to 1.5 feet. In one location, the gravel blanket layer appeared to be absent from beneath the grouted riprap. However, this observation was made after the removal of the overlying grouted riprap, which may have scraped the gravel blanket layer from that location.

  The excavation beneath the remnant spillway slab (sloping portion) encountered the gravel blanket to depths ranging from about 2.3 to 2.9 feet below the bottom of the slab. However, along one section, located about 2 feet from the cutoff wall, the gravel blanket was only about 1-foot-thick. In some locations the gravel blanket contained a 0.4- to 1.2-foot-thick layer of soil similar to the core material. Where encountered, the top of this soil layer was about 0.5 feet below the bottom of the slab. Thin layers (1- to 3-inches-thick) of fine to medium sand (similar to the filter sand) were also encountered within the gravel blanket in some locations.

  The presence of core material in the gravel blanket and the potential absence of gravel blanket from areas beneath the grouted riprap would result in lower permeability and higher frost susceptibility of the materials beneath the spillway than desired. In our opinion, these deviations from the design could have contributed to the failure.

- As shown in the design drawings, the riprap within approximately 10 feet (scaled dimension) of the upstream edge of the spillway slab should have been grouted. Whether or not the riprap was actually grouted could not be determined during the post-failure field investigation since the riprap in this area was washed away during the failure. However, based on our interview with Mr. Roger Putnam, we understand that Putnam Concrete did not grout the riprap upstream of the spillway. During our interview with Mr. Bergeron, he did not include the grouting of the upstream riprap in his discussion concerning maintenance of the dam. Based on these interviews, it appears that the upstream riprap was not grouted as required in the design.

  This apparent deviation from the design could have contributed to the failure.

8.2 Concrete

Comparison of as-built concrete strength, reinforcement, and construction joints with design requirements for the spillway indicates the following:

8.2.1 Concrete Quality Control

The Specifications (Sheet C3 of the design drawings) state that all concrete work must comply with ACI 318. Sections 5.6.1, 5.6.2, and 5.6.3 of ACI 318-89, revised 1992, require strength testing of the concrete if the total quantity of concrete is 50 cubic yards or more. Although the estimated volume of concrete in the spillway slab, cutoff wall, and concrete abutment walls exceeds 50 cubic yards, concrete strength testing was not conducted during construction. In our opinion, this deviation did not contribute to the failure.

8.2.2 Compressive Strength

Concrete strength of the remaining right section of the spillway slab was evaluated by compression tests conducted on nominal 4-inch-diameter cores obtained from the spillway slab. The strength tests on the cores were performed in accordance with ASTM C42 to evaluate compliance with the specified design strength. In addition, the specimens sawed from the cores were selected to evaluate any difference in strength between the light-gray colored concrete in the upper half of the spillway and the blue-green colored concrete placed in the lower half of the spillway (see field observation report for March 20, 1996 in Appendix A). Compressive strength testing of the upper halves of Cores W6, W7, and W9, which consisted of the light gray colored concrete, ranged from 3,450 to 4,120 pounds per square inch (psi). The core strengths for the bottom half of each core, which consisted of the blue-green colored concrete, ranged from 3,960 psi to 4,200 psi. The 4-inch core compressive strengths were adjusted for the length to diameter ratio of the specimens tested, in accordance with ASTM C42.

The concrete strength of the cutoff wall was evaluated by compression tests on three nominal 4-inch-diameter cores (Cores S2, S4 and S5) drilled perpendicular to the face of the cutoff wall. These cores had compressive strengths ranging from 5,460 psi to 5,670 psi.

The specified strength at 28 days is based on 6- by 12-inch cylinders. Using figure 227 of reference [5], the equivalent 6- by 12-inch cylinder strength can be estimated as 96 % of the 4-inch core strength. In addition to the correction for specimen size, a correction for specimen age at the time of the test must be made to estimate the 28-day strength. The age of the concrete in the core specimens at the time of test was approximately 1 year and 9 months. Using reference [6], table 2.2.1, and assuming the concrete strength gain over time for a type I cement, the estimated 28 day, 6- by 12-inch cylinder strength would be 86 % of the strength at 1 year and 9 months. Reference [5] indicates that for type II cements, as specified for this project, the reduction will be even larger, even though no quantitative data are provided. Using the corrections for specimen size and age, the estimated 28-day strength of the concrete is no more than 82 % of the core test results. This gives a range of 28-day compressive strength of the concrete in the spillway slab of 2,830 psi to 3,380 psi. The estimated range of 28-day compressive strength for the cutoff wall was 4,480 psi to 4,650 psi.

The concrete in the right section of the spillway slab was also evaluated using a Type N Rebound Hammer in accordance with ASTM C805. Rebound tests were performed on the sawed edge of a portion of the west spillway slab after it was removed. The rebound hammer was oriented horizontally, perpendicular to the sawed face of the slab section. The rebound number measured on the upper half of the slab section on the light-gray colored concrete was 29 and on the bottom half of the slab section on the blue-green colored concrete was 25. These rebound numbers correlate to a compressive strength of 2,700 psi and 2,000 psi for the light gray concrete and the blue-green concrete, respectively.

The concrete strength of the left section of the spillway slab, pieces of which were found downstream of the dam, also was evaluated using a Type N Rebound Hammer. The rebound testing was performed in accordance with ASTM C805. The test hammer was oriented vertically, perpendicular to the slab top surface. The rebound number measured on two test locations was 26 and 28. These rebound numbers correlate to a compressive strength of 2,750 psi and 3,100 psi. Although the rebound hammer data do not correlate very well with the core strength test results, the data do give an indication that there is very little variation in concrete quality between the east and west spillway sections and between the two different color concretes.

As indicated in the Specifications (Sheet C3 of the design drawings), the specified 28-day compressive strength of the concrete was 4,000 psi. Based on these results, the field-cured concrete from the cutoff wall complied with the 28-day strength requirement of the Specifications, but the concrete from the spillway slab did not. In our opinion, this deviation did not contribute to the failure.

8.2.3 Reinforcement

No testing was performed on any of the remnants of the reinforcement in the spillway sections after the failure. Therefore, conformance to the specified grade of reinforcement was not checked. However, all reinforcing visible after the failure was a deformed type as required by the specifications.

The specifications require that the clear cover over the reinforcement be no less than 3 inches for concrete placed against earth. The average clear cover over the single mat of reinforcement in the spillway slab sections was found to be approximately 3/4 inch, which is a violation of the specification. In fact, in many areas, the steel reinforcement was visible at the surface of the base of the slab, as if the reinforcing bars were placed directly on the ground prior to casting the slab. In our opinion, this deviation did not contribute to the failure.

The drawings call for No. 4 bars at 15 inches on center vertically and longitudinally in the center of the spillway cutoff wall. No longitudinal reinforcement was observed protruding from any of the broken sections of the cutoff wall. In our opinion, the lack of longitudinal steel reinforcement in the cutoff wall could have contributed to the failure.

8.2.4 Construction Joints

The spillway structure was built with one construction joint oriented horizontally between the spillway slab and the cutoff wall. No waterstop was installed in the horizontal construction joint between the spillway slab and the cutoff wall. The design drawings indicate that there should be no construction joint between the cutoff wall and the spillway slab. It is our opinion that this deviation could have contributed to the failure.

8.3 Soils

Comparisons of the soils used in the construction of the dam with those specified in the design documents are provided below:

8.3.1 Core

Gradation tests were performed on seven samples of the core obtained during the post failure investigations. As shown in Figure 4 none of the samples fully meets the gradation range in the specifications. Six of the seven samples are finer than specified throughout the full gradation range. Although no permeability tests were performed as part of this investigation, it is our opinion that six of the seven samples tested for gradation are likely to have a permeability below the specified upper limit of 10^{-5} cm/sec and the seventh sample would be close to 10^{-5} cm/sec. In our opinion, the core material used in the construction of the dam was of adequate gradation and permeability.

The design documents require the embankment core to be compacted to at least 92 % of its maximum dry density (ASTM D 1557). During the field investigations, field density tests were conducted using a nuclear density gauge on the core materials at ten locations in the excavation along the right side of the breach. At all but two of the density test locations, core samples were obtained for one-point compaction tests so that the maximum densities indicated by the five-point compaction tests could be corrected to account for differences in sample gradation. The one-point compaction tests also provided data on gravel content so that appropriate gravel corrections could be made. The results of the field density testing (Table 2) indicate that core densities typically ranged from about 89.4 to 96.7 % of the maximum density, with one test indicating a density of 84.1 %. Densities at seven of the ten test locations were below the specified compacted density of 92 %. Note that due to consolidation, the density of the core material during construction would have been slightly lower than that measured during the investigation.

As discussed in Subsection 8.4, the lower-than-specified compacted density of the core material, in our opinion, may have contributed to the failure since it would lead to greater settlements and cracking of the spillway structure, and possibly the formation of voids between the spillway slabs and cutoff wall and the underlying soils.

8.3.2 Filter Sand

Gradation tests were made on seven filter sand samples obtained from the chimney and blanket drains during the post failure investigations. As shown on Figure 5, none of the samples fully meets the gradation specifications. For the filter sand application, the most important aspect of the gradation is the percentage of finer particles because it determines the permeability and the ability to filter the base soils. The percentage passing the No. 100 sieve (the finest sieve in the specified gradation) exceeds the specification range of 0 to 10% for four of the seven samples. A permeability test performed on sample with about 10% passing the No. 100 sieve indicated a permeability of approximately 10^{-3} cm/sec, i.e., at the lower limit of acceptability according the specifications. The four samples that had a higher percentage passing the No. 100 sieve are likely to have lower permeabilities.

The design documents require the filter sand to be compacted to at least 92 % of its maximum dry density (ASTM D1557). The results of field density tests (and one-point compaction testing) conducted on the chimney drain filter sand at six locations exposed during the excavation along the right side of the breach indicate compacted densities ranging from about 83.3 to 95.2 % of the maximum dry density. Only two of the six density tests indicate compacted densities meeting the specifications.

In our opinion, the deviations from the specifications for the filter sand did not contribute to the failure. However, in the long term, these deviations could have resulted in outbreaks of seepage on the downstream slope, potentially leading to piping of the lower embankment core materials. Note that the actual failure was caused by piping of the soils

8.3.5 Grouted Riprap

The design documents required that the grouted riprap placed downstream of the spillway slab be a minimum of 18 inches thick, and be built with stones with a minimum diameter of 12 inches with angular faces protruding 1-1/2 inches above the top of the grout.

Measurements of the downstream grouted riprap along the right side of the breach indicate that the grouted riprap thickness typically ranged from 10 to 17 inches and contained one layer of riprap stones. The riprap stones protruded from the grout a distance of about 2 to 13 inches, instead of the 1½ inches specified. These measurements indicate that the some of the riprap stones were undersized and that the grout thickness was less than specified in the design. In our opinion, these deviations did not contribute significantly to the failure.

8.4 Summary of Differences Between Design and As-Built Conditions Contributing to the Failure

In this section, we summarize the differences between the design and the observed as-built conditions discussed in Subsections 8.1 through 8.3 that, in our opinion, contributed to the failure.

- The seepage cutoff was substantially shorter than as designed. The cutoff extended about 16 feet instead of the required 27 feet beyond the edge of the horizontal portion of the spillway slab. Thus, the seepage path around the end of the wall was substantially shorter than in the design, which probably contributed to the initiation of piping.

- The lack of longitudinal reinforcement in the cutoff wall contributed to the vertical cracking. Flow through such cracks would have a shortened seepage path and could have contributed to the piping of the soils downstream of the cutoff wall.

- A horizontal construction joint was located between the top of the cutoff wall and the spillway slab, even though no such joint was indicated in the drawings. No waterstops were provided across the joint. Leakage through the as-built construction joint could have caused piping due to shortened seepage path.

- Two out of three samples of the gravel blanket had a higher fines content than specified. Also, the gravel blanket was observed in some areas to be contaminated with fine grained soil. Thus, the gravel blanket was less pervious than if the soil had met the specified gradation. Furthermore, the higher fines content in the gravel blanket increased its frost susceptibility. The low permeability and the frost susceptibility of the gravel blanket were contributing factors to the failure mechanism.

- The core material was looser than specified, making it more compressible under: a) its own weight (with part of the compression likely to occur after spillway construction), and b) under the reservoir loads. Larger deformations of the embankment would be more likely to induce cracks on the spillway structure.

- The lack of the horizontal bench section at the top of the embankment upstream of the spillway resulted in a shortened seepage path through low permeability core material between the reservoir and the bottom of the cutoff wall.

- The apparent omission of grouting of the riprap upstream of the spillway would also cause a reduction in the seepage path.

9. OVERALL SUMMARY OF DESIGN AND CONSTRUCTION FACTORS CONTRIBUTING TO THE FAILURE

As indicated in Section 6, it is our opinion that the failure occurred due to erosion and piping beneath the spillway slab. We have identified several design features and deviations from the design that we feel contributed to the initiation of the piping that lead to the failure. These factors are described below in terms of their effect on different aspects of seepage control, namely:

- Seepage reduction to be achieved by the seepage cutoff and the soils upstream of the cutoff.
- Drainage downstream of the cutoff.
- Avoidance of voids.

9.1 Factors Affecting Seepage Reduction

Seepage reduction for the Meadow Pond Dam was to be accomplished by the use of low permeability soils (core material) in the embankment, the construction of the concrete seepage cutoff (cutoff wall and abutment wall footings), and the placement of grouted riprap over the upper portions of the upstream embankment in front of the spillway. Factors that adversely impacted the effectiveness of these seepage reduction measures are described below in order of importance.

- *The lateral extent of the seepage cutoff (cutoff wall and abutment wall footings) into the embankment to the left and to the right of the spillway was about 11 feet shorter than designed.* This resulted in a shorter seepage path, which may have lead to the piping failure. This conclusion appears to be corroborated by the presence of the void observed around the right end of the cutoff wall that was probably caused by seepage, erosion and piping. It is reasonable to assume that a similar seepage pattern developed around the left end of the wall near the area in which the piping failure eventually developed. The presence of heavily rusted steel reinforcing bars and staining observed on the bottom of the sloping slab from the left side of the spillway (observed in the debris pile downstream of the dam) appears to support this conclusion.

- *Cracks in the cutoff wall and in the spillway slab, which were observed during and after construction, and the construction joint between the cutoff wall and the slab provided a direct hydraulic connection to the gravel blanket downstream of* *the cutoff wall.* This direct hydraulic connection shortened the seepage path, facilitating the initiation of piping.

The cracks in the cutoff wall were probably caused by a combination of factors, including:

- The lack of longitudinal steel reinforcement in the cutoff wall, which was required in the design.

- Settlement of the embankment core material, which was not compacted sufficiently to meet the specifications.

- Heaving of the spillway slab and cutoff wall due to the formation of ice lenses in the gravel blanket and the underlying core material.

  In our opinion, the gradation specified in the design for the gravel blanket did not adequately limit the fines content to avoid frost susceptibility. The frost susceptibility of the gravel blanket was further increased by the use of soil containing even more fines than allowed in the specifications and the contamination of the gravel blanket with silty core materials.

  The core material beneath the gravel blanket in the area of the spillway also could develop ice lenses since it was placed within the expected frost penetration depth of about 4 to 5 feet. The combined thickness of the spillway slab and the gravel blanket specified in the design drawings was only about 2.9 feet (based on scaled gravel blanket thickness).

- *The distance between the open water in the reservoir and the bottom of the cutoff wall provided too short a seepage path* to provide an adequate barrier against seepage. As designed, this seepage path included the upstream grouted riprap and the underlying gravel blanket and core material. GEI feels that it would be unrealistic to count on the upstream grouted riprap as a seepage barrier since it is likely to crack due to embankment settlement. It is our opinion that the seepage path, as designed, was too short. As built, the seepage path was even shorter due to the absence of the horizontal bench required immediately upstream of the spillway.

9.2 Factors Affecting Drainage

Drainage features used in the Meadow Pond Dam include the gravel blanket, which was intended to drain seepage from beneath the spillway slab and downstream grouted riprap, and the chimney and blanket drains, which were intended to intercept and control seepage through the core material in the lower portions of the embankment. Since the piping failure occurred beneath the spillway slab, only the drainage characteristics of the gravel blanket are considered relevant to the failure.

The gravel blanket under the spillway slab downstream of the cutoff wall was not sufficiently pervious to safely drain seepage passing the cutoff wall. The gradation for the gravel blanket specified in the design did not adequately limit the fines content to provide for sufficient permeability. The permeability of the as-built gravel blanket was even lower than that of the specified material, since it contained more fines than allowed by the Specifications. In addition, the contamination of the gravel blanket beneath the spillway slab with silty core material further reduced its effectiveness as a drain.

9.3 Factors Affecting the Formation of Voids

In our opinion, the formation of voids in the soils beneath the spillway and along the interfaces between these soils and the spillway slab, cutoff wall, and/or downstream grouted riprap contributed to the initiation of the piping that lead to the failure. Factors affecting the formation of the voids are discussed below in order of importance:

- *Due to the frost susceptibility of the gravel blanket, it is likely that frost penetration caused the formation of ice lenses and heaving of the spillway, cutoff wall, and downstream grouted riprap.* The heaving may have caused voids along the interfaces between these structures and the adjacent soils (core material against the cutoff wall and gravel blanket against the downstream side of cutoff wall, the base of spillway, and the base of the grouted riprap). Upon thawing, the ice lenses would leave voids within the gravel blanket. Weather data indicates that conditions appeared to have been favorable for thawing of ice lenses.

- *The gravel blanket was not thick enough to prevent frost penetration into the underlying core material.* The development of ice lenses in the core material may have had similar effects as the frost action on the gravel blanket described above.

REFERENCES

[1] U.S. Department of Agriculture, Soil Conservation Service, Engineering Division **"Earth Dams and Reservoirs"** Technical Release N 60. revised October 1985.

[2] U.S. Department of Agriculture, Soil Conservation Service, **"Engineering Guide for Determining the Gradation of Sand and Gravel Filters"**, Soil Mechanics Note No. 1, revised January 1986.

[3] U.S. Department of Interior, Bureau of Reclamation, **"Design of Small Dams"**, 1987.

[4] Terzaghi, Karl and Peck, Ralph **"Soil Mechanics in Engineering Practice"** John Wiley and Sons, 1968.

[5] **USBR, Concrete Manual**, Eight Edition Revised, 1981.

[6] **ACI Manual of Concrete Practice**, Part 1, Materials and General Properties of Concrete, 1987.

TABLE 1 - SOIL SAMPLE SUMMARY
Meadow Pond Dam
Alton, New Hampshire

Sample Identification	Date collected	Approximate Station(1)	Approximate Off-set(1)	Approximate Elevation(2) (feet)	Dam Feature	Material Name (per design drawings)	Geotechnical Testing(4)
SS1	3-19-96	1+48	8' DS	NM(3)	Chimney drain	Filter sand	Grain size
SS2	3-19-96	1+47	1' DS	NM	Embankment fill	Core	Grain size (with hydrometer analysis), five-point compaction test, water content
SS3	3-19-96	1+47	1' DS	NM	Embankment fill	Core	Grain size (with hydrometer analysis)
SS4	3-19-96	1+47	5' DS	NM	Chimney drain	Filter sand	Grain size
SS5	3-20-96	1+28	4' US	681.1	Embankment fill	Core	Grain size, water content
SS6	3-20-96	1+28	NR	681.1	Chimney drain	Filter sand	Grain size, one-point compaction, triaxial permeability test
SS7	3-20-96	1+28	NR	677.8	Embankment fill	Core	Grain size (with hydrometer analysis), water content
SS8	3-20-96	1+28	NR	673.4	Embankment fill	Core	Grain size (with hydrometer analysis), water content
SS9	3-20-96	1+28	NR	684.4	Embankment fill	Core	Grain size (with hydrometer analysis), water content
SS10	3-20-96	1+33	9' DS	665.1	Blanket drain	Sand and gravel	Gain size (with hydrometer analysis), water content
SS11	3-20-96	1+33	20' DS	664.1	Blanket drain filter sand (bottom of blanket)	Filter sand	Grain size, water content
SS12	3-20-96	1+33	20' DS	663.6	Blanket drain	Sand and gravel	Grain size (with hydrometer analysis), water content
SS13	3-20-96	1+33	32' DS	664.6	Blanket drain	Sand and gravel	Grain size (with hydrometer analysis), water content
SS14	3-20-96	1+33	41' DS	NM	Collected above 4 HDPE perforated drain pipe (toe drain)	Toe drain backfill	Grain size, water content

TABLE 1 - SOIL SAMPLE SUMMARY
Meadow Pond Dam
Alton, New Hampshire

Sample Identification	Date collected	Approximate Station(1)	Approximate Off-set(1)	Approximate Elevation(2) (feet)	Dam Feature	Material Name (per design drawings)	Geotechnical Testing(4)
SS15	3-20-96	2+30	8' DS	663.4	Chimney drain	Filter sand	Grain size, water content
SS16	3-20-96	2+50 ±	15' DS	NM	Beneath grouted riprap	Gravel blanket	Grain size (with hydrometer analysis), water content
SS17	3-20-96	2+30	NR	658.9	Dam foundation (below crest of dam)	Glacial till foundation	Grain size (with hydrometer analysis), water content
SS18	3-20-96	2+30 ±	12' DS	NM	Drainage blanket (filter sand at bottom of blanket)	Filter sand	Grain size, water content
FD1	4-2-96	2+48	5' US	682.0	Beneath spillway slab	Gravel blanket	Grain size five-point compaction test
SS19	4-2-96	2+41	2' US	678.2	Embankment fill	Core	Not tested
FD2	4-2-96	2+48	4' US	678.0	Embankment fill	Core	Grain size (with hydrometer analysis), one-point compaction test
SS20	4-2-96	2+42	12' DS	NM	Beneath grouted riprap	Core	Not tested
FD3	4-3-96	2+47	5' DS	678.9	Chimney drain	Filter sand	Grain size, five-point compaction test
FD4	4-3-96	2+57	0' DS	678.8	Embankment fill	Core	One-point compaction test
SS21	4-3-96	NM	NM	677±	Embankment fill	Core	Not tested
FD7	4-3-96	2+63	10' DS	675.9	Embankment fill	Core	One-point compaction test
FD8	4-3-96	2+63	5' DS	675.9	Chimney drain	Filter sand	One-point compaction test
FD9	4-3-96	2+63	2.5' US	675.9	Embankment fill	Core	One-point compaction test
FD10	4-3-96	2+56	1' DS	671.2	Embankment fill	Core	One-point compaction test
FD11	4-3-96	2+63	6' DS	671.2	Chimney drain	Filter sand	One-point compaction test
FD12	4-3-96	NR	10' DS	671.2	Embankment fill	Core	One-point compaction test

TABLE 1 - SOIL SAMPLE SUMMARY
Meadow Pond Dam
Alton, New Hampshire

Sample Identification	Date collected	Approximate Station(1)	Approximate Off-set(1)	Approximate Elevation(2) (feet)	Dam Feature	Material Name (per design drawings)	Geotechnical Testing(4)
SS22	4-4-96	2+30	29' DS	NM	Below grouted riprap	Gravel blanket	Grain size (with hydrometer analysis)
SS23	4-4-96	2+23	50' DS	NM	Below grouted riprap	Gravel blanket	Grain size
SS24	4-4-96	2+26	16.4 DS	655.2	Organics between boulders at dam foundation	None	Not tested
SS25	4-4-96	2+41	5 DS	655.4	Embankment fill	Core	Not tested
SS26	4-4-96	2+26	6 DS	655.2	Chimney drain	Filter sand	Not tested
SS27	4-4-96	2+26	12 DS	NM	Blanket drain	Sand and gravel	Grain size, triaxial permeability (at 92% of maximum density), five-point compaction test
FD13	4-4-96	2+50	5 DS	667.1	Chimney drain	Filter sand	One-point compaction test
FD14	4-4-96	2+50	11 DS	667.0	Embankment fil	Core	One-point compaction test
FD15	4-4-96	2+41	0 DS	663.6	Embankment fill	Core	One-point compaction test
FD16	4-4-96	2+41	6.5' DS	662.8	Chimney drain	Filter sand	One-point compaction test
FD17	4-4-96	2+41	13.5' DS	662.3	Embankment fill	Core	One-point compaction test
FD19	4-4-96	2+32	12' DS	657.8	Blanket drain	Sand and gravel	Grain size (with hydrometer analysis), one-point compaction test
SS28	4-5-96	2+48	14 DS	NM	Backfill around low level outlet pipe	Filter sand	Not tested
SS29	4-5-96	2+51	14 DS	NM	Blanket drain	Sand and gravel	Grain size
SS30	4-5-96	1+75	8' DS	652.8	Foundation	Foundation	Grain size
SS31	4-5-96	1+75	8' DS	653.8	Foundation	Glacial till foundation	Grain size

Notes:

1. Station and offset measured relative to baseline stationing established along the crest of the dam by Civil Consultants on March 19, 1996. The Civil Consultants drawings showing the stationing are provided in Appendix C. US indicates upstream of baseline stationing. DS indicates downstream of baseline stationing.

2. Elevations were surveyed by GEI relative to elevations at baseline station stakes established in the field by Civil Consultants on March 19, 1996. Elevations are referenced to "Rivers Datum".

3. NM indicates not measured.

4. Geotechnical testing results are presented in Appendix E.

TABLE 2 - FIELD DENSITY TESTING RESULTS[1]
Meadow Pond Dam
Alton, New Hampshire

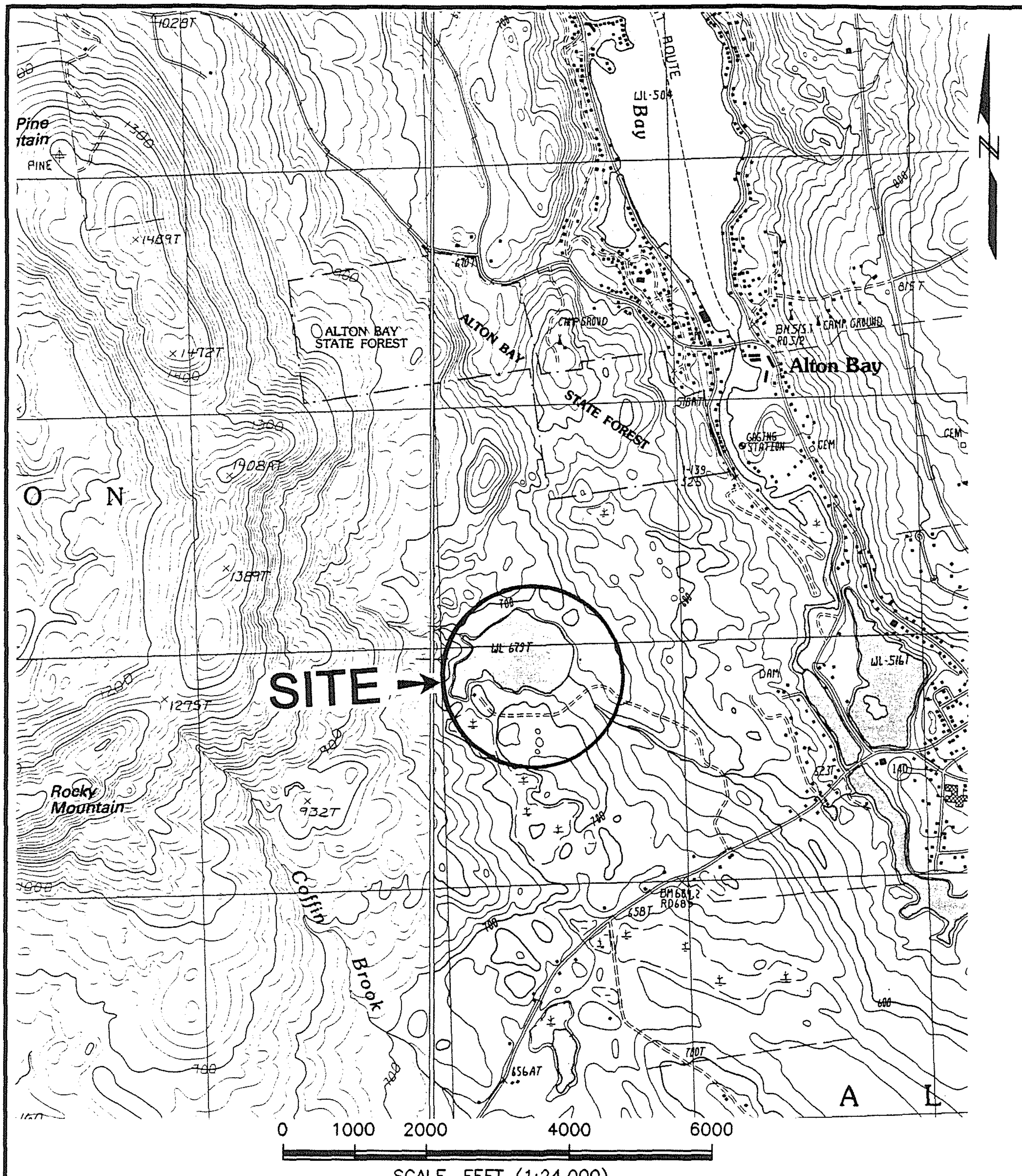
Test No.	Material Name	Station[2]	Offset[2]	Elevation[3]	In Situ Dry Density (pcf)	In Situ Wet Density (pcf)	In Situ Water Content (%)	Maximum Density[4] (pcf)	Percent Compaction[5]	Required Percent Compaction
FD1-GEI	Gravel blanket	2+48	5' US	682.0	125.2	137.6	9.9	134.9	92.8	95
FD1-H&A	Gravel blanket	2+48	5' US	682.0	123.8	136.6	10.3	134.9	92.8	95
FD2-H&A	Core	2+48	4' US	678.0	119.7	135.2	13.0	131.0	91.4	92
FD3-GEI	Filter sand	2+47	5' DS	678.9	108.0	114.4	5.9	115.7	93.3	92
FD3-H&A	Filter sand	2+47	5' US	678.9	106.8	113.9	6.6	115.7	92.3	92
FD4-GEI	Core	2+57	0' DS	678.8	111.2	124.8	12.4	132.2	84.1	92
FD4-H&A	Core	2+57	0' US	678.8	110.9	124.6	12.4	132.2	83.9	92
FD5-H&A	Filter sand	2+53	4' DS	676.2	101.4	109.7	8.1	[6]		92
FD6-H&A	Core	2+51	1' DS	676.2	123.1	137.1	11.4	[6]		92
FD7-H&A	Core	2+63	10' DS	675.9	119.1	134.9	13.3	130.4	91.3	92
FD8-H&A	Filter sand	2+63	5' DS	675.9	93.0	99.1	6.6	109.4	85.0	92
FD9-H&A	Core	2+63	2.5' US	675.9	122.1	136.1	11.4	128.4	95.1	92
FD10-H&A	Core	2+56	1' DS	671.2	122.6	138.4	12.9	128.6	95.3	92
FD11-H&A	Filter sand	2+56	6' DS	671.2	95.6	100.5	5.2	114.1	83.4	92
FD12-H&A	Core	2+56	10' DS	671.2	120.2	134.7	12.1	132.4	90.8	92
FD13-H&A	Filter sand	2+50	5 DS	667.1	113.5	121.7	7.2	119.2	95.2	92
FD14-H&A	Core	2+50	11 DS	667	125.3	138.0	10.1	129.6	96.7	92
FD15-H&A	Core	2+41	0 DS	663.6	117.3	132.0	12.5	126.6	92.7	92
FD16-H&A	Filter sand	2+41	6.5' DS	662.8	102.1	108.3	6.2	122.5	83.3	92

TABLE 2 - FIELD DENSITY TESTING RESULTS[1]
Meadow Pond Dam
Alton, New Hampshire

Test No.	Material Name	Station[2]	Offset[2]	Elevation[3]	In Situ Dry Density (pcf)	In Situ Wet Density (pcf)	In Situ Water Content (%)	Maximum Density[4] (pcf)	Percent Compaction[5]	Required Percent Compaction
FD17-H&A	Core	2+41	13.5' DS	662.3	124.0	140.4	13.2	138.7	89.4	92
FD18-H&A	Core/filter sand	2+32	3' DS	657.8	109.6	123.9	13.1	[7]		
FD19-H&A	Sand and gravel	2+32	12' DS	657.8	125.8	136.3	8.3	135.4	92.9	92

Notes:

1. Field density tests were conducted between April 2 and April 4, 1996, using a nuclear density gauge. Tests with a "GEI" suffix were performed by GEI Consultants, Inc. (GEI) and tests with a "H&A" suffix were performed by Haley & Aldrich (H&A). Tests with the same numbers (e.g., FD1-GEI and FD1-H&A) were performed at the same location.
2. Station and offset measured relative to baseline stationing established along the crest of the dam by Civil Consultants on March 19, 1996. The Civil Consultants drawings showing the stationing are provided in Appendix C. US indicates upstream of baseline stationing. DS indicates downstream of baseline stationing.
3. Elevations were surveyed by GEI relative to elevations at baseline station stakes established in the field by Civil Consultants on March 19, 1996. Elevations are referenced to "Rivers Datum".
4. Maximum densities obtained from the five-point compaction test (ASTM D 1557) were corrected using the results of one-point compaction tests conducted on samples obtained from the density test location. This correction accounts for subtle variations in gradation between the five-point compaction test samples and the soils at the density test location. The results of laboratory compaction tests are presented in Appendix E.
5. Percent compaction is the in situ dry density divided by the maximum dry density.
6. Maximum density not known for FD5-H&A and FD6-H&A since samples for one-point compaction testing were not collected at the test locations.
7. Maximum density not known for FD18. One-point compaction test not conducted because FD18-H&A spanned two different materials (core and filter sand).

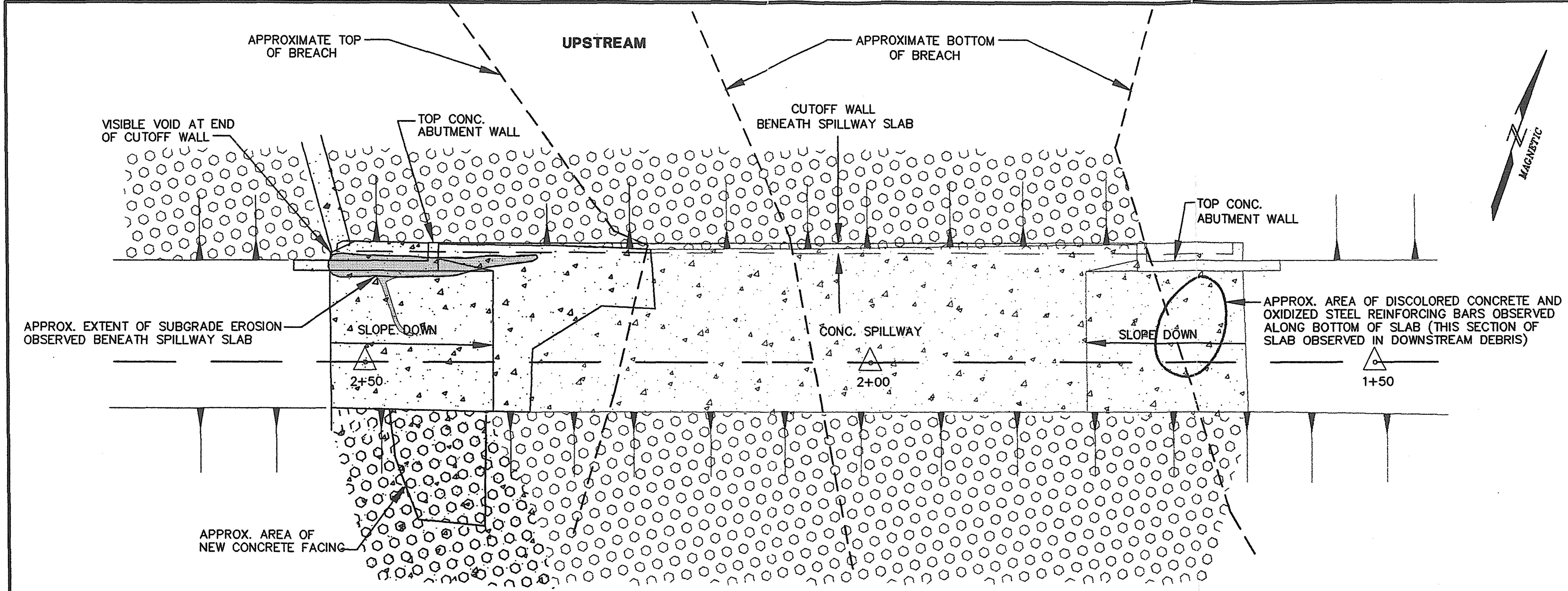


Map is taken from U.S.G.S. Topographic 7.5 Minute Series, Gilmanton, NH (1987) and Alton, NH (1987) Quadrangles.
Datum is National Geodetic Vertical Datum (NGVD) 1929
Contour Interval is 20 Feet

NHDES Water Resources Division Concord, New Hampshire	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	SITE LOCATION MAP
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 1

96069 SLM 6/5/96 PCL A-1

96069 A2 6/10/96 PGL B:10



DETAIL OF SPILLWAY SECTION

0 10 20
SCALE, FEET

LEGEND:

- CONCRETE SPILLWAY INTACT ON 4/1/96
- GROUTED RIPRAP INTACT ON 4/1/96
- ASSUMED EXTENT OF GROUTED RIPRAP PRIOR TO FAILURE (BASED ON DESIGN DRAWINGS)
- ASSUMED EXTENT OF CONCRETE SPILLWAY PRIOR TO FAILURE (BASED ON DEBRIS OBSERVED DOWNSTREAM AND DESIGN DRAWINGS)
- ASSUMED EXTENT OF RIPRAP PRIOR TO FAILURE (BASED ON DESIGN DRAWINGS)

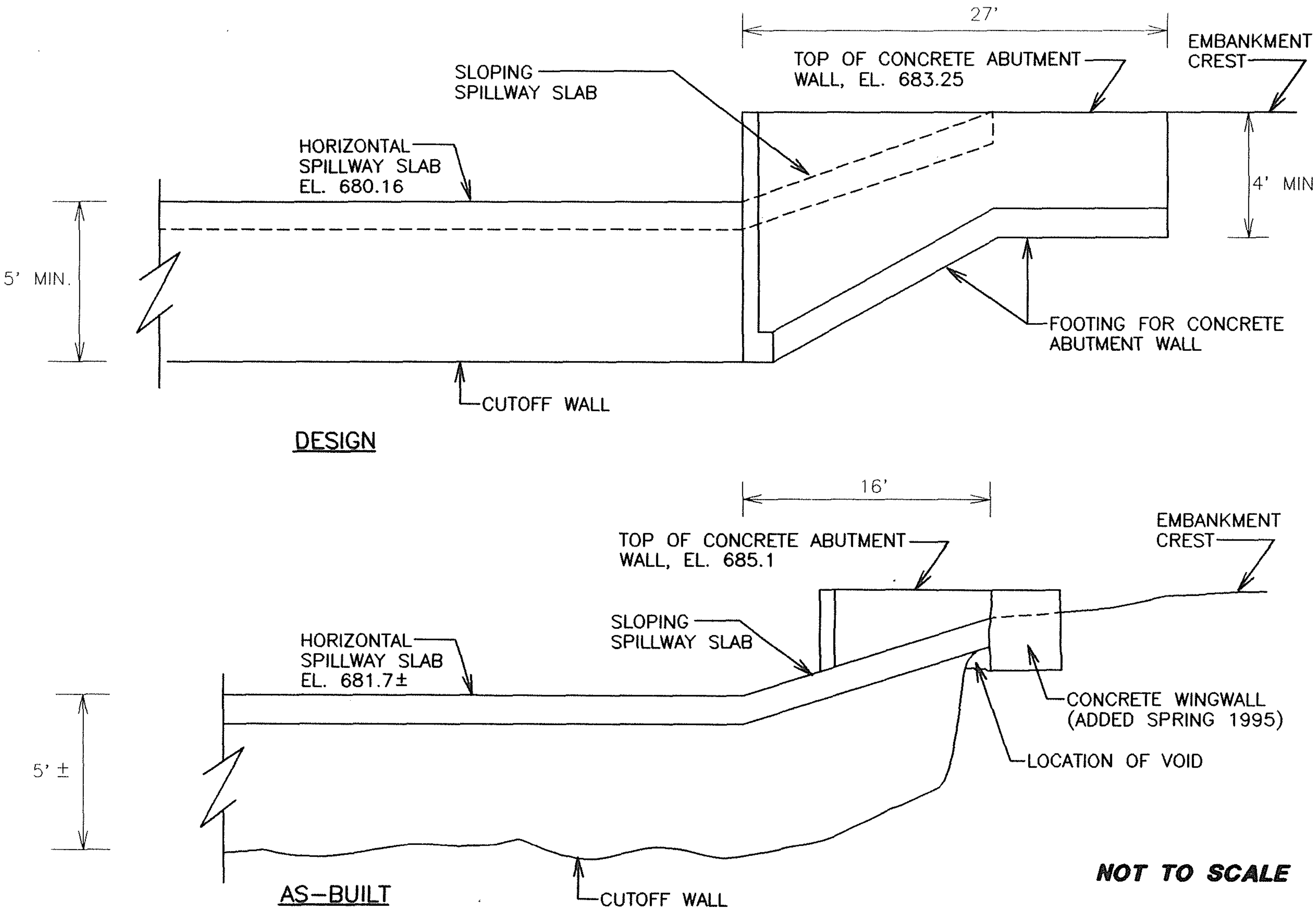
NOTES:

1. FIGURE DEVELOPED FROM "PLAN VIEW OF BASELINE AND SECTIONS, BREACHED EARTHEN DAM, ALTON, NH, BERGERON PROPERTY" BY CIVIL CONSULTANTS, 4/1/96 AND FIELD MEASUREMENTS BY GEI CONSULTANTS, INC.

2. EMBANKMENT CREST AND SLOPE LINES, OBSERVATIONS OF SUBGRADE EROSION AND CONCRETE DISCOLORATION, AND ASSUMED EXTENT/CONFIGURATION OF FEATURES NOT INTACT AS OF APRIL 1, 1996 WERE ADDED BY GEI.

NHDES Water Resources Division Concord, New Hampshire	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	SPILLWAY POST FAILURE OBSERVATIONS PLAN
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 2

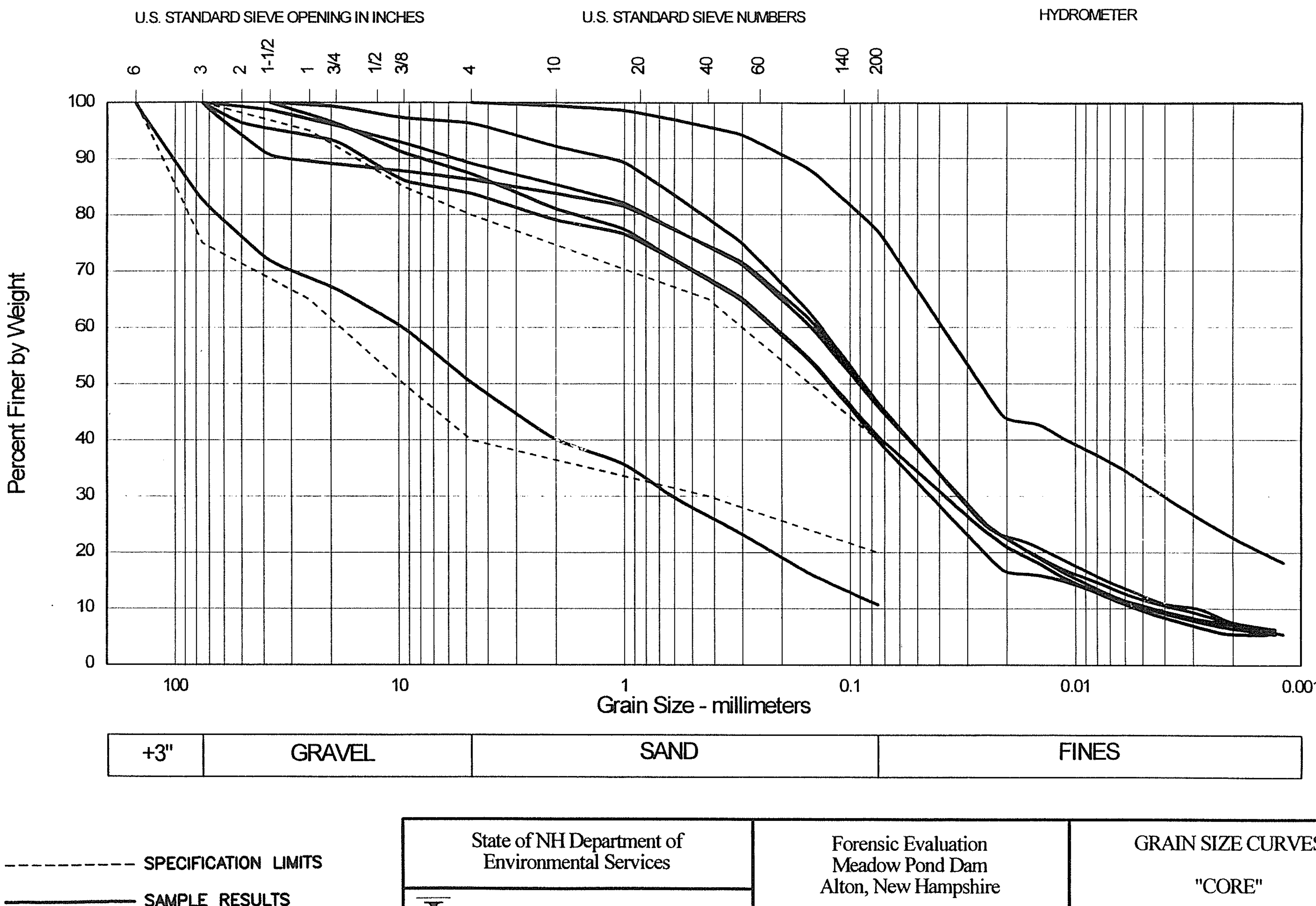
96069 A4 6/25/96 PGL A:1



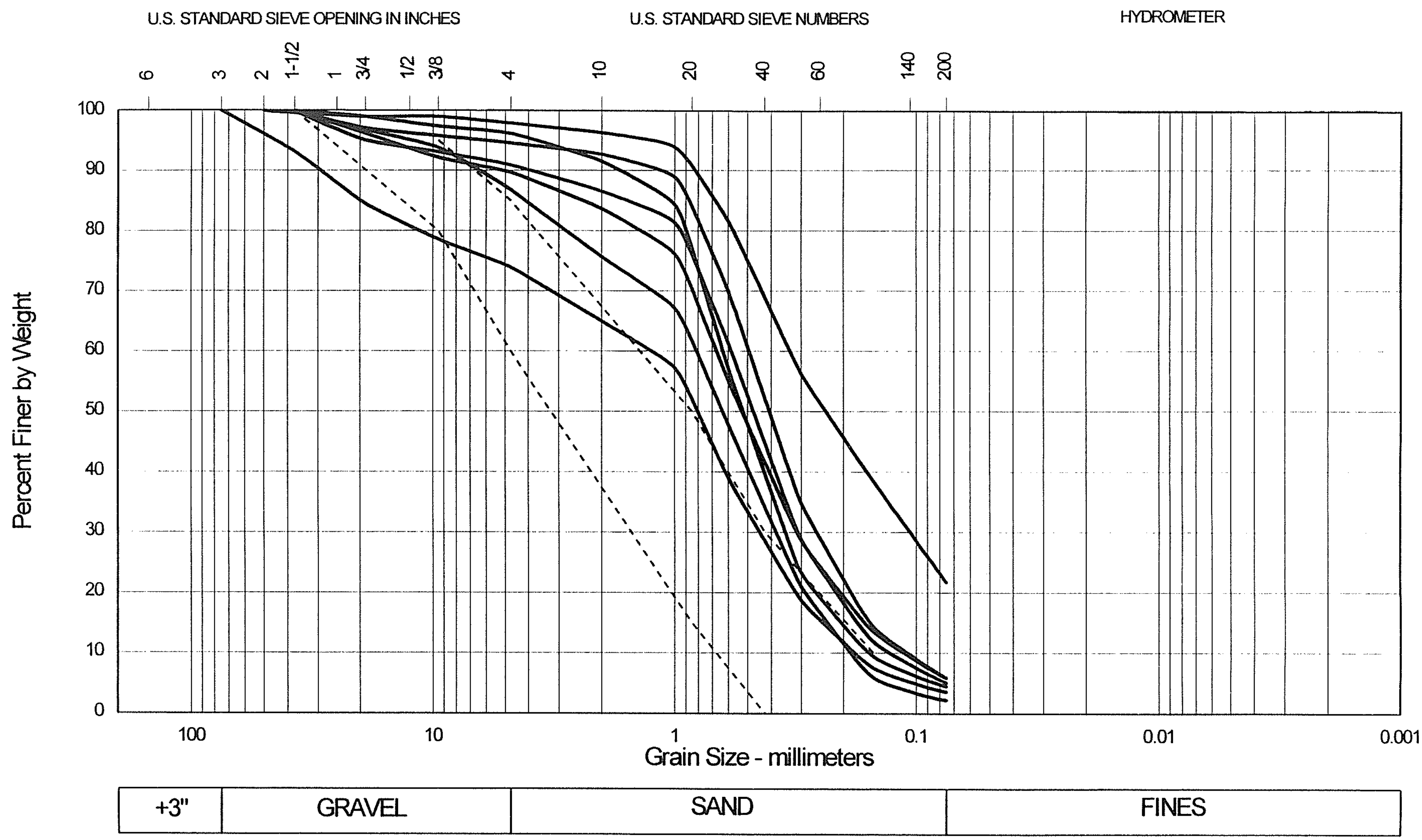
NOTES:

1. VALVE STEM GUIDE NOT SHOWN.
2. ELEVATIONS OF THE AS–BUILT SPILLWAY MEASURED BY CIVIL CONSULTANTS REFERENCED TO "RIVERS DATUM". SEE APPENDIX C FOR CIVIL CONSULTANTS SURVEY DRAWING.

NHDES Water Resources Division Concord, New Hampshire	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	ELEVATION – RIGHT END OF SPILLWAY
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 3



State of NH Department of Environmental Services	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	GRAIN SIZE CURVES "CORE"
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 4



SPECIFICATION LIMITS

SAMPLE RESULTS

State of NH Department of Environmental Services

GEI Consultants, Inc.

Forensic Evaluation
Meadow Pond Dam
Alton, New Hampshire

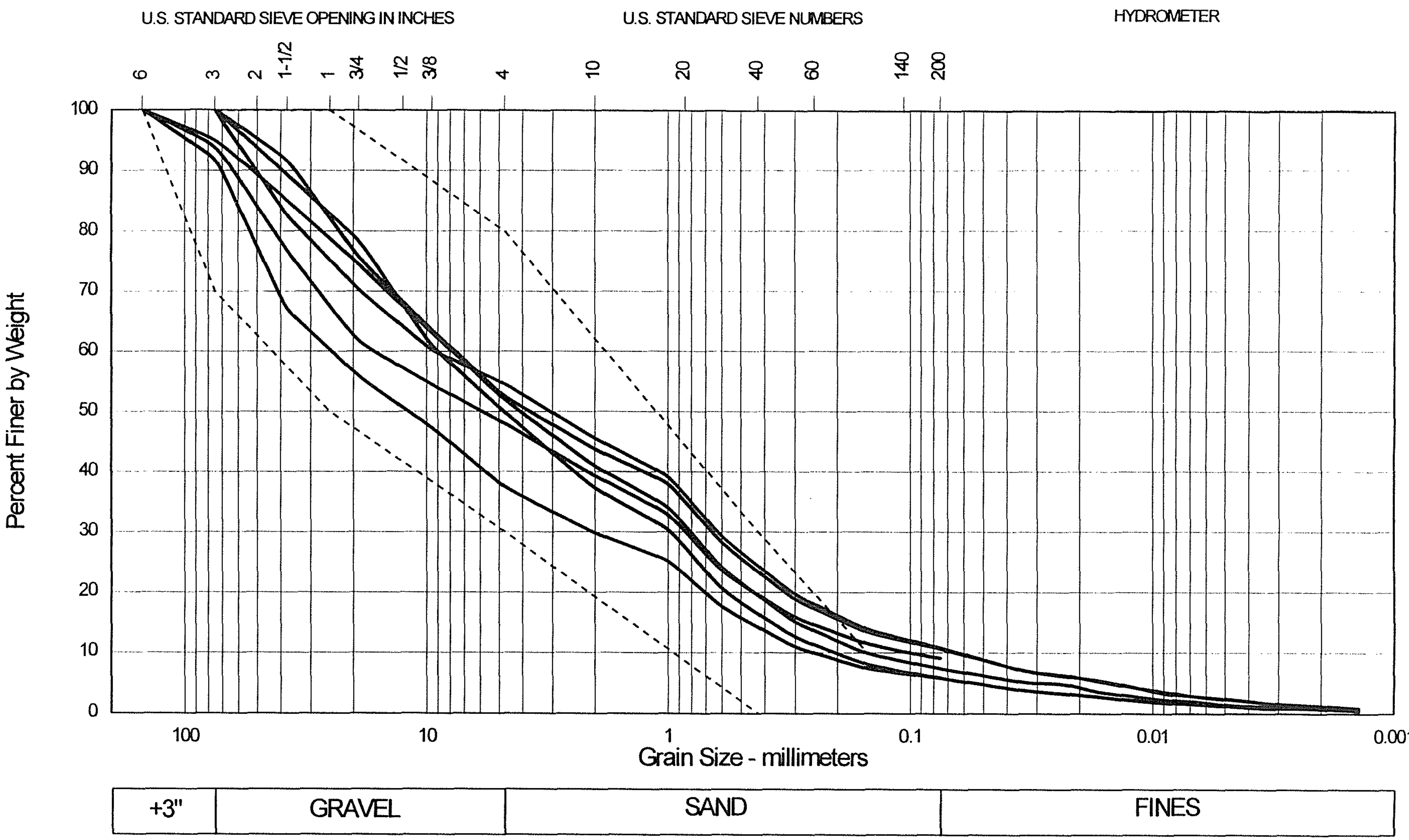
Project 96069

GRAIN SIZE CURVES

"FILTER SAND"

June 1996

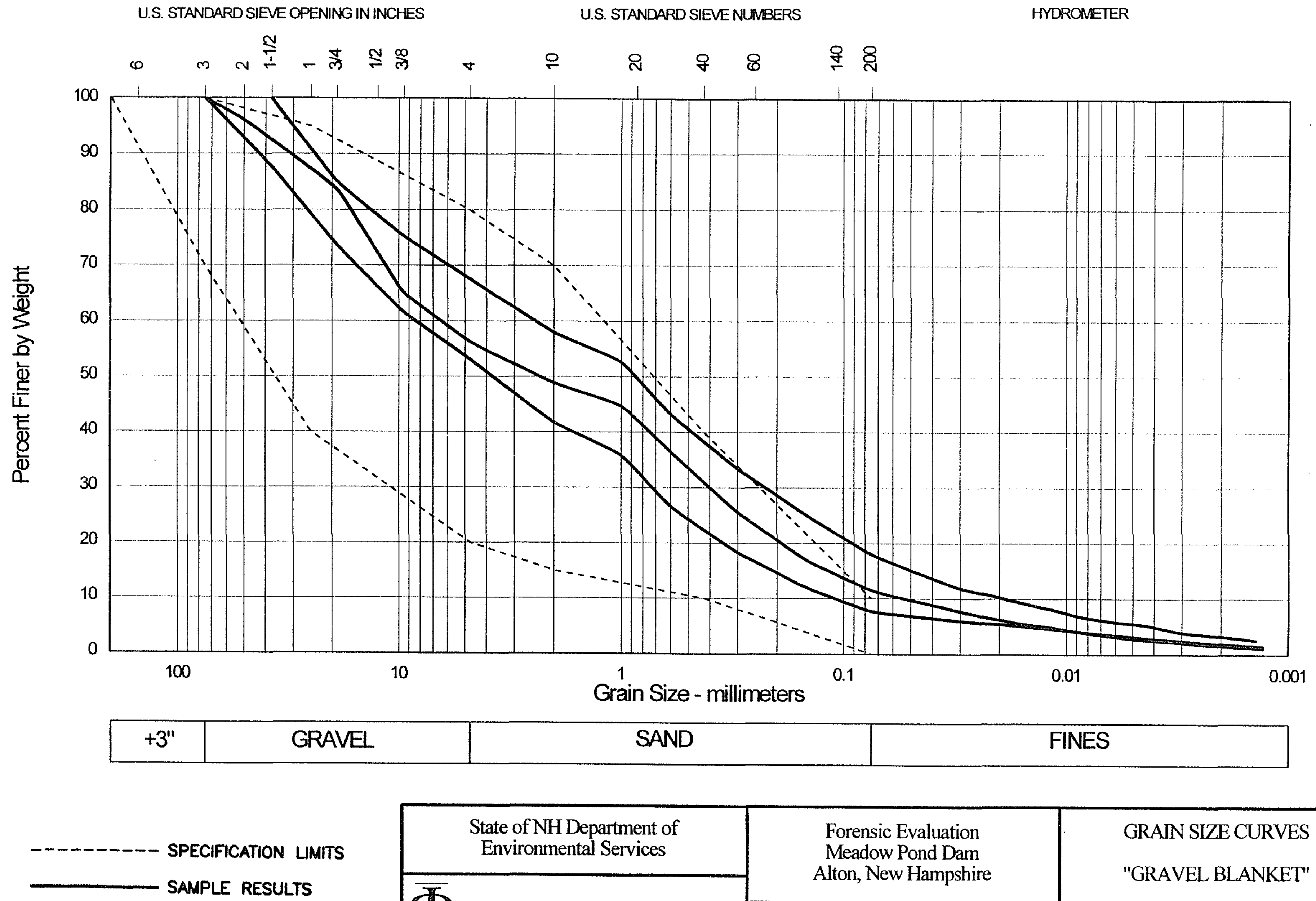
Fig. 5



SPECIFICATION LIMITS (dashed line)

SAMPLE RESULTS (solid line)

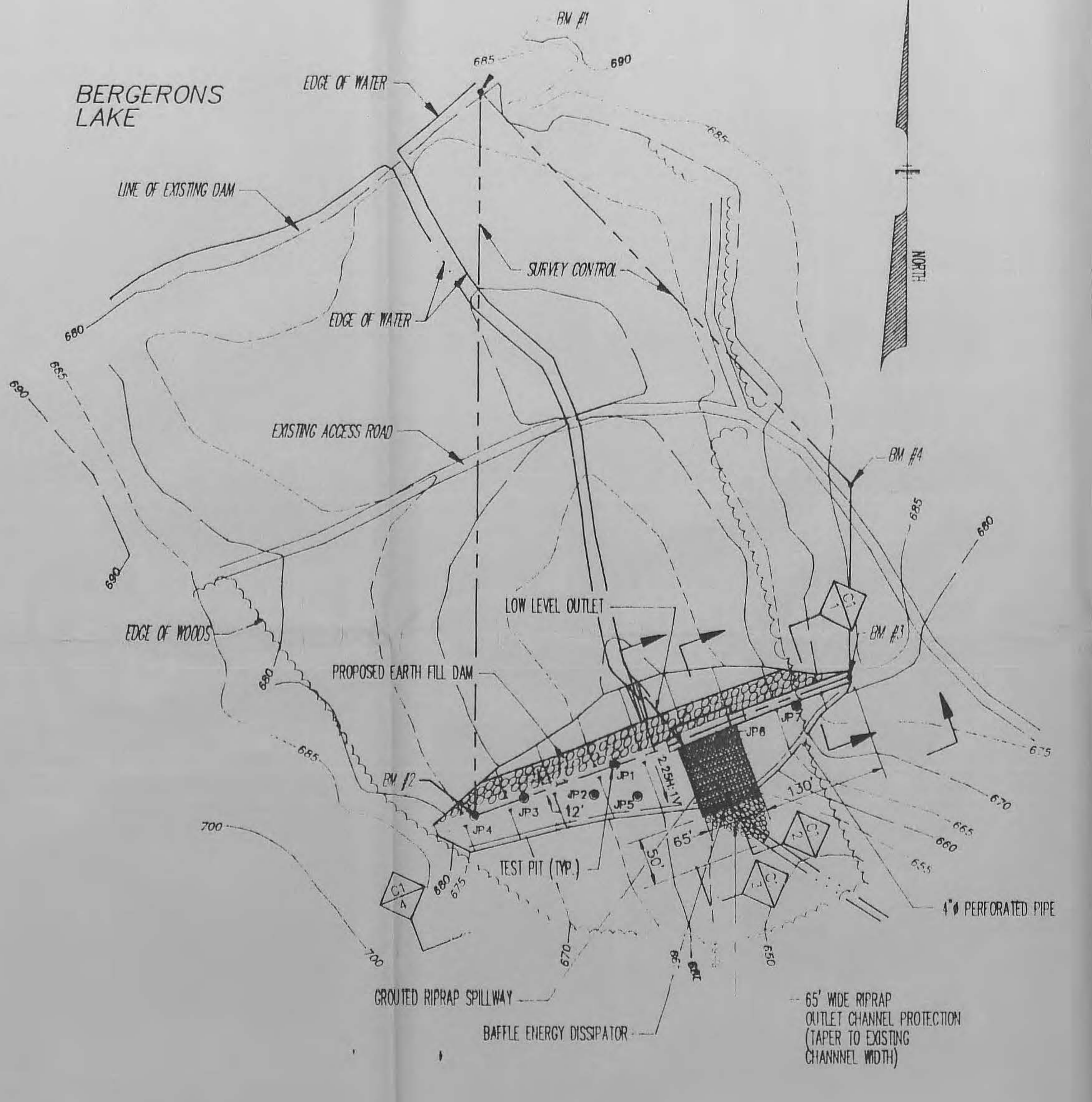
State of NH Department of Environmental Services	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	GRAIN SIZE CURVES "SAND AND GRAVEL"
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 6



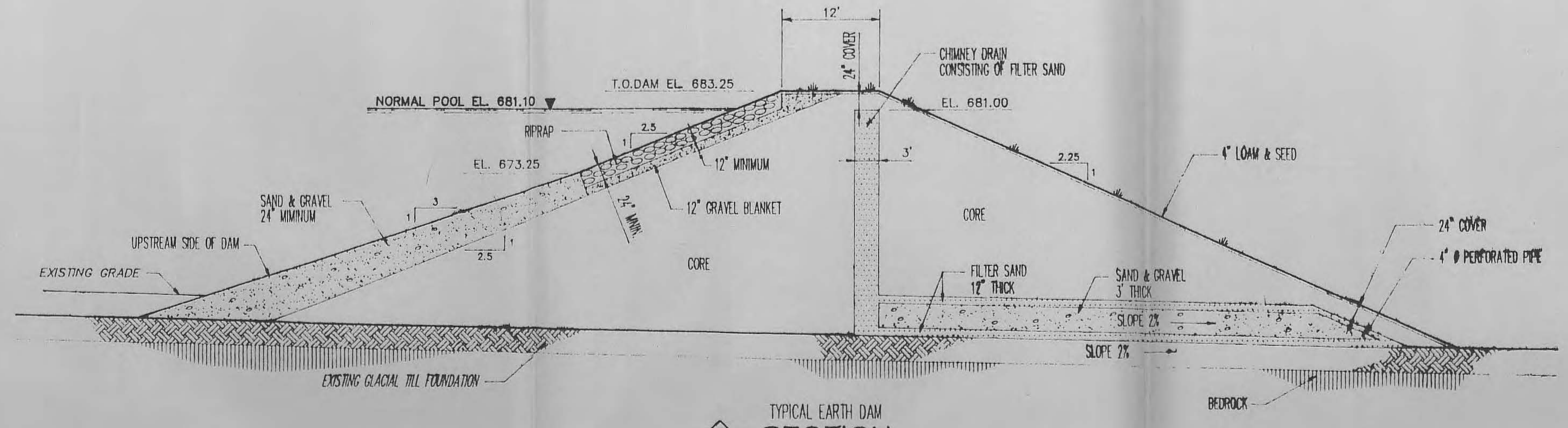
State of NH Department of Environmental Services	Forensic Evaluation Meadow Pond Dam Alton, New Hampshire	GRAIN SIZE CURVES "GRAVEL BLANKET"
GEI Consultants, Inc.	Project 96069	June 1996 Fig. 7

APPENDIX A

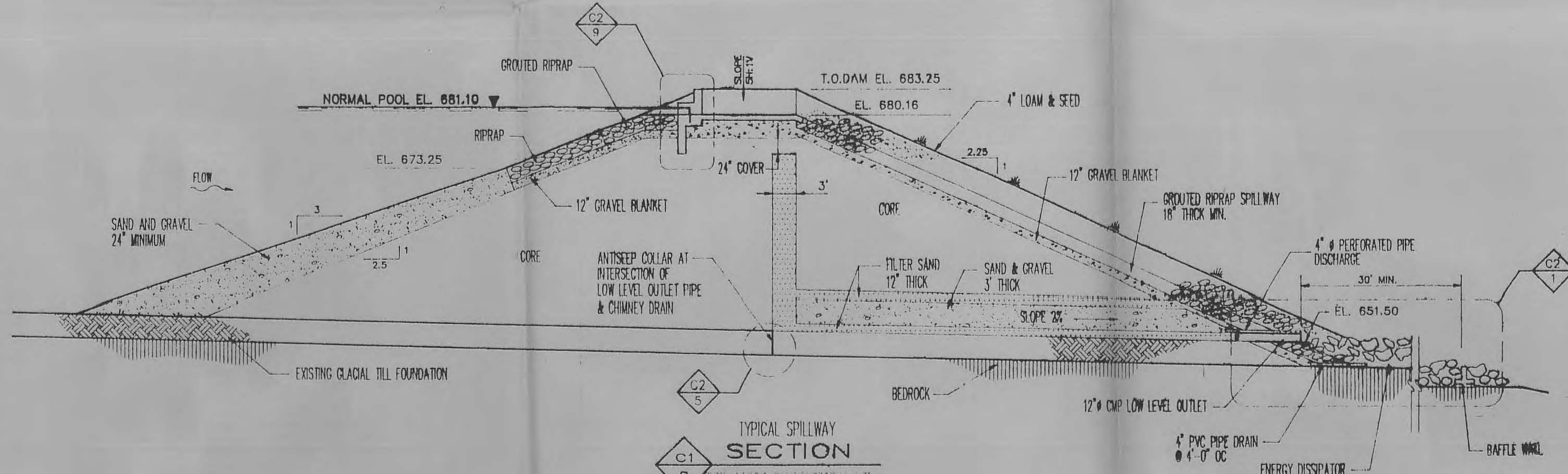
Design Documents



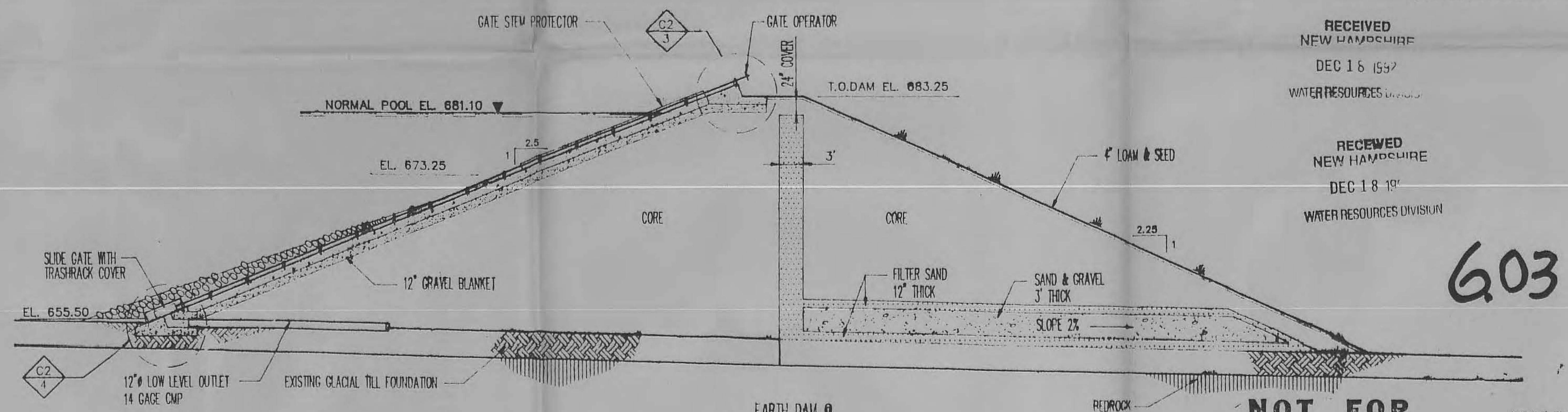
PROPOSED SITE
PLAN
C1 / 1
1" = 100'



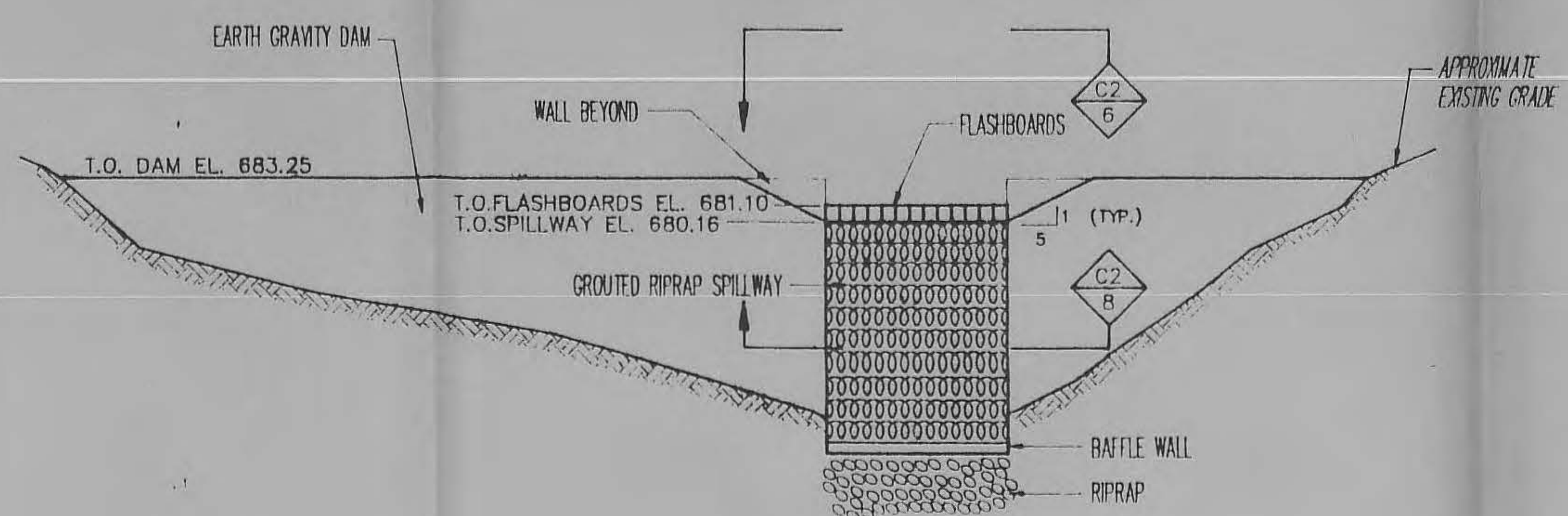
TYPICAL EARTH DAM
SECTION
C1 / 1
1" = 10'



TYPICAL SPILLWAY
SECTION
C1 / 2
1" = 10'



EARTH DAM @ LOW LEVEL OUTLET
SECTION
C1 / 3
1" = 10'



EARTH DAM
ELEVATION
C1 / 4
NOT TO SCALE

NOTES:
REFER TO JAWORSKI GEOTECH REPORT FOR ADDITIONAL INFORMATION AND SPECIFICATIONS.

RECEIVED
NEW HAMPSHIRE
DEC 18 1992
WATER RESOURCES DIVISION

RECEIVED
NEW HAMPSHIRE
DEC 16 1992
WATER RESOURCES DIVISION

RECEIVED
NEW HAMPSHIRE
DEC 18 1992
WATER RESOURCES DIVISION

6.03

NOT FOR CONSTRUCTION

DEC 17 1992

BERGERONS LAKE DAM
ALTON, NEW HAMPSHIRE
6.03

NO.	REVISION	DATE	CHK'D
4	AS PER NHWRD COMMENTS	12/17/92	JRL
3	AS PER NHWRD COMMENTS	12/8/92	JRL
2	JCI COMMENTS	11/18/92	JRL
1	ORIGINAL ISSUE	10/27/92	JRL

SCALE: AS NOTED
CAD FILE No. 92044C1
DESIGNED JLD DATE 10/92
DRAWN JLD DATE 10/92
CHECKED JLD DATE 10/92
APPROVED JRL DATE 10/26/92

PLAN AND SECTIONS

RIVERS ENGINEERING CORPORATION
1600 CANDIA ROAD
MANCHESTER, NEW HAMPSHIRE
(603)647-8700 FAX (603)647-4128

SHEET
C1

R9201


GROUTED RIPRAP SPILLWAY
4" PERFORATED PIPE
12"Ø CMP LOW LEVEL OUTLET
TOE OF SLOPE
EL. 651.50
30' MINIMUM
ANGULAR RIPRAP
BAFFLE WALL
4" PVC WEEP HOLE @ 8'-0" OC (NO SCREEN)
12" GRAVEL BLANKET
CORE MATERIAL
BEDROCK
#4 @ 12" OC/EW TYPICAL
#6 DOWELS @ 60" OC STAGGERED – DRILL 2"Ø HOLE & FILL w/ NONSHRINK GROUT
ENERGY DISSIPATOR SECTION
1/4" = 1'-0"
4" HOSE CLAMP
4" PVC PIPE
#4 MESH, 23 GA GALV. WIRE CLOTH HARDWARE GRADE
PLAN
SECTION
PIPE SCREEN DETAIL
1 1/2" = 1'-0"
GATE OPERATOR PEDESTAL
GATE OPERATOR
GATE STEM
STEM PROTECTOR
STEM GUIDE
4" LOAM & SEED
12" CONCRETE CAP
12" GRAVEL BLANKET
7'-3"
GATE OPERATOR DETAIL
1/4" = 1'-0"
STEM GUIDE
GATE FULLY OPENED
12" CMP PIPE OUTLET
12" SLUICE GATE
CONCRETE CAP
GATE STEM
PLAN
12" CONCRETE CAP
12" GRAVEL BLANKET
EL. 655.50
EXISTING GLACIAL TILL
12" CMP PIPE
SECTION
LOW LEVEL OUTLET DETAIL
1/4" = 1'-0"
FLOW
2 x 12 P.T. FLASHBOARDS
2 x 12 P.T. NAILER
3'-0" CONCRETE CAP OVER SPILLWAY
1/2"Ø FLASHBOARD PINS
2'-6" EA. END
10' EACH END
5'-0" TYP.
15' TYPICAL
12" CONCRETE ABUTMENT
TOP OF WALL EL. 683.25
27'-0"
T.O.DAM EL. 683.25
SLOPE DOWN 5H:1V
SPILLWAY EL. 680.16
15'-6"
SPILLWAY PLAN
1/4" = 1'-0"
4'-0"
24" MIN.
CONTINUOUS WLED FULL CIRCUMFERENCE BOTH SIDES
ANTISEEP COLLAR DETAIL
1/2" = 1'-0"
2 x 12 P.T. FLASHBOARDS
2 1/4" GALV. COMMON NAILS @ 6" OC T & B
2 x 12 P.T. NAILER
FLASHBOARD NAILER DETAIL
1 1/2" = 1'-0"
2:1 SLOPE EACH SIDE
65'-0"
18" GROUTED RIPRAP SPILLWAY
12" GRAVEL BLANKET
SPILLWAY SECTION
NTS
2 x 12 P.T. FLASHBOARD
1" SCH.40 A53 GRADE B GALVANIZED PIPE
#4 @ 12" OC/ EW
GROUTED RIPRAP SPILLWAY
FLASHBOARD PIN
CONCRETE SPILLWAY CAP
2'-0"
#5 @ 15" OC
CUT-OFF WALL
#4 @ 15" OC
FLASHBOARD SECTION
3/4" = 1'-0"
3/16" RUBBER SHEATING LENGTH EQUAL TO FLASHBOARD
TIE WIRE
1/2"Ø A53 GRADE B GALVANIZED PIPE
BRICK @ 3'-0" OC
1 1/4" GALV. ROOFING NAILS @ 6" OC T & B
CONCRETE SPILLWAY CREST
FLASHBOARD DETAIL
3" = 1'-0"
Side View
End View
STANDARD TYPE
NEOPRENE GASKET
PIPE COUPLER DETAIL
NOT TO SCALE
NOT FOR CONSTRUCTION
DEC 17 1992
BERGERONS LAKE DAM
ALTON, NEW HAMPSHIRE
6.03
DETAILS
SCALE: AS NOTED
CAD FILE No. 92044C2
DESIGNED
DRAWN
CHECKED
APPROVED
DATE
AS PER NHWRD COMMENTS 12/17/92 JRL
AS PER NHWRD COMMENTS 12/3/92 JRL
BAFFLE ENERGY DISSIPATOR 11/16/92 JRL
ORIGINAL ISSUE 10/23/92 JRL
REVISION DATE CHK'D
ENGINEERING CORPORATION
CANDIA ROAD
NEW HAMPSHIRE
SHEET C2

I. GENERAL

A. **Work Included**
Provide all labor, materials, equipment and services and perform all operations required to complete the work as indicated on the drawings and specified herein.

B. **Subsurface Conditions**
Data indicated as subsurface conditions are not intended as representations or warranties of accuracy or continuity between test pits.

C. **Quality Control**
A qualified soils engineer should be retained by the owner as needed during construction to perform necessary soil testing and observe compliance with the design drawings and specifications.

D. **Tolerances**
The geometry of fill materials for the embankment dam shall be constructed to within 5 percent tolerance to that indicated on the drawings.

E. **Borrow Areas**
Borrow areas should be quantified prior to construction to determine sufficient and consistent soil materials.

F. **Lay Out and Grades**
All lines and grades shall be defined prior to and during construction. A permanent bench mark shall be established and replaced if destroyed.

G. **Samples and Testing**
Core materials shall be tested for approval for every 4,000 yards of material. Filter materials shall be tested for approval for every 1,000 yards of material. Samples should be at least 30 pounds in weight and submitted prior to use. Additional testing will be required if fill materials change as directed by the soils engineer.

H. **Inspection of Rock Surface**
The bedrock surface 20 feet from the upstream toe in the reservoir area shall be inspected prior to construction for the presence of fractures, seams, fissures, joints, bedding planes of other anomalies which create seepage paths beneath the dam. The bedrock shall be pressure washed to obtain an unobstructed view of the surface.

I. **Frost Protection**
Soils which become frozen within the limits of the embankment dam shall be removed to the full depth of frost. Placed soils should be protected from frost should ambient air temperatures fall below freezing.

J. **Dewatering**
Excavated and fill areas shall be kept sufficiently dry from groundwater or surface water runoff so that it does not adversely affect construction procedures or cause excessive disturbance of borrow and fill areas. In no case should fill materials be placed if ponded or groundwater is observed.

K. **Turbidity**
Quantitatively measure turbidity of the water emanating from the embankment dam with a turbimeter in units of Nephelometric Turbidity Units (NTUs). Measurements should be accomplished daily during reservoir filling and one week upon attainment of full reservoir. Measurements shall be reported to the soils engineer within 24 hours. Measurements shall be taken on a weekly basis thereafter. Measurements shall be ceased once it can be demonstrated that the turbidity of the water is dissipating or at the discretion of the soils engineer.

L. **Erosion Control Measures**
Temporary control consists of furnishing and placing temporary erosion and pollution control devices as specified by field engineer. All work regarding erosion and pollution control will be completed and properly installed in conformance with all federal, state and local permits and regulations.

M. **Bearing Capacity**
The net allowable bearing capacity used for the foundation design is 4000 psf as provided in specifications by Jaworski Geotech, Inc.

II. MATERIALS

Materials shall be placed where indicated on the project drawings.

A. **Core**
Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Core materials shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	75 - 100
1 inch	65 - 95
3/8 inch	50 - 85
No. 4	40 - 80
No. 40	30 - 65
No. 200	20 - 40

The core materials shall possess as coefficient of permeability less than 10 E-5 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

B. **Filter Sand**
Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Filter sand shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
1.5 inch	100
3/8 inch	80 - 95
No. 4	60 - 85
No. 20	15 - 50
No. 40	0 - 30
No. 100	0 - 10

The filter sand should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

C. **Sand and Gravel**
Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Sand and gravel shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	70 - 100
1 inch	50 - 100
No. 4	30 - 80
No. 40	0 - 30
No. 100	0 - 10

The sand and gravel should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

D. **Gravel Blanket**
Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Gravel shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
8"	100
3"	70 - 100
1"	40 - 95
No. 4	20 - 80
No. 10	15 - 70
No. 40	10 - 40
No. 200	0 - 10

The dry density of the compacted material shall not be less than 95 percent of the maximum dry density as determined by ASTM D-1557 for the materials being compacted.

E. **Rip-Rap**
Shall be sound, resistant to weathering, of approved quality, and free from structural defects. The maximum size by weight shall be 1,250 pounds. The stones shall be angular in shape and shall conform to the following gradation requirements:

Size By Weight	Percent By Weight
626 - 1,250 lbs.	30 - 40
50 - 625 lbs.	60 - 70
50 lbs.	0 - 10

Rock available at the site may be used with permission from the field engineer. Stone used for riprap shall be durable, angular in shape; free from overburden, spoil, shale and organic material; and shall meet the gradation requirements specified.

Grouted angular riprap along spillway shall be minimum of 12" in diameter with angular face protruding one and one half inch above the surface of the grout.

Grout for grouted riprap shall consist of one part portland cement and three parts sand, thoroughly mixed with water to produce grout having a think creamy consistency. The minimum amount of water shall be used to prevent excess shrinkage of the grout after placement.

Riprap at downstream end of spill way contained in energy dissipator shall be angular with uniform diameter not to be less than 12" in diameter.

F. **Topsoil**
Shall consist of fertile, friable, natural topsoil typical of the locality, without admixture of subsoil, and shall be obtained from a well drained arable site. It shall be such a mixture of sand, silt and clay particles as to exhibit sandy and clayey properties in about equal proportions. It shall be screened of all stones two inches or more in diameter, sticks, plants and other foreign materials. The topsoil shall contain not less than 4% nor more than 20% organic matter as determined by the loss of ignition of oven-dried samples.

G. **Reinforced Concrete**
All concrete work shall be in accordance with the "Building Code Requirements for Reinforced Concrete (ACI 318)" latest edition with supplements and all pertinent specifications contained therein.

All concrete shall attain a minimum 28-day compressive strength of 4000 psi. Portland cement shall be type II in accordance with ASTM C-150. Concrete shall be air entrained with total air as a percent by volume of concrete equal to 5%. The air entraining admixture shall be Daravair, or as equal, conforming to ASTM C-260. The aggregates shall conform to ASTM C-33 and shall have a 3/4-inch maximum size.

Reinforcing steel shall be Grade 60 deformed billet steel bars conforming to ASTM A-615.

The minimum clear concrete cover for reinforcing shall be 3 inches for cast concrete cast against earth and 2 inches elsewhere, unless otherwise noted.
All grout shall be a Portland cement based non-shrink grout, such as CG-86 construction grout as manufactured by W. R. Meadows, or equal. The grout shall be mixed and installed according to the manufacturer's specifications.

H. **Slide Gate**
Slide gate provided should be a model SC-5000 as manufactured by Waterman Industries or equal upon approval of Engineer. Compliance of manufacturers specifications is required. A trashrack cover shall be provided as approved by the engineer.

Protection from ice or other forces upon the stem of the slide gate shall be provided from the elevation at top of dam to a point 25 feet in length below this point. Construction of this device is subject to the approval of the engineer.

I. **Low Level Outlet**
Pipe shall conform to AASHTO specifications designation M-196 and shall be 12", 14 gauge aluminized steel Type 2 pipe. Installation shall be in accordance with AASHTO Guide Specifications for Highway Construction.

J. **Anti-Seep Collar**
Either a steel plate shall be continuously welded around the low level outlet or a collar with gasket and sealant provided by Contech, Inc. shall be installed. The collar is placed such that seepage along the existing glacial till foundation is diverted to the filter sand. A sealant shall be placed over the weld for the option with the steel plate to prevent corrosion.

K. **Perforated Pipe**
Shall be an ADS (Advanced Drainage Systems, Inc.) four-inch diameter continuous section wrapped in a nylon protective fabric or equivalent. The pipe shall be sloped a minimum of one percent throughout the entire length. The pipe should outlet at both the stream bed and abutment. The abutment outlet shall be capped with a split end cap. Installation should be in accordance with manufacturer's guidelines and specifications. Pipe shall also be placed along both sides of low level outlet.

L. **Seed Mix**
Slope Seed Type 44 shall normally be used for all slope work, and shall conform to the table below unless amended by the engineer to suit special conditions encountered.

Kind of Seed	Minimum Purity (%)	Minimum Germination (%)	Lbs/Acre
Creeping Red Fescue	96	85	50
Perennial Ryegrass (1)	98	90	40
Redtop	95	80	10
Alsike Clover	97	90 (4)	10
Birdsfoot Trefoil (4)	98	80 (4)	10

III. EXECUTION

A. **Clearing and Grubbing**
Remove topsoil and subsoil within the limits of the earthfill dam and in borrow areas. Exposed subgrade in which root structure or organic materials are encountered shall be overexcavated to the depth of the root line. Pile and store excavated materials in designated or approved locations where it will not interfere with construction operations.

B. **General Excavation**
Excavation within the limits of the embankment dam shall be excavated of all topsoil and subsoil to a depth greater than the root line.

C. **Placement**
Fill materials shall be placed and spread in a manner to minimize particle segregation. Care will be taken to not contaminate filter materials. Filter materials which become contaminated shall be removed and replaced. No fill materials shall be placed on uncompacted soil, wet/weaving soil, frozen soil or other soil conditions unacceptable to the soils engineer.

The location of the chimney drain shall be 9 to 12 feet downstream of the upstream crest of the dam placed in a vertical position.

Surfacial soils shall be uniformly distributed and evenly spread to compensate for shrinkage. Irregularities in the surface resulting from construction operations shall be corrected to prevent the formation of depressions where water will stand.

D. **Disking and Harrowing**
Each lift shall be uniformly disked or harrowed to a depth of at least 2 inches prior to the placement fill materials.

E. **Moisture Control**
The water content of fill materials shall be within -3 percent to +2 percent of the optimum moisture content determined by ASTM D-1557. Soils which are dry shall be uniformly wetted. Wet soils shall be aerated by blending, mixing or other satisfactory means until the moisture content is as specified. Borrow and fill areas should be protected from precipitation when necessary. Placed fill which exceeds the specified moisture shall be removed.

F. **Compaction**
Lift sizes should be limited to 18 inch loose lift thickness. Compact fill materials to 92 percent relative compaction as determined by ASTM D-1557. Field density tests shall be performed at 100 foot intervals for each lift. Soils which do not meet compaction requirements shall be recompacted or removed.

G. **Slush Grouting**
The bedrock surface should be exposed in the reservoir area at least 20 feet from the upstream toe of the dam. All fractures, seams, joints or fissures shall be slush grouted with a lean sand and cement grout in which to establish an impermeable seam. The ratio of sand to cement shall not exceed 2 parts sand to 1 part cement. All areas to be slush grouted shall be thoroughly cleaned of all loose materials and shall be wetted prior to the placement of the grout. Placement of slush grout shall be by brooming into all fractures, seams, joints or fissures with a stiff-bristled broom or other approved method. All fractures, seams, joints or fissures shall be chased at least 100 feet from the upstream toe and/or 30 feet into the embankment dam.

H. **Grouted Riprap**
The stones shall be placed on the prepared slope substantially to the dimension shown on the Drawings. The stones shall be thoroughly moistened and any excess of fines shall be sluiced to the underside of the stone before grouting.

Pressure grouting shall not unseat the stones; and after placing by this method, the grout shall be spaded or rodded into the voids. Penetration of the grout shall be to the depth specified on the Drawings.

Grout shall be placed only when the temperature is above 35° F. and rising. It shall be protected and not allowed to freeze.

I. **Baffle Wall**
Prior to construction of the baffle wall, the field engineer shall determine if adequate bedrock has been reached. In the event that bedrock is not encountered at the desired elevation, the engineer shall be contacted for further modifications.

J. **Mulching**
Shall consist of hay or straw mulch loosely spread to a uniform depth over all grassed areas indicated on the plans. Mulch shall be spread following approval of the surfacial soils by the soils engineer.

K. **Seeding**
Shall be performed early spring or late summer. Seed shall be evenly spread. Reseeding of bare spots and maintenance requirements shall be performed when necessary.

NOT FOR CONSTRUCTION DEC 17 1992

THE STATE OF NEW HAMPSHIRE PROFESSIONAL ENGINEER

	REVISION	DATE	CHK'D
4	AS PER NHWRD COMMENTS	12/17/92	JRL
3	AS PER NHWRD COMMENTS	12/3/92	JRL
2	JGI COMMENTS	11/16/92	JRL
1	ORIGINAL ISSUE	10/23/92	JRL

SCALE: N/A
CAD FILE No. 9204403

DESIGNED — DATE
DRAWN — DATE
CHECKED DATE 10/23/92
APPROVED JRL DATE 10/23/92

BERGERONS LAKE DAM
ALTON, NEW HAMPSHIRE 6.03

SPECIFICATIONS

RIVERS ENGINEERING CORPORATION
1600 CANDIA ROAD
MANCHESTER, NEW HAMPSHIRE
(603)647-8700 FAX(603)647-4128

SHEET C3

CORRESPONDENCE

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
6 Hazen Drive, P.O. Box 95, Concord, NH 03302-0095
603-271-3503 FAX 603-271-2867
TDD Access: Relay NH 1-800-735-2964

NHDES

PERMIT No. 6.03
REGISTRATION OF A NEW DAM

On December 31, 1992, the Department of Environmental Services (DES), under authority of RSA 482:9-11 issues the following permit:

WHEREAS, Mr. Robert Bergeron has filed with the DES on June 26, 1992 an application for approval to construct a dam in the Town of Alton, in Belknap County, New Hampshire; and

WHEREAS, the DES has considered the application and finds that if said structure is constructed in accordance with plans and specifications provided with said application and accepted construction standards and is properly maintained, it would not be a menace to public safety; now therefore

THIS APPLICATION, is approved and said dam is hereby registered and authorized to the following terms and conditions:

1. The Dam shall be constructed in accordance with the approved plans and specifications and the dam shall be properly operated and maintained at all times in compliance with the provisions of Revised Statues Annotated Chapter 482.

2. The Dam owner shall provide a qualified inspector to insure compliance with approved plans and specifications.

3. The inspector shall be a professional engineer registered in New Hampshire, or his duly authorized agent, familiar with dam construction.

4. The frequency of inspections shall be as follows:

   a. Class B structures shall be inspected periodically but not less than once per week.

   b. Structures shall be inspected upon the completion of major items of work including but not limited to excavation, pipe placement, final grading, pouring of concrete.

5. Materials of construction shall be periodically tested for compliance with design requirments in accordance with approved plans and specifications.

6. The inspector shall submit an inspection report to the DES upon the completion of the project. The report shall include a copy of all test results, changes in design, foundation conditions observed during excavation and any other data pertinent to determining the integrity of the structure. "As-built" drawings shall be submitted if the original design is modified.

7. The inspector shall provide the DES with an affidavit of compliance with approved plans and specifications upon completion of the project.

8. The DES shall be notified prior to the back filling of the low level drain pipe so that an inspection may be made.

9. A schedule shall be submitted within 30 days which provides for the completion of an Emergency Action Plan by January 1, 1995.

10. As specified by the consultant (Rivers, Inc.), through contact with its geotechnical subcontractor (JGI Inc.), in a letter to the DES dated December 17, 1992, the approved design of the spillway should withstand the effects of frost-induced seepage/piping.

11. The construction of this dam must be completed no later than two years from date of issuance of this permit.

12. Upon completion of construction, the dam owner shall notify, in writing, by certified mail, the DES five (5) days prior to filling of the reservoir. Filling of the reservoir shall comply with WR.501.03.

13. Registration of the dam by the DES does not relieve the owner from meeting the requirements of public safety or other provisions of the law.

14. Registration of the dam by the DES does not convey a property right or authorize any injury to property or invasion of other rights.

15. The dam owner shall notify the DES if the property is sold and include the new owner's name and address.

Please forward all correspondence to me at the Water Resources Division address shown on the first page.

DEPARTMENT OF ENVIRONMENTAL SERVICES
WATER RESOURCES DIVISION

BY Delbert F. Downing
DELBERT F. DOWNING, DIRECTOR

DATE 12/31/92

RECEIVED
Rachel M. Normandin
1993 JAN -4 AM 11:19
REGISTRY OF DEEDS
BELKNAP COUNTY
Register

BK1237 PG0144

cc: Town of Alton
Public Information and Permitting

DFD/SND/was.6/permit/006-03.per

RIVERS ENGINEERING CORPORATION
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109-5512

(603) 647-8700 FAX (603) 647-4128

LETTER OF TRANSMITTAL

DATE 12/23/92 JOB NO. R92044

ATTENTION

RE: BERGERONS LAKE DAM

TO BOB BERGERON

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via ____ the following items:

☐ Shop drawings ☐ Prints ☒ Plans ☐ Samples ☐ Specifications

☐ Copy of letter ☐ Change order ☐ ____

COPIES	DATE	NO.	DESCRIPTION
5	12/17/92	C1	PLAN AND SECTIONS
5	12/17/92	C2	DETAILS
5	12/17/92	C3	SPECIFICATIONS

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submitted ☐ Resubmit ____ copies for approval

☒ For your use ☐ Approved as noted ☐ Submit ____ copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return ____ corrected prints

☐ For review and comment ☐ ____

☐ FOR BIDS DUE ____ 19 ____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS ____

COPY TO ____

SIGNED: Jonathan L. Dolland

4

If enclosures are not as noted, kindly notify us at once.

RIVERS
ENGINEERING CORP.
CIVIL • ENVIRONMENTAL • WATER RESOURCES

FAX TRANSMITTAL COVER PAGE

DATE: Dec 17, 1992

PROJECT NO: R92044

RE: Bergerons Lake Dam
Alton NH

TO: NH Water Resources Div.
Attn. Steve Doyon

FROM: Jonathan Dollard

FAX #: 1-271-1381

TOTAL NUMBER OF PAGES TRANSMITTED (INCLUDING COVER SHEET) 3

REMARKS:

LETTER & REVISED DRAWING SET WILL BE SENT TO YOU BY MAIL LATER TODAY.

Copy To: ______

Signed: Jonathan L. Dollard

59

PLANNING STUDIES DESIGN CONSTRUCTION SERVICES
1600 Candia Road • Manchester, New Hampshire 03109-5512 • (603) 647-8700 FAX 647-4128

Form #1001

RIVERS
ENGINEERING CORP.
CIVIL • ENVIRONMENTAL • WATER RESOURCES

FAX TRANSMITTAL COVER PAGE

DATE: DEC 17, 1992

PROJECT NO: R92044

RE: BERGERONS LAKE DAM

TO: BOB BERGERON

FROM: JONATHAN DOLLARD

FAX #: 1-329-5036

TOTAL NUMBER OF PAGES TRANSMITTED (INCLUDING COVER SHEET) 3

REMARKS:

Copy To: ______________________

Signed: Jonathan L. Dollard

This facsimile transmission is intended only for use by the individual or entity to which it is addressed. It may contain information that is privileged, client confidential and exempt from disclosure under applicable law. If the reader of this facsimile message is not the intended recipient or the employee or agent responsible for delivering the message to the recipient, you are hereby notified that reading the contents and/or any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this communication in error, please notify the sender immediately by telephone at 1-800-370-1600 and return the original message to us at the address below via U.S. Mail. Thank you.

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PLANNING STUDIES DESIGN CONSTRUCTION SERVICES

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Form #1001

RIVERS
ENGINEERING CORP.
CIVIL • ENVIRONMENTAL • WATER RESOURCES

December 17, 1992

New Hampshire Water Resources Division
64 North Main Street
Concord, NH 03301-2008

ATTN: Mr. Steve Doyon

RE: Bergeron's Lake Dam in Alton, NH   Our Project No. R92044
a.k.a. Meadows Pond Dam

Dear Mr. Doyon:

We have contacted our geotechnical consultant regarding your concerns of frost penetration below the pond level causing separation of materials at the soil and concrete wall interface allowing for potential seepage paths.

Based on these concerns, the gradation specifications of the gravel blanket base to the riprap has been revised to incorporate a finer material with lower permeability characteristics. Additionally, the concrete wall length has been extended some seven feet to create a longer seepage path similar to the path perpendicular to the dam. These modifications incorporated with proper construction practices in conformation with plans and specifications, specifically regarding compaction and moisture content, should adequately address your concerns regarding this matter.

If you have any remaining questions or questions regarding changes to either the drawings or specifications, please do not hesitate to call.

PLANNING STUDIES DESIGN CONSTRUCTION SERVICES
1600 Candia Road • Manchester, New Hampshire 03109-5512 • (603) 647-8700 FAX 647-4128

Very truly yours,

RIVERS ENGINEERING CORPORATION

Jonathan L. Dollard

Jonathan L. Dollard

JLD/WP9\BER.LET
Encl.

CC: J. Lavigne Jr., P.E. (RIVERS)
K. Martin (JGI)
B. Bergeron (OWNER)

RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03103

(603) 647-8700 FAX (603) 647-4128

LETTER OF TRANSMITTAL

DATE 12/17/92 JOB NO. 92344

ATTENTION Steve Doyon

RE: Zeeceross Lake Dam Alton NH
AKA Meadow Pond Dam

To NH Water Resources Division
64 North Main Street
Concord NH 03301-2003

WE ARE SENDING YOU ☑ Attached ☐ Under separate cover via ________ the following items:

☐ Shop drawings ☐ Prints ☑ Plans ☐ Samples ☐ Specifications
☑ Copy of letter ☐ Change order ☐ ________

COPIES	DATE	NO.	DESCRIPTION
1	12/17/92	C1	Plans and Sections
1	12/17/92	C2	Details
1	12/17/92	C3	Specifications
1	12/17/92		Letter

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☐ For your use ☐ Approved as noted ☐ Submit ____ copies for distribution
☐ As requested ☐ Returned for corrections ☐ Return ____ corrected prints
☐ For review and comment ☐ ________
☐ FOR BIDS DUE ________ 19____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS ________

COPY TO ________

SIGNED: Jonathan L. Williams

PRODUCT 240-3 NEBS Inc., Groton, Mass. 01471.

If enclosures are not as noted, kindly notify us at once.

NEW HAMPSHIRE DEPARTMENT OF
Environmental Services

WATER RESOURCES DIVISION
64 North Main Street
P.O. Box 2008
Concord, NH 03302-2008

Telephone # 603-271-3406
Fax # 271-1381

TO: Johnathan Pollard

OFFICE: Rivers Eng. PHONE: 647-8200

TELECOPIER #: 647-4128

FROM: Steve Dorgan

OFFICE: WRD PHONE: 271-3406

NUMBER OF PAGES TO FOLLOW: 3

COMMENTS: Contact Don & me with your comments.

NEW HAMPSHIRE WATER RESOURCES BOARD

CONCORD, NH

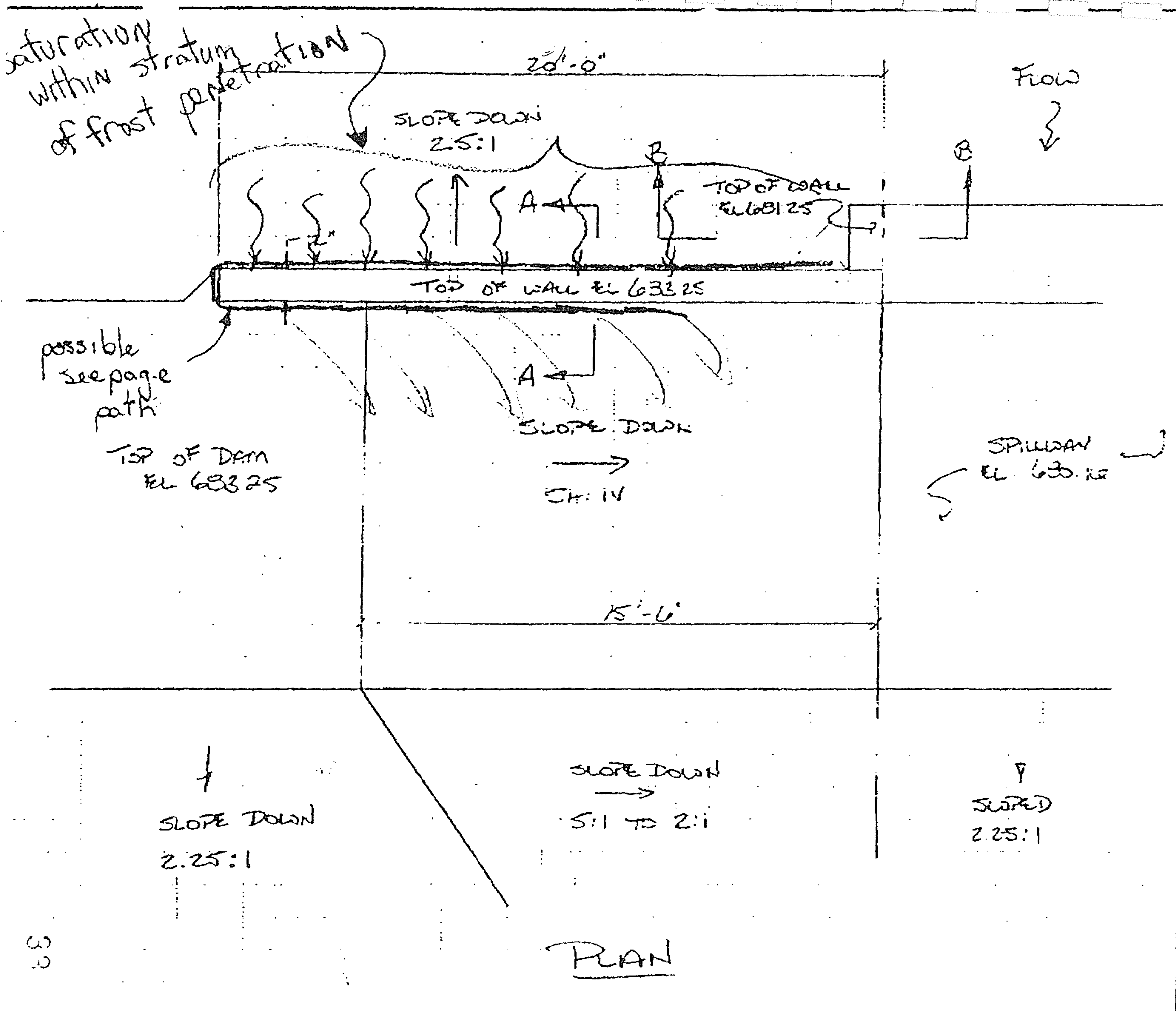
PROJECT MEADOW DAM DAM # 6.03 DATE 12/11/92

SUBJECT DESIGN BY DMR/SND CHECKED ______ SHEET ____ OF ____

- depth of cutoff is O.K.

- because of limited freeboard the frost penetration extends below the pond level. Any separation between soil and cutoff could provide a path for seepage/piping.

Because of this potential problem, the design should be modified to address it.



RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109
(603) 647-8700 FAX (603) 647-4128

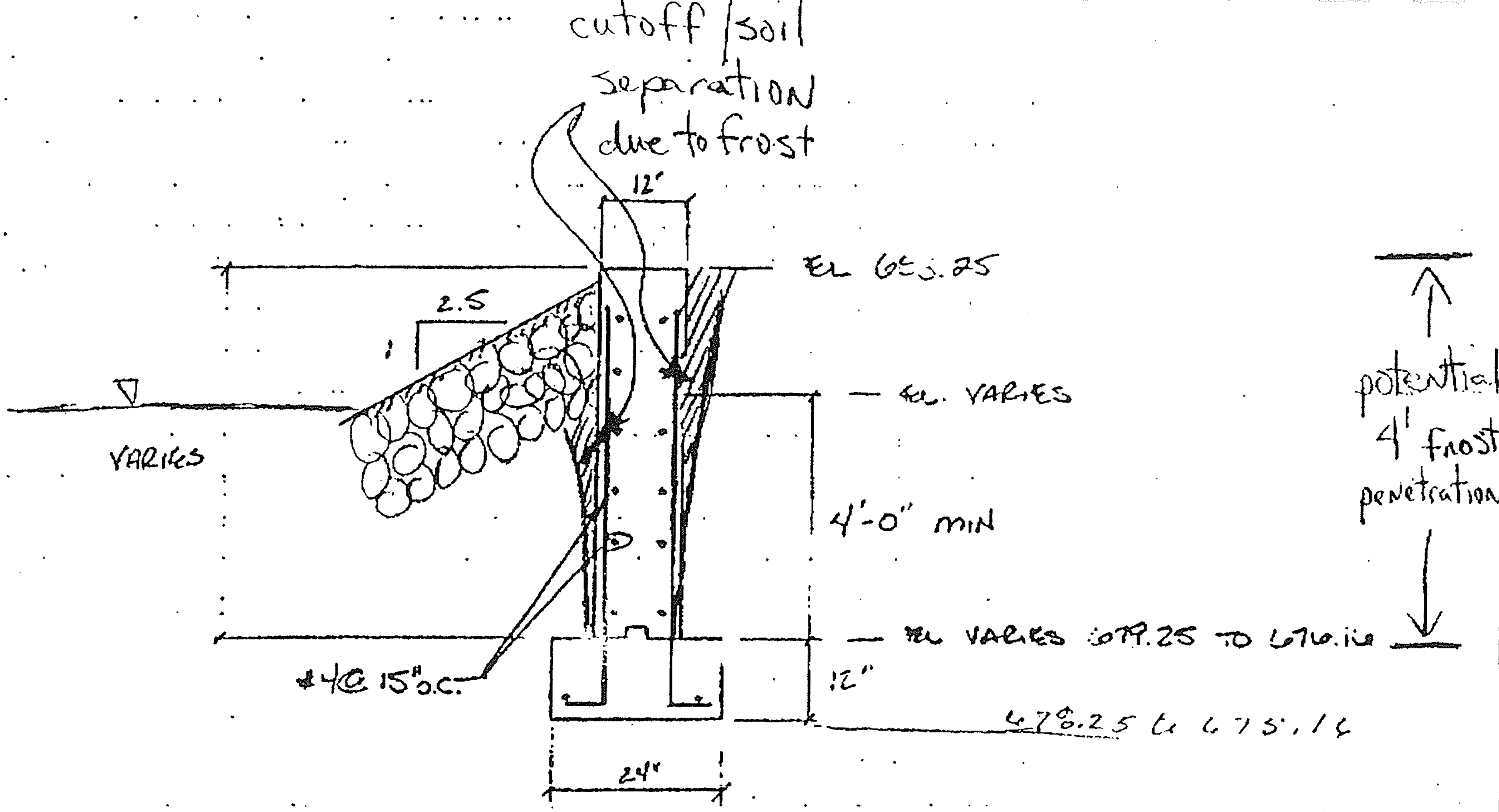
JOB Pleasant Lake Dam E92044

SHEET NO. 1 OF 3

CALCULATED BY JLD DATE 12/11/92

CHECKED BY [illegible] DATE 12/11/92

SCALE 1/4" = 1'-0"



SECTION AA

'92 12/11 18:51 ☎1 603 647 4128 Rivers Eng.Corp 03

RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109
(603) 647-8700 FAX (603) 647-4128

JOB [illegible] Lake Dam 89204
SHEET NO. 2 OF 3
CALCULATED BY [illegible] DATE 12/11/92
CHECKED BY [illegible] DATE 12/11/92
SCALE 1:15

RIVERS
ENGINEERING CORP.
CIVIL • ENVIRONMENTAL • WATER RESOURCES

FAX TRANSMITTAL COVER PAGE

DATE: Dec 11, 1992

PROJECT NO: R92044

RE: Bergerons Lake Dam
Alton NH

NH Water Resources
Division

TO: Steve Doyon &
Don Raposa

FROM: Jonathan Dollard

FAX #: 1-271-1381

TOTAL NUMBER OF PAGES TRANSMITTED (INCLUDING COVER SHEET) 4

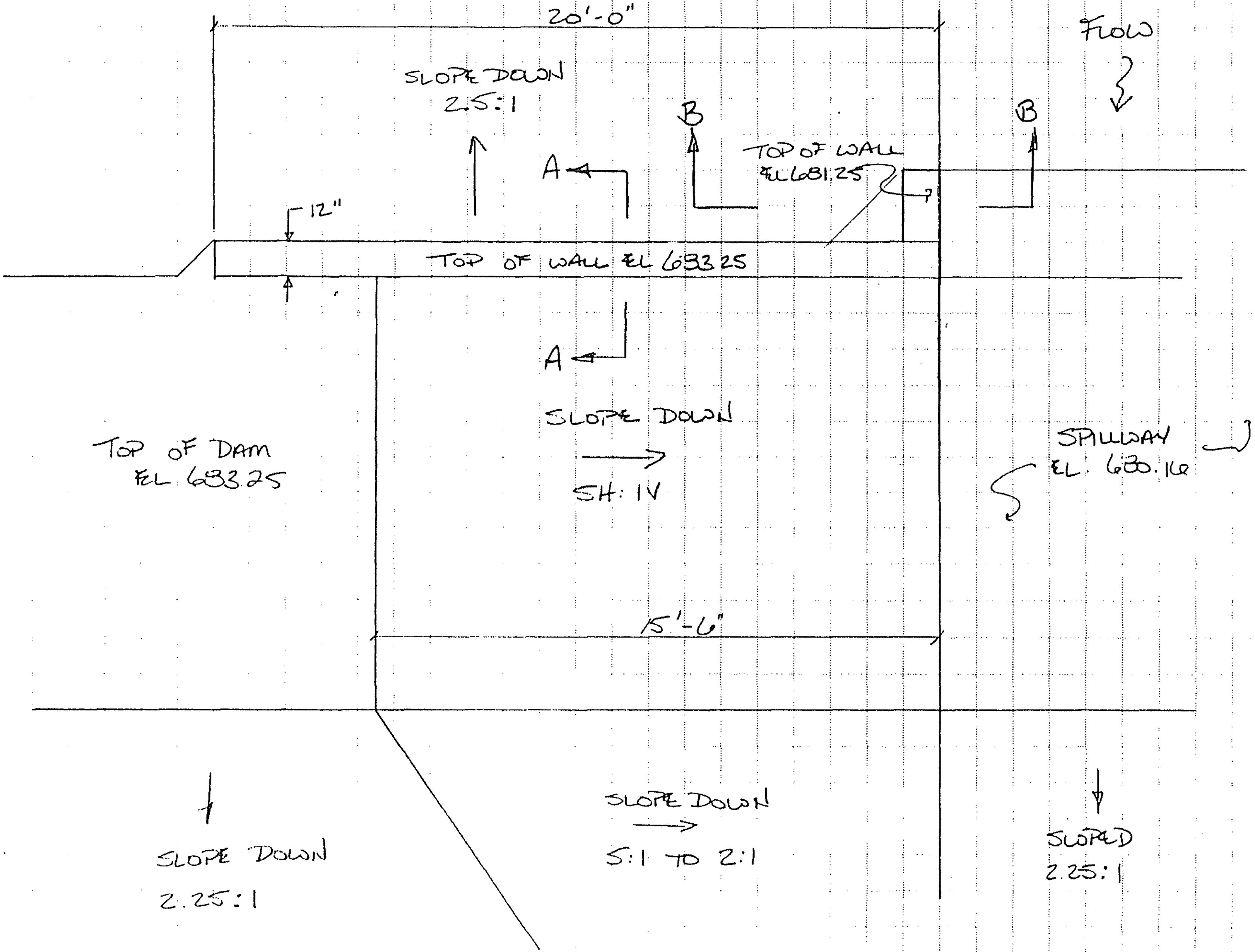
REMARKS:

Hopefully the attached sketches clears up any misconceptions and clarifies the design of the spillway. Note changes to the location of the sloped surface from top of dam to the spillway and length of the embankment wall. If you have any questions please call.

Thanks

Copy To: ____________________

Signed: Jonathan L. Dollard



PLAN

RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109
(603) 647-8700 FAX (603) 647-4128

JOB DERBEVONE LAKE DAM 292044

SHEET NO. 1 OF 3

CALCULATED BY ALD DATE 12/11/92

CHECKED BY [illegible] DATE 12/11/92

SCALE 1/4" = 1'-0"

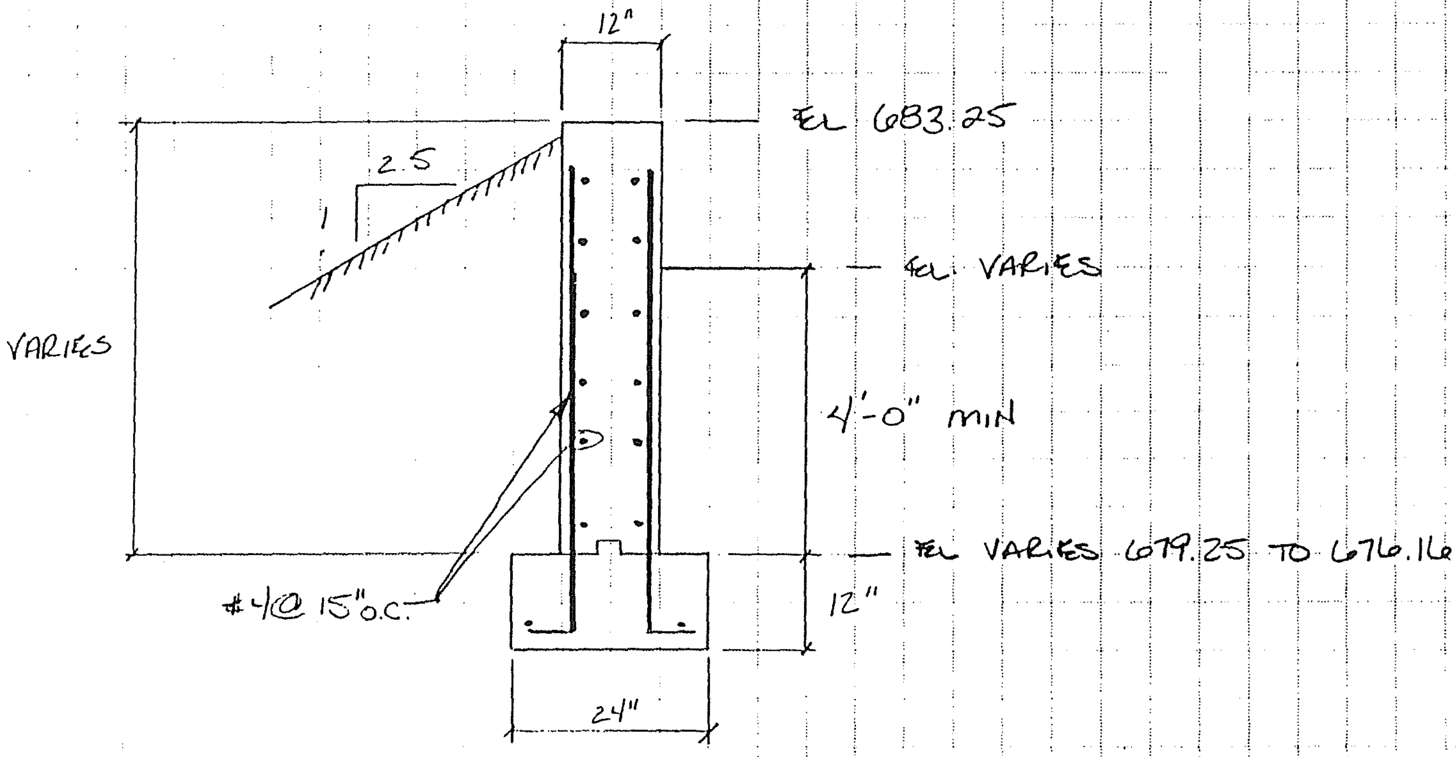
RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109
(603) 647-8700 FAX (603) 647-4128

SHEET NO. 2 OF 3

CALCULATED BY [signature] DATE 12/11/92

CHECKED BY [signature] DATE 12/11/92

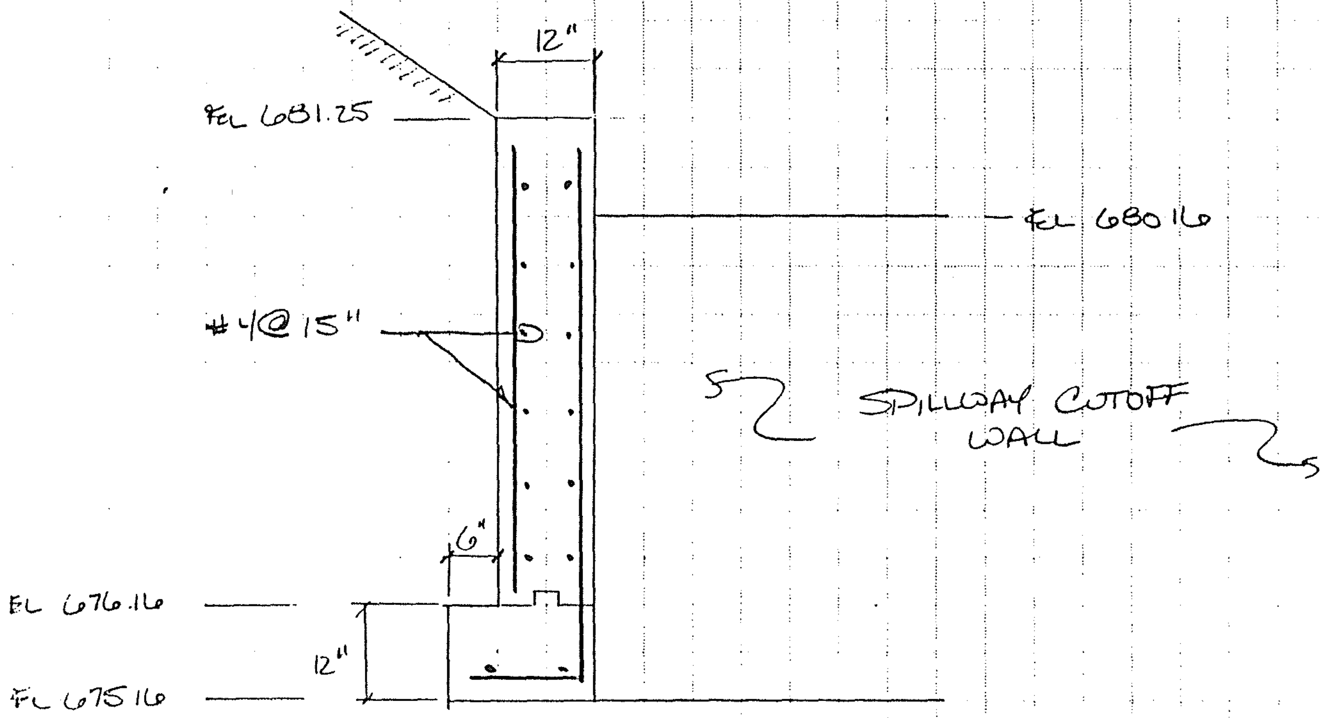
SCALE NTS



SECTION AA

RIVERS ENGINEERING CORP.
1600 Candia Road
MANCHESTER, NEW HAMPSHIRE 03109
(603) 647-8700 FAX (603) 647-4128

JOB ____
SHEET NO. 3 OF 3
CALCULATED BY ____ DATE 12/11/92
CHECKED BY ____ DATE 12/11/92
SCALE ____



ECTION B-B

JAWORSKI GEOTECH, INC.

GEOTECHNICAL REPORT

MEADOW'S POND DAM
ALTON, NEW HAMPSHIRE

PROJECT NO. J92214

OCTOBER 22, 1992

JGI
JAWORSKI
GEOTECH, INC.

JAWORSKI
GEOTECH, INC.

GEOTECHNICAL REPORT

MEADOW'S POND DAM
ALTON, NEW HAMPSHIRE

PROJECT NO. J92214

OCTOBER 22, 1992

Prepared for:

Mr. John Lavigne, P.E.
Rivers Engineering Corporation
1600 Candia Road
Manchester, NH 03109

150 Zachary Road • Manchester, New Hampshire 03109 • (603) 647-9700 • FAX 647-4432

JGI
JAWORSKI
GEOTECH, INC.

SERVICES
- Geotechnical
- Environmental
- Construction
- Underground Tank & Materials Testing

OFFICES
- Manchester, N.H.
- White River Jct., VT.

October 22, 1992

Mr. John Lavigne, P.E.
Rivers Engineering Corporation
1600 Candia Road
Manchester, NH 03109

re: Meadow's Pond Dam (a.k.a Adam's Pond Dam)
Alton, New Hampshire
Dam # 6.03 JGI Project No. J92214

Dear Mr. Lavigne:

Jaworski Geotech, Inc. (JGI) is pleased to submit the following geotechnical report concerning design criteria and technical specifications for the above-referenced project. The work scope was performed in general accordance with our proposal dated June 30, 1992. The contents of this report are subject to the Limitations found in Section 8.00.

The embankment dam design was completed in general accordance with criteria set forth by the New Hampshire Water Resources Division, Department of Environmental Services. More specifically, the embankment design was completed as outlined in the New Hampshire Code of Administrative Rules, Chapter 3, Part Wr 307, Section Wr 307.08 - Earth Embankment Design Criteria.

Attached is a summary of the project, our design assumptions and methodology, a proposed section of the earthfill dam, supporting calculations and technical specifications.

150 Zachary Road • Manchester, New Hampshire 03109 • (603) 647-9700 • FAX 647-4432

We trust the attached is responsive to your needs at this time. Should you have any questions or require further assistance, please do not hesitate to contact our office.

Very Truly Yours,

JAWORSKI GEOTECH, INC.

Kevin Martin

Kevin M. Martin

Gary W. Jaworski. P.E., Ph.D.

KMM5/etc

Attachments

cc: Mr. Robert Bergeron

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1.00 PROJECT DESCRIPTION

The project site is located in Alton, New Hampshire. It is proposed to construct an earthfill dam to impound an existing stream to achieve a pool area of some 35 acres. The proposed dam has been classified as a Class B dam by the U.S. Department of Agriculture's Soil Conservation Service.

The dam is to be an earthen embankment structure approximately 470 feet in length and up to 29 feet in height. The top elevation of the dam is to be 683.25 feet with a normal pool elevation of 681.10 feet. Water outflow is to be accommodated with a drop-inlet trickle tube and tail race. A low level outlet consisting of a submerged slide gate and drain pipe is provided at the base of the dam. A 100 foot wide emergency spillway section consisting of a rip-rap swale is to be provided at the western section of the dam.

The dam is to be a homogeneous soil embankment with an internal chimney and downstream blanket drain. Seepage discharge from the drains is to be regulated with a four inch diameter perforated, high density polyethylene resin pipe encased in a nylon wrap. The drain pipe is to outlet from the embankment at both the stream bed and abutments for maintenance. Rip-rap is to be provided on the upstream face to shield against wave action. The crest and downstream surfaces of the dam are to consist of grassed areas to protect against surface erosion and raveling.

The embankment structure is to be constructed with on-site soils. Basal tills excavated from the reservoir area will comprise the majority of the dam. Some borrow sources may be required for the internal filter drains.

2.00 SITE CONDITIONS

The site encompassing the proposed earthfill dam and pool is approximately 45 acres in area. An existing embankment dam (Meadow's Pond Dam) impounding a pool of approximately eight acres is situated on the site.

Site topography gently descends from north to south with increasing elevation towards the east and west. Topographic relief is on the order of 30 to 40 feet.

Vegetation within the limits of the impoundment consists of underbrush, grass and immature tree growth. Mature hardwood and evergreen encompass the site.

3.00 SUBSURFACE CONDITIONS

A test pit exploration program was performed to characterize near surface soil conditions expected at the site and supply bulk soil samples for related laboratory testing. The test pits, identified as JP-1 through JP-7, were excavated on September 21, 1992, with a Cat 215 LC excavator owned and operated by C.S.S.I. The test pits were excavated within the foundation area of the proposed dam to depths of 4 to 10 feet below existing grade. The Test Pit Logs identifying subsurface conditions and a Subsurface Profile detailing conditions through the centerline of the dam are included in Appendix A.

Subsurface conditions, in general, consist of the following stratigraphic units in descending order of occurrence.

3.10 Topsoil/Root Mat

The surficial soils at the site consist of a thin organic root mat approximately four to six inches in thickness. This unit is comprised of organic silty sand and root structure.

3.20 Subsoil

Underlying the surficial organic soils is an orange-brown strata of fine to coarse sand with little gravel and silt. The subsoil contains organic constituents resulting from an accumulation of materials leached from the surface as well as an abundant root structure. Occasional cobbles and boulders are embedded within this strata. The subsoil was encountered in all the test pits ranging from approximately 18 to 24 inches in thickness.

3.30 Glacial Till

A grey-brown, silty-clayey sand with some gravel was found to underlie the subsoil towards the central and western portions of the embankment dam. This deposit exhibits a very dense structure and appears to be a basal till. The test pit excavations reveal that this deposit is three to five feet in thickness, attenuating towards the east. Boulders and cobbles were identified in the unit.

3.40 Sand and Gravel

A localized deposit of light brown to grey, fine to coarse sand and gravel with little silt and cobbles was encountered beneath the subsoil in JP-7. JP-7 is located on the eastern abutment of the proposed dam. The deposit was found to be approximately eight feet in thickness.

3.50 Bedrock

Bedrock was encountered in all the test pits at depths ranging from four to ten feet below the existing ground surface. The bedrock contour through the centerline of the dam mimics the surface topography. The bedrock encountered appears to consist of a light gray, coarse grained mica schist.

Based on review of the Geologic Map of New Hampshire, (1955) the geology in the general area consists of the Littleton Formation which includes gray, micaceous quartzite and gray, coarse grained mica schist. Other geologic formations in the general vicinity include Conway Granite, a coarse to medium grained biotite granite and Quartz Diorite, a dark gray to gray medium grained biotite-quartz diorite.

The bedrock mass structure could not be assessed during the test pit exploration program. Although fractures, seams, fissures, joints, bedding planes and other anomalies may exist, these were not revealed in the test pit exploration. There were no observed outcrops from which to identify rock type or fractures. However, construction sequencing has been directed towards dealing with these anomalies should they exist, as discussed further herein.

3.60 Groundwater

Groundwater was encountered in the test pits in the immediate vicinity of the stream. Groundwater elevations were approximately similar to the stream elevation.

It should be noted that groundwater conditions vary depending upon factors such as temperature, season, precipitation, and other conditions which may be different from those at the times these explorations were made.

4.00 LABORATORY TESTING PROGRAM

A laboratory testing program was undertaken to assess the engineering properties of the foundation soils, core materials and proposed filter materials. The laboratory testing program included gradation analyses, Proctor tests, and permeability tests.

The gradation analyses were performed to identify the particle size distribution of the sample constituents. The Proctor tests were performed to demonstrate the moisture-density relationship of the soils. Both tests were performed in accordance with ASTM standards. Graphical presentations of the Grain Size Distributions and Proctor tests are contained in Appendix B.

The permeability tests were performed employing the falling head test for fine grained soils and the constant head test for coarse grained soils. The coefficients of permeability and the dry densities at which the tests were performed, are illustrated on the Grain Size Distribution curves. The coefficient of permeability is inversely related to density.

Table 1, Field and Laboratory Test Results, illustrates all relevant soil testing in tabular form. This table is contained in Appendix B.

5.00 DESIGN CONSIDERATIONS

Particular design considerations associated with the embankment dam include bearing capacity of the foundation materials, settlement of the embankment structure, seismic concerns and seepage control. Recommended embankment construction specifications may be found in Appendix C.

5.10 Bearing Capacity

Based on the height of the earthfill dam, and the expected density of soil proposed to be used for its construction, it is not expected that total stresses imposed on the foundation will exceed 4,000 psf. It is expected that the glacial soils and bedrock provide sufficient shearing resistance to support the proposed embankment. A recommended design bearing capacity for support of the hydraulic appurtenances, both within undisturbed and recompacted glacial till soils, is 4,000 psf.

5.20 Settlement

Settlements associated with the foundation are expected to be negligible. However, settlements of the embankment shall be dictated by the compactive efforts of the embankment materials. Soils compacted to greater than 92 percent relative compaction per ASTM D-1557 should experience minor settlements which should not adversely effect the structural integrity of the embankment.

5.30 Seismic Concerns

Based on review of the Seismic Risk Map of the United States illustrated in the Design of Small Dams, Bureau of Reclamation, the site is located in Seismic Zone 2. The zones are recorded on a scale of 0 to 5 with Zone 0 being the least intensity. Zone 2 is identified as moderate damage.

It is not expected that seismic disturbance will have a profound effect on the structural integrity of the proposed earthfill dam.

5.40 Seepage Control

Due to the limited exploration activity at the site, the bedrock will need to be reviewed for the presence and attitude of fractures, fissures, seams, joints, bedding planes or other anomalies in which seepage paths may exist beneath the proposed dam during construction. Continuous joints that exist beneath the dam may cause piping of soil constituents from the earthfill dam due to seepage forces.

Where bedrock upstream of the earthfill dam is fractured, it may be necessary to slush grout fractures and seams. It is recommended that the bedrock surface be thoroughly exposed in the reservoir area at least 20 feet from the upstream toe of the embankment. Exposure of the bedrock may be limited to where the depth of reservoir soils is greater than five feet excluding the topsoil and subsoil. Fractures and seams encountered shall be slush grouted to create an upstream impervious blanket. Slush grouting should be continued where fractures intersect the earthfill dam.

6.00 EMBANKMENT DESIGN

The embankment design was completed as required by the State of New Hampshire Water Resources Division. Soil parameters, seepage analyses and embankment stability were evaluated as it pertains to the expected loading and site specific conditions. The supporting calculations and a typical section of the proposed embankment dam are provided in Appendix D.

6.10 Soil Parameters

Gradation distribution, unit weight and permeability were obtained as part of the laboratory testing program. Soil strength parameters were based on typical engineering values.

Filter materials used for the chimney and blanket drain were evaluated for both stability against migration of fines into the filter media and permeability characteristics. Filter criteria was referenced from specifications outlined by the U.S. Corps of Engineers. Filter materials should conform to the gradation and permeability specified herein.

6.20 Seepage

Seepage conditions were evaluated assuming steady state seepage and isotropic soil characteristics. The phreatic surface through the dam was modeled using the Casagrande Method. Seepage through the embankment was assessed for two-dimensional flow utilizing for a graphical solution for the equation of continuity (i.e. flow net). Flow rate and pore pressures were evaluated from the flow net.

Internal seepage will be intercepted by a chimney and blanket drain. The chimney drain will allow a steeper downstream slope and control anisotropic seepage should such flow conditions prevail. The blanket drain will collect water from the chimney drain and flow beneath the dam. A four inch diameter perforated pipe wrapped in a nylon filter will collect flow in the blanket drain and discharge it to the stream area. The blanket drain and pipe drain should be sloped a minimum of one percent to allow for the drainage of water.

6.30 Embankment Stability

Embankment stability was assessed for loading conditions pertaining to end-of-construction, steady state seepage, and rapid drawdown. The allowable factors of safety against failure for embankment stability were referenced from criteria published by the U.S. Corps of Engineers.

Both translational and rotational failure mechanisms were evaluated. Translational stability was assessed using total stress equilibrium theory. Rotational failure was evaluated referencing theories of limit equilibrium. Rotational stability analysis was performed utilizing the computer program SLIDE which is a 2-D Bishop slope stability computer program. This program was developed by the Geotechnical/Rock Engineering Group, University of Toronto, Canada.

7.0 REFERENCES

Shepard, Woodward, Gizienski, Clevenger, "Earth and Rock-Fill Dams", John Wiley and Sons, Inc., 1963.

"Design of Small Dams", U.S. Department of the Interior, Bureau of Reclamation, 1973.

"Seepage and Leakage from Dams and Impoundments", Proceedings of a Symposium sponsored by the Geotechnical Engineering Division in conjunction with the ASCE National Convention, May 1985.

Das, Braja M., "Advanced Soil Mechanics", McGraw Hill Book Company, 1983.

"Stability of Earth and Rock-Fill Dams", U.S. Corps of Engineers, EM 110-2-1902, April 1970.

"SLIDE". B.T. Corkum, J.M. Ting, A. Wyllie, 1989

8.0 LIMITATIONS

Explorations

1. The analyses, recommendations and designs submitted in this report are based in part upon the data obtained from preliminary subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to re-evaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretation of widely spaced explorations and samples; actual soil transitions are probably more gradual. For specific information, refer to the individual test pit and/or boring logs.

3. Water level readings have been made in the test pits and/or test borings under conditions stated on the logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors differing from the time the measurements were made.

Review

4. It is recommended that this firm be given the opportunity to review final design drawings and specifications to evaluate the appropriate implementation of the recommendations provided herein.

5. In the event that any changes in the nature, design, or location of the proposed areas are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of the report modified or verified in writing by Jaworski Geotech, Inc.

Construction

6. It is recommended that this firm be retained to provide geotechnical engineering services during the earthwork phases of the work. This is to observe compliance with the design concepts, specifications, and recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

Use of Report

7. This report has been prepared for the exclusive use of Rivers Engineering Corporation in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

8. This report has been prepared for this project by Jaworski Geotech, Inc. This report was completed for preliminary design purposes and may be limited in its scope to complete an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to evaluation considerations only.

APPENDIX A

Test Pit Log

Project: MEADOW'S POND DAM, ALTON, NH	JGI Representative: K. MARTIN	Test Pit No.: TP-1
Project No.: J92214	Weather: 70'S SUNNY	Location: SEE PLAN
: SEPT. 21, 1992		Surface Elev.: 661.0(±)

Excavation Equipment:

Contractor:	C. S. S. I.
Operator:	
Make:	CAT
Model:	215B LC
Capacity:	
Reach:	

Groundwater Observations

Date	Time	Depth	Notes
9/21		5.0' (±)	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	0.5'	FOREST MAT - ORGANIC SAND		
1		ORANGE-BROWN, f-c SAND, little SILT (SUBSOIL) ROOTS, BOULDERS		
2	2.1'			
3		GREY-BROWN, SILTY-CLAYEY SAND, little GRAVEL		
4				
5	5.0'			
		BEDROCK		
6				
7				

Notes:

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JGI JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH Project No.: J92214 Date: SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-2 Location: SEE PLAN Surface Elev.: 663.0(±)

Excavation Equipment:

Contractor: C. S. S. I.
Operator:
Make: CAT Model: 215B LC
Capacity: Reach:

Groundwater Observations

Date	Time	Depth	Notes
9/21		N/A	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	4"	FOREST MAT - ORGANIC SAND		
1		ORANGE-BROWN, f-c SAND, little Silt & Gravel COBBLES, BOULDERS, ROOTS (SUBSOIL)		
2	2.0'			
3		BROWN-GREY, SILTY CLAYEY SAND, SOME GRAVEL		
4	4.0'			
		BEDROCK		
5				
6				
7				

Notes:

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH Project No.: J92214 Date: SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-3 Location: SEE PLAN Surface Elev.: 669.0(±)

Excavation Equipment:			
Contractor:	C. S. S. I.		
Operator:			
Make:	CAT	Model:	215B LC
Capacity:		Reach:	

Groundwater Observations

Date	Time	Depth	Notes
9/21		N/A	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	10"	FOREST MAT - ORGANIC SAND		
1				
2	2'-4"	ORANGE-BROWN, f-c SAND, little SILT AND GRAVEL, BOULDERS, ROOTS (SUBSOIL)		
3				
4	4'-8"	TAN-GREY, SILTY CLAYEY SAND, little GRAVEL, OCCASIONAL BOULDER, MINOR ROOT STRUCTURE		
5		BEDROCK		
6				
7				

Notes:

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JGI
JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH Project No.: J92214 Date: SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-4 Location: SEE PLAN Surface Elev.: 673.5 (±)

Excavation Equipment:

Contractor: C.S.S.I.
Operator:
Make: CAT Model: 215B LC
Capacity: Reach:

Groundwater Observations

Date	Time	Depth	Notes
9/21		N/A	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	3"	FOREST MAT - ORGANIC SAND		
1		ORANGE-BROWN, f-c SAND, little SILT BOULDERS, ROOTS (SUBSOIL)		
2	2.0'			
3		LT. GREY-TAN, SILTY-CLAYEY SAND, SOME GRAVEL DEPTH = 2FT γ_D =	107.8 pcf	(1)
		ω =	13.6%	
4				
	4.5'			
5		BEDROCK		
6				
7				

Notes: (1) SAMPLE S-1 OBTAINED AT 3 FT.

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JGI
JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH Project No.: J92214 : SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-5 Location: SEE PLAN Surface Elev.: 660.5(±)

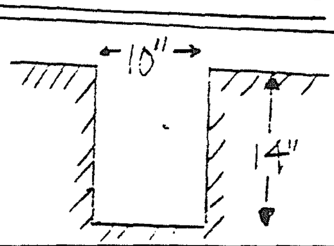
Excavation Equipment:

Contractor: C.S.S.I.
Operator:
Make: CAT Model: 215B LC
Capacity: Reach:

Groundwater Observations

Date	Time	Depth	Notes
9/21	2 HRS	4.0'(±)	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	4"	FOREST MAT - ORGANIC SAND		
1		ORANGE-BROWN, f-c SAND, SOME GRAVEL, little SILT, BOULDERS, ROOTS (SUBSOIL)		
2	2.0'			
3		TAN-GREY, f-c SAND, SOME GRAVEL AND SILT	DEPTH = 3FT γ_D = 108.4 pcf ω = 16.8 %	(1)
4				
5	5.0'			
		BEDROCK		
6		PERC TEST AT 3FT		
7				



WATER LEVEL	TIME
10"	10:10
9"	10:20 (10 MIN)
8"	10:25 (15)
7"	10:32 (22)
10"	10:35 —
5"	11:15 (40)

PERC RATE ≈ 8 MIN/IN

Notes: (1) SAMPLE S-1 OBTAINED AT 3FT.

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH Project No.: J92214 Date: SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-6 Location: SEE PLAN Surface Elev.: 659.0(±)

Excavation Equipment:			
Contractor:	C.S.S.I.		
Operator:			
Make:	CAT	Model:	215B LC
Capacity:		Reach:	

Groundwater Observations

Date	Time	Depth	Notes
9/21		N/A	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
	0.5'	FOREST MAT - ORGANIC SAND		
1		ORANGE-BROWN, f-c SAND, little SILT AND GRV., BOULDERS, COBBLES, ROOTS (SUBSOIL)		
2	2'-3"			
3		LT. GREY-TAN, VERY DENSE, STRATIFIED f-c SILTY SAND and GRAVEL		
4		DEPTH = 3 FT γD = 93.0/97.1 pcf ω = 18.0/16.4%		
5				
6	6.0'	MOTTLING @ 5 FT		
		//R//F BEDROCK (GRANITE DIORITE) //R//F		
7		PERC TEST @ 3 FT DIAM = 9" DEPTH = 8"		

WATER LEVEL	TIME
7 1/2	11:55
7	12:05 (10 MIN)
7	12:15 (20)
6 5/8	12:25 (30)

PERC RATE ≈ 48 MIN/IN

Notes:

Pit Dimensions: Length ______ ft. Width ______ ft. Depth ______ ft.

Remarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

JAWORSKI GEOTECH, INC.

Test Pit Log

Project: MEADOW'S POND DAM ALTON, NH [Proj]ect No.: J92214 Date: SEPT. 21, 1992	JGI Representative: K. MARTIN Weather: 70'S SUNNY	Test Pit No.: TP-7 Location: SEE PLAN Surface Elev.: 672.0 (±)

Excavation Equipment:

Contractor: C. S. S. I.
Operator:
Make: CAT Model: 215B LC
Capacity: Reach:

Groundwater Observations

Date	Time	Depth	Notes
9/21		N/A	

Depth ft.	Strata Change	Soil Description	Boulder Size/Count	Notes
1	4"	FOREST MAT - ORGANIC SAND		
2	2.0'	ORANGE-BROWN, f-c SAND, little SILT, BOULDERS, ROOTS. (SUBSOIL)		
3–10	10.0'	LT. BROWN-GREY, f-c SAND AND GRAVEL, little SILT, Cobbles		(1)
11		BEDROCK		
12				
13				
14				
15				

Notes: (1) SAMPLE S-1 OBTAINED AT 6 FT

Pit Dimensions: Length ________ ft. Width ________ ft. Depth ________ ft.

[R]emarks: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
Water level readings have been made in the test pits at times and under conditions stated on the test pit logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.
Proportions used: trace (0-10%), little (10-20%), some (20-35%), and (35-50%)

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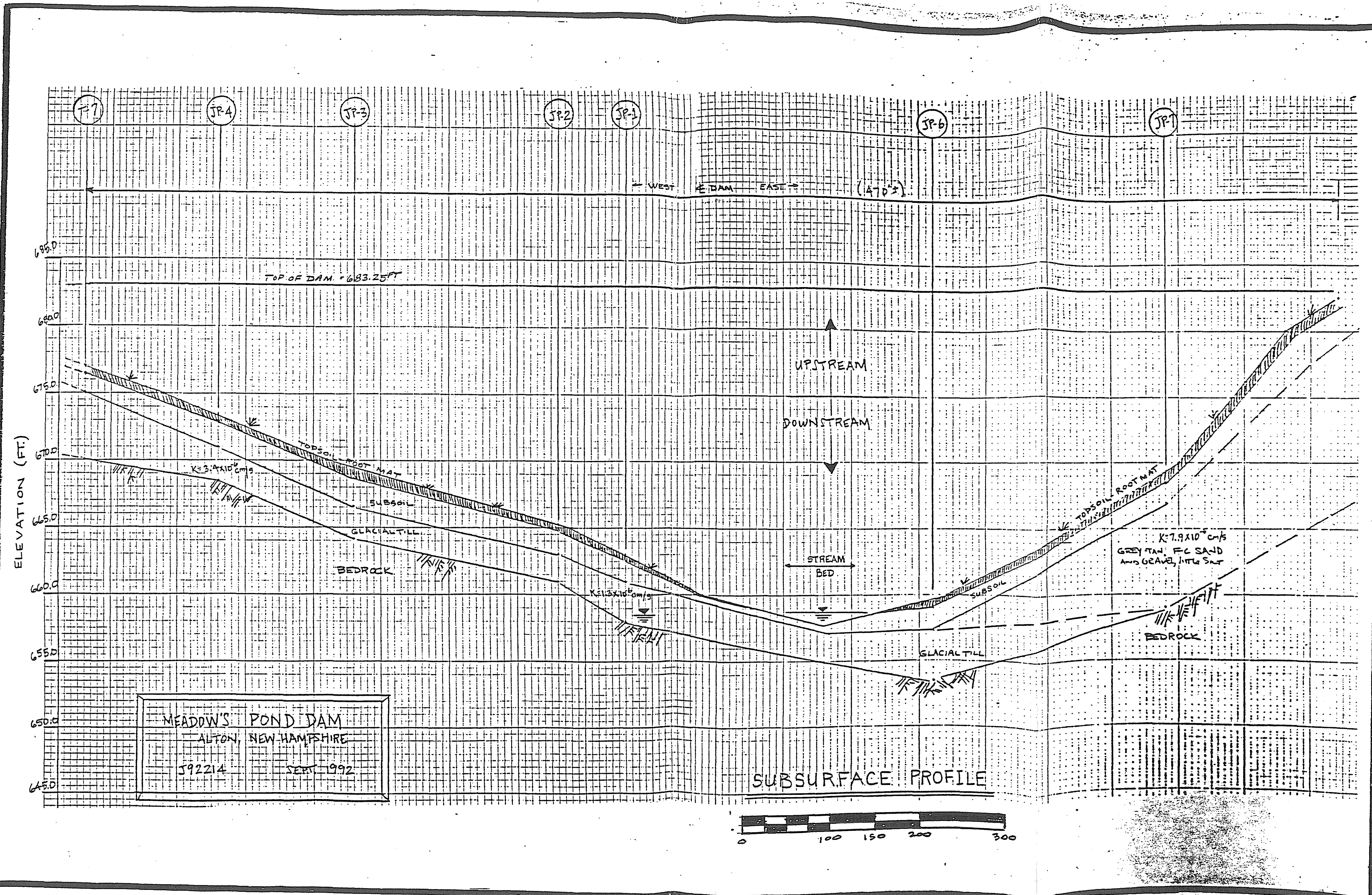

JP-7
JP-4
JP-3
JP-2
JP-1
JP-6
JP-T
← WEST ℄ DAM EAST →
(1470'±)
685.0
680.0
675.0
670.0
665.0
660.0
655.0
650.0
645.0
ELEVATION (FT.)
TOP OF DAM = 683.25FT
UPSTREAM
DOWNSTREAM
TOPSOIL ROOT MAT
K=3.4X10^-6 cm/s
SUBSOIL
GLACIAL TILL
BEDROCK
K=1.3X10^-6 cm/s
STREAM BED
TOPSOIL ROOT MAT
SUBSOIL
K=7.9X10^-5 cm/s
GREY TAN F-C SAND AND GRAVEL, LITTLE SILT
BEDROCK
GLACIAL TILL
MEADOW'S POND DAM
ALTON, NEW HAMPSHIRE
J92214
SEPT. 1992
SUBSURFACE PROFILE
0
100
150
200
300

APPENDIX B

TABLE 1

Meadow's Pond Dam
Project No. J92214

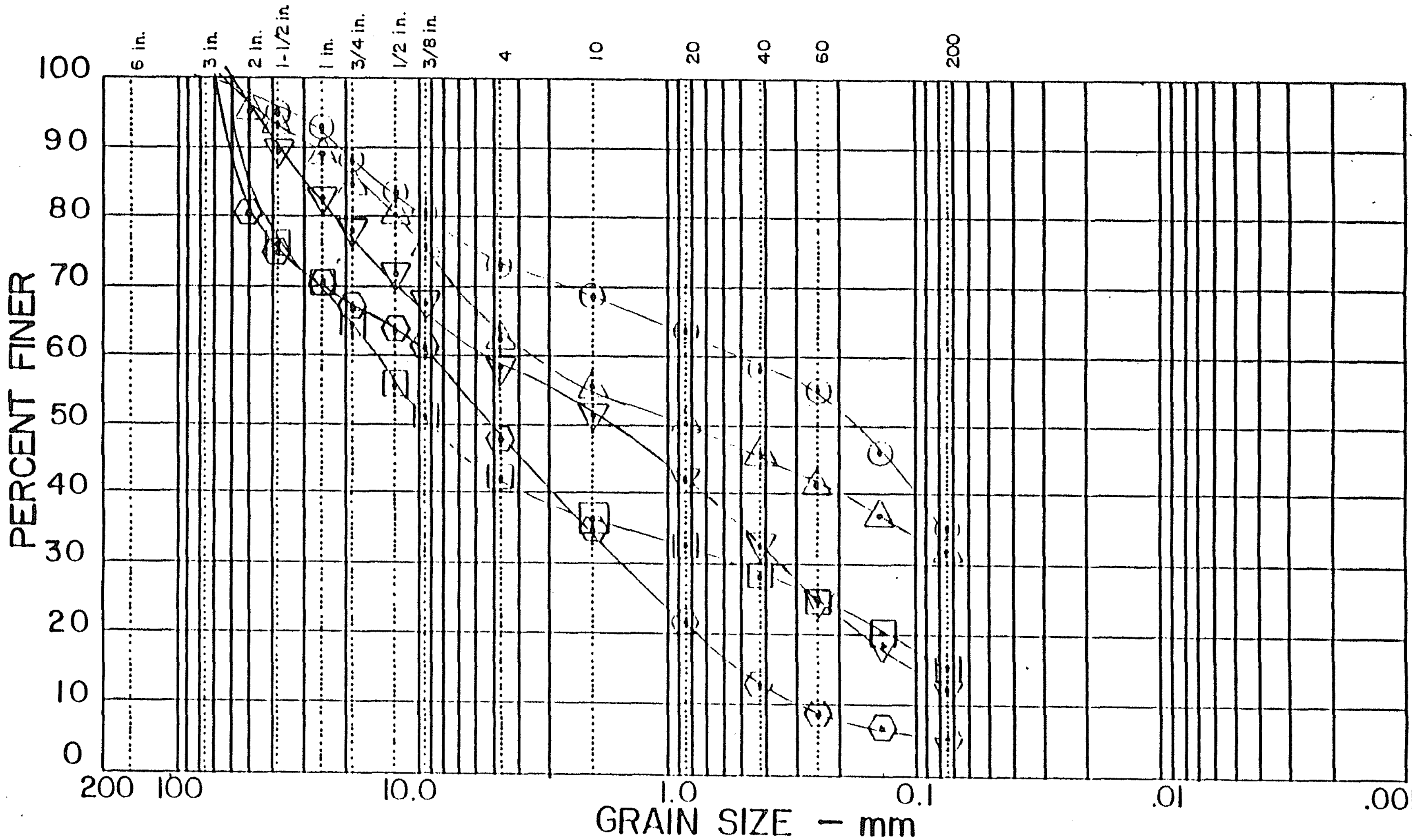
Field and Laboratory Test Results

(1) Location	Lab No.	Proposed Use	Field Dry Unit Weight/Moisture	Max. Dry Unit Weight/Moisture	Grain Size (%)			USCS (2) Classification	Coefficient of Permeability (cm/s)	Dry Density of Permeability Test	Percolation Rate
					Gravel	Sand	Fines				
TP-1	L210-92	Core/ Foundation			57.8	26.9	15.3	GM			
JP-4	L294-92	Core/ Foundation	107.8PCF 13.6%	127.3PCF 7.2%	35.1	30.5	34.5	GM	3.36 X 10^{-6} cm/s	122.0PCF	
JP-5	L291-92	Core/ Foundation	108.4PCF 16.8%	125.0PCF 9.8%	26.2	38.2	35.6	SM	1.32 X 10^{-6} cm/s	115.0PCF	8 Min/In
JP-7	L295-92	Foundation			41.3	45.5	13.1	SM	7.90 X 10^{-5} cm/s	127.7PCF	
TP-18	L293-92	Filter Drain/ Gravel			49.5	43.9	6.5	GP-GM	2.00 X 10^{-3} cm/s	121.8PCF	

(1) Test Pits Designated TP Performed by Expert Construction Services.
Test Pits Designated JP Performed by Jaworski Geotech, Inc.

(2) Unified Soil Classification System

GRAIN SIZE DISTRIBUTION TEST REPORT



% 3"	% GRAVEL	% SAND	% SILT	% CLAY

JGI JAWORSKI GEOTECH, INC.

PREPARED FOR:

DATE: Sept 1992

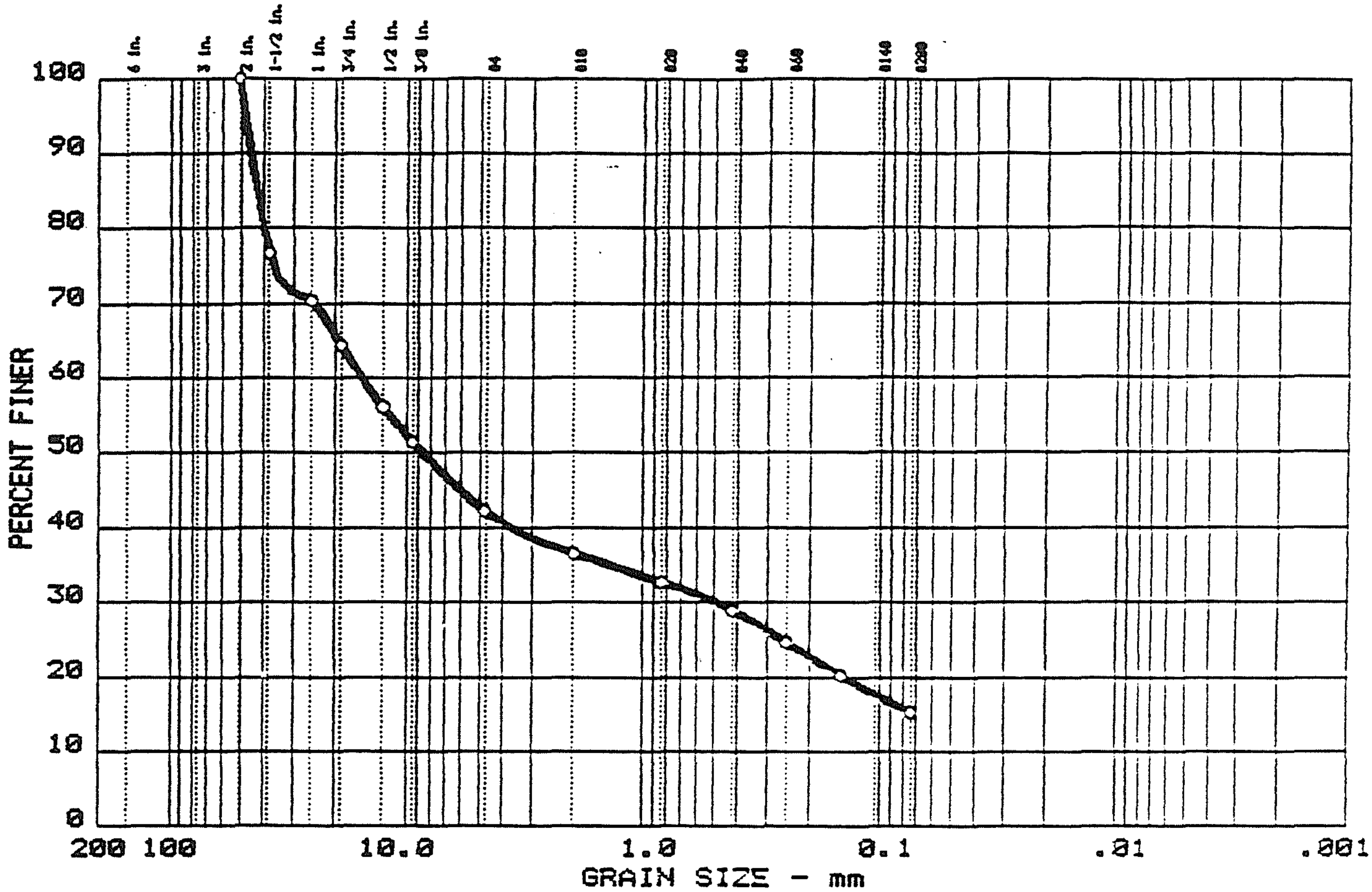
PROJECT NO. J92214

MEADOWS POND DAM

JP-7 L295-92
TP-18 L293-92

JP-5 L291-92
JP-4 L294-92
TP-1 L210-92

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
o	15	0.0	57.8	26.9	15.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			43.10	15.61	8.68	0.494				

MATERIAL DESCRIPTION	USCS	AASHTO
o coarse GRAVEL, some sand, little fines	GM	

Project No.: J92214
Project: Meadows Pond Dam
o Location: TP-1

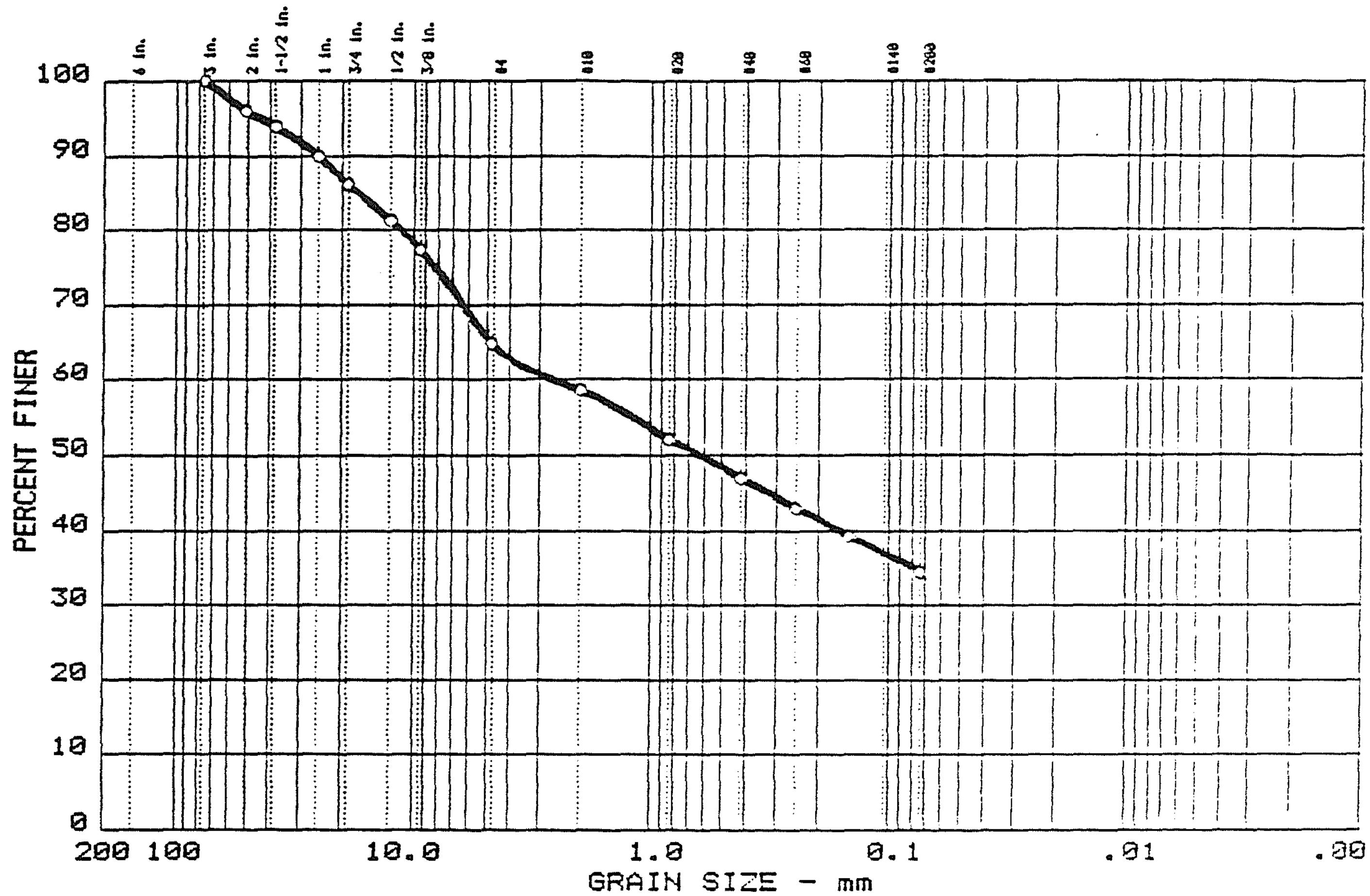
Date: June 19, 1992

Remarks:
L210-92

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Fig. No. 2

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
o	2	0.0	35.1	30.5	34.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			17.38	2.63	0.63					

MATERIAL DESCRIPTION	USCS	AASHTO
o Silty Clayey, S+G	GM	

Project No.: J92214
Project: Meadows Pond Dam
o Location: JP-4
K = Coefficient of Permeability = 3.36×10^{-6} cm/s;
γ_d = 122.0 PCF.
Date: September 29, 1992

Remarks:
L294-92
S-1, 3Ft.

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

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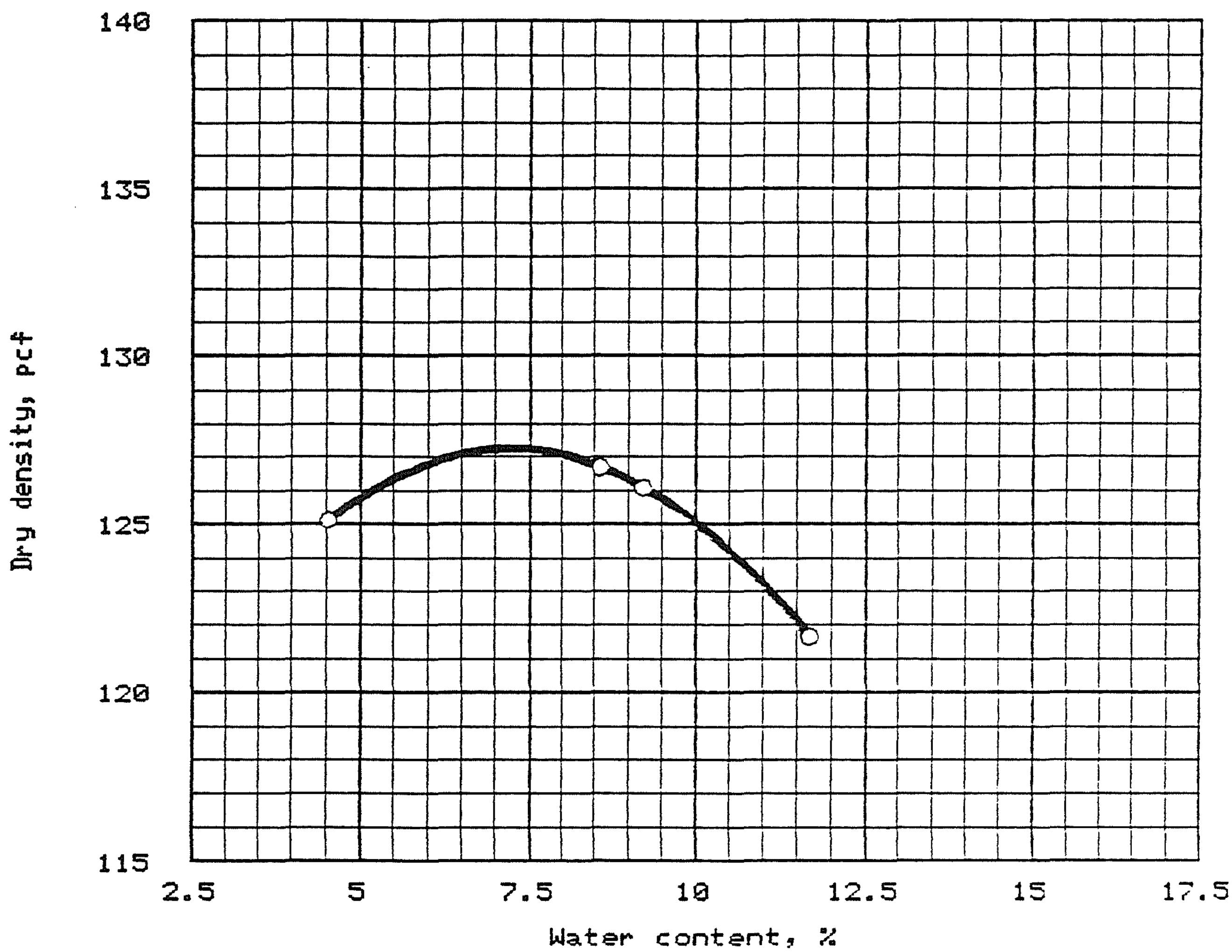
Fig. No. 1

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
3 feet			%	2.65			37.2 %	53.1 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 7.2 % Maximum dry density = 127.3 pcf	Silty Clayey, S&G

Project No.: J92214
Project: Meadows Pond Dam
Location: JP-4

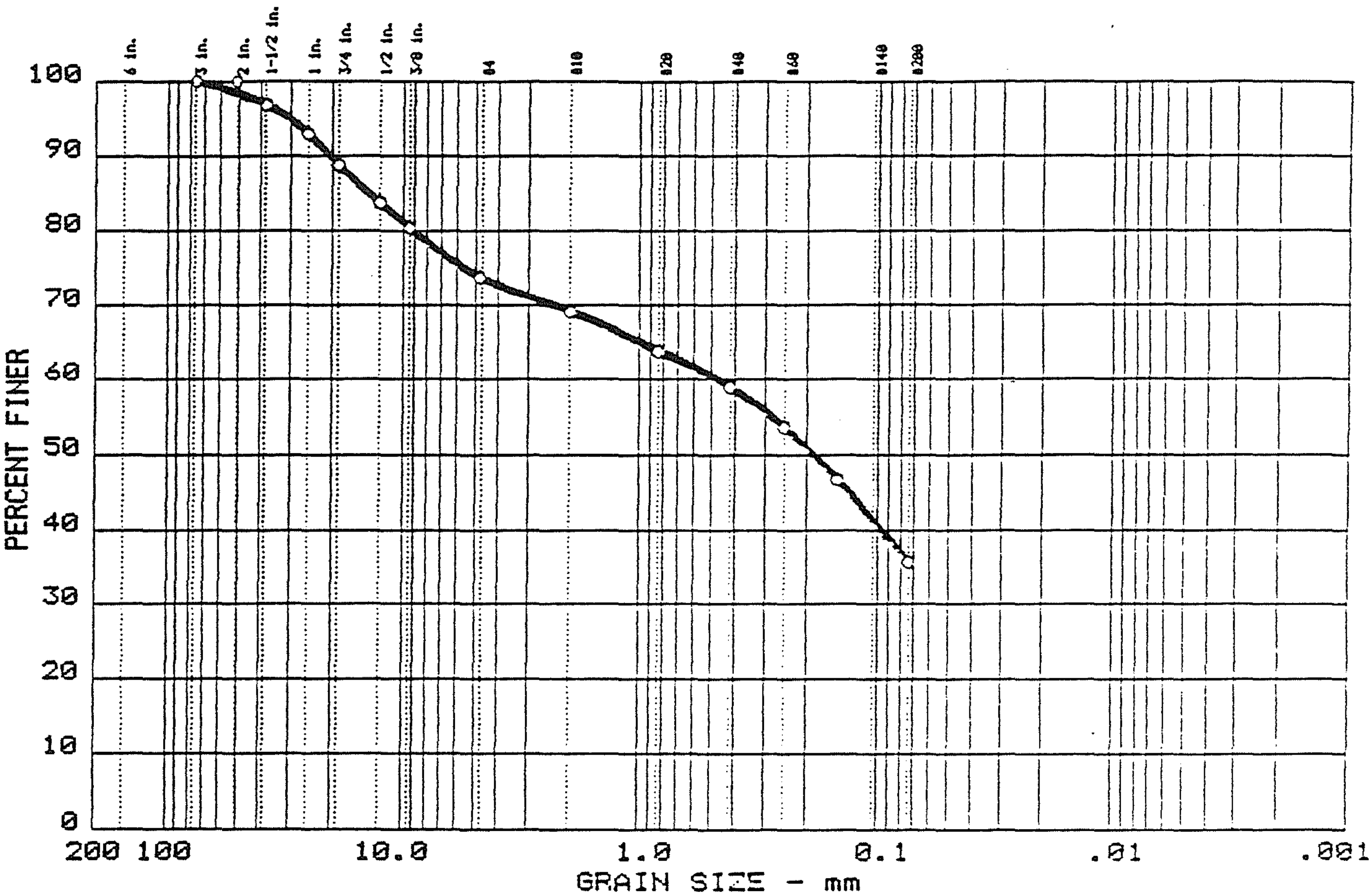
Date: 9-29-1992

PROCTOR TEST REPORT
JAWORSKI GEOTECH, INC.

Remarks:
L294-92
S-1, 3 ft.

Fig. No. 2

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
o	3	0.0	26.2	38.2	35.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			14.13	0.47	0.19					

MATERIAL DESCRIPTION	USCS	AASHTO
o Silty Clayey, S+G	SM	

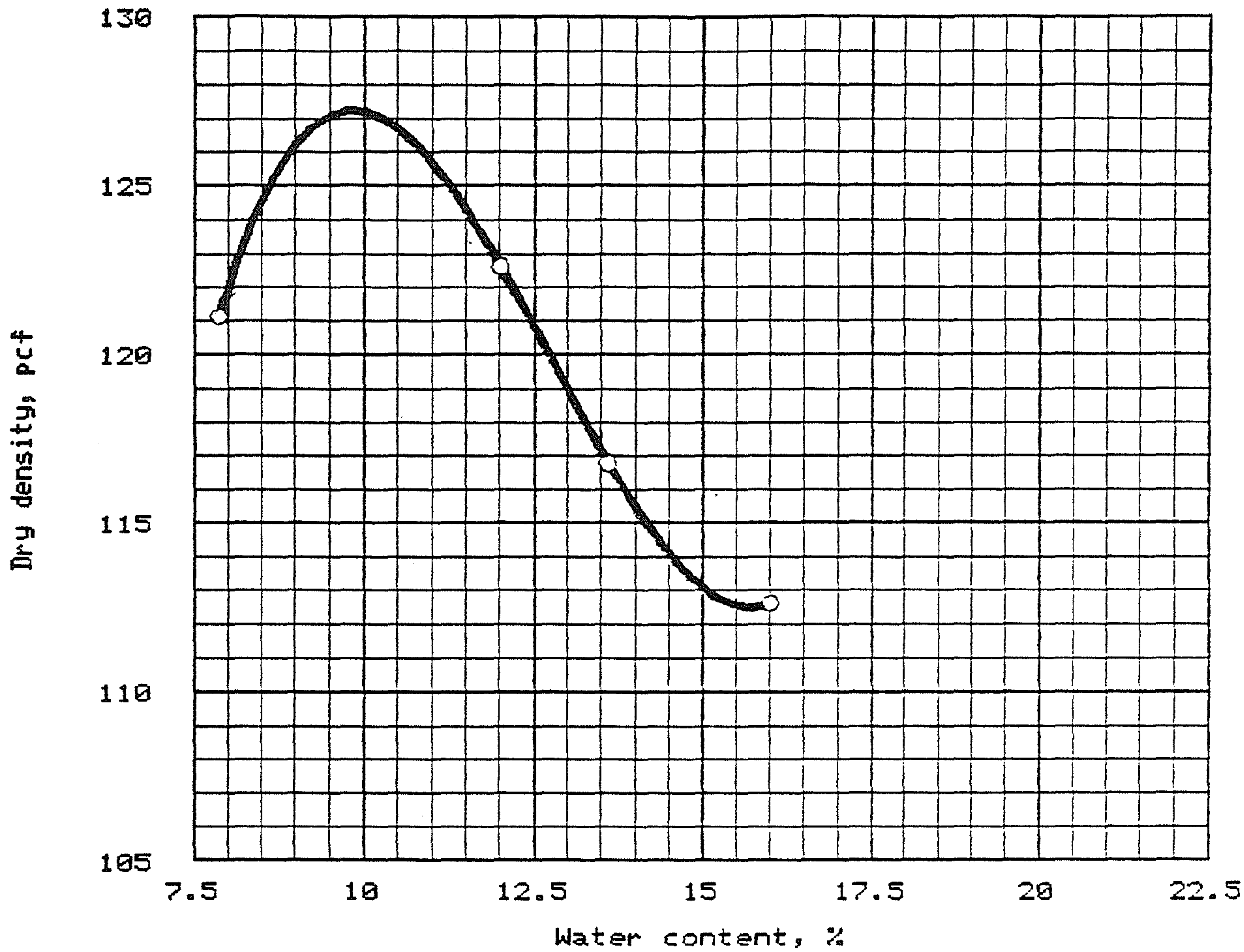
Project No.: J92214
Project: Meadows Pond Dam
o Location: JP-5
K = Coefficient of Permeability = 1.32×10^{-6} cm/s;
γ_d = 115.0PCF.
Date: September 29, 1992

Remarks:
L291-92
S-1, 3Ft.

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Fig. No. 1

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification USCS	AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
3 feet			%	2.65			26.2 %	46.3 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 9.8 % Maximum dry density = 127.2 pcf	Silty Clayey, S&G

Project No.: J92214
Project: Meadows Pond Dam
Location: JP-5

Date: 9-29-1992

Remarks:
L291-92

PROCTOR TEST REPORT
JAWORSKI GEOTECH, INC.

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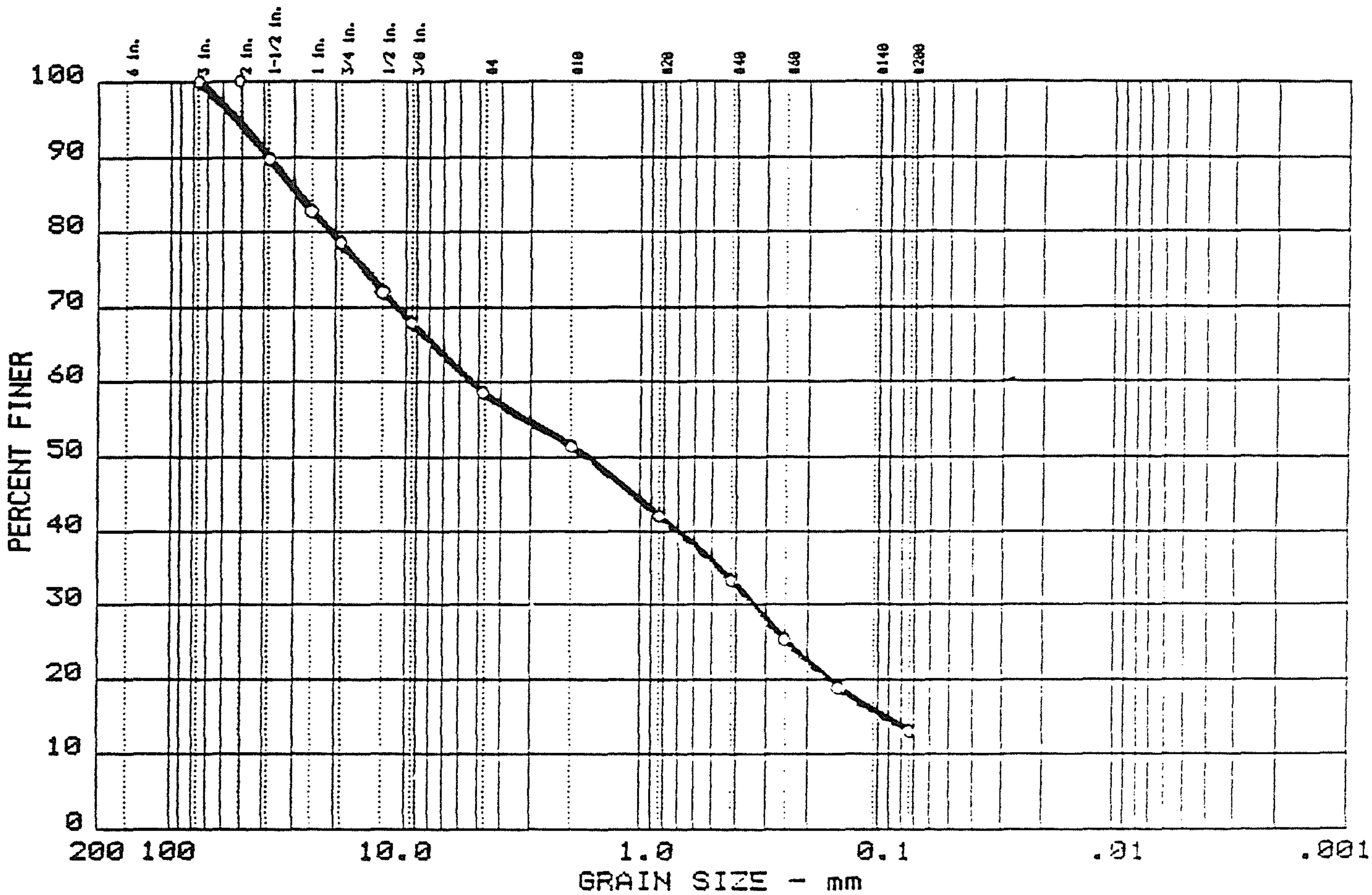
Fig. No. 2

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
○	4	0.0	41.3	45.5	13.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			28.84	5.31	1.70	0.339	0.0933			

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silty S&G	SM	

Project No.: J92214
Project: Meadows Pond Dam
○ Location: JP-7
K = Coefficient of Permeability = 7.90 X 10^{-5} cm/s;
γ d = 127.7 PCF.

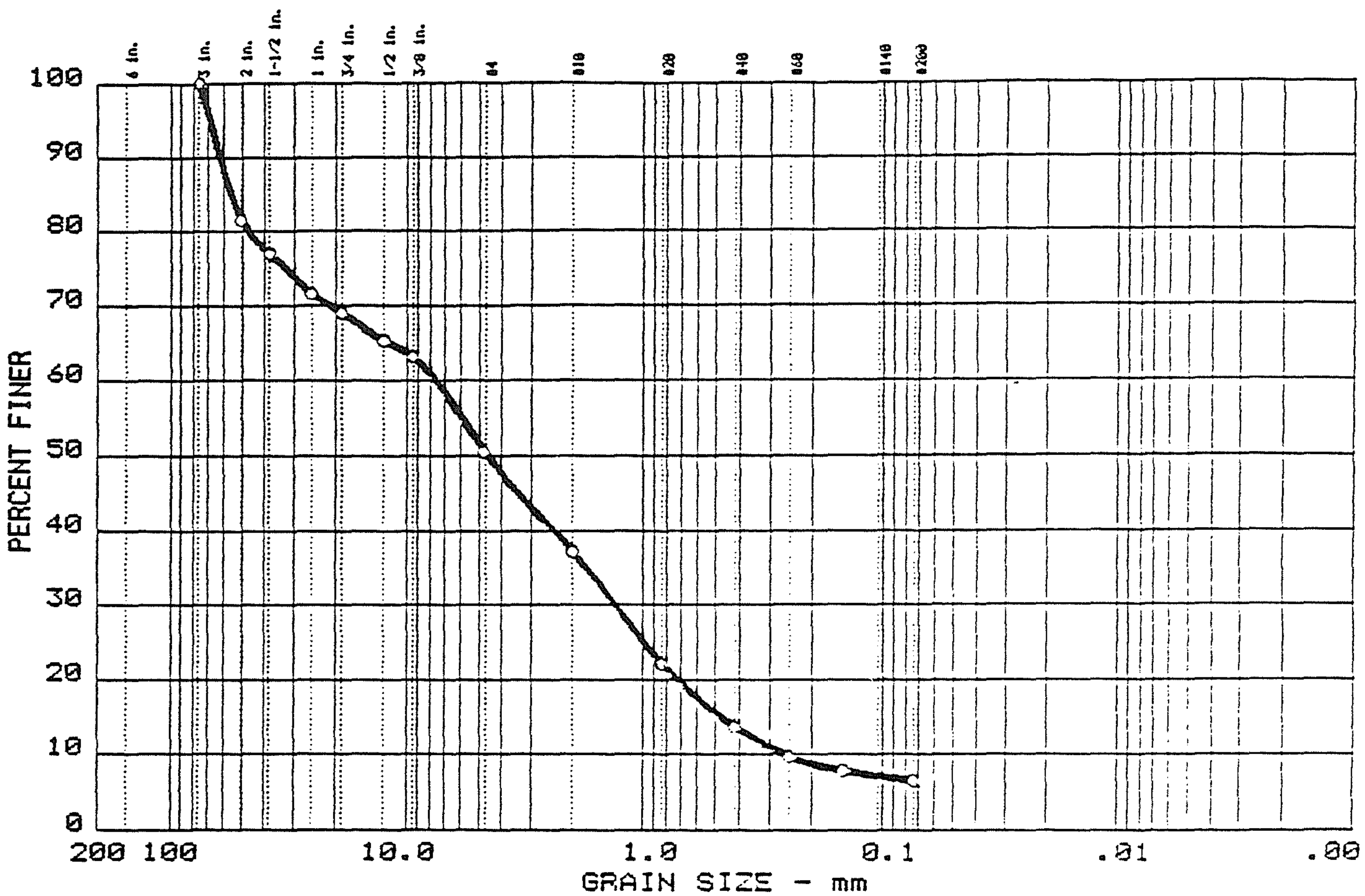
Date: September 29, 1992

Remarks:
L295-92
S-1, 6 Ft.

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Fig. No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
○	1	0.0	49.5	43.9	6.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			56.23	7.59	4.62	1.318	0.4732	0.2600	0.88	29.2

MATERIAL DESCRIPTION	USCS	AASHTO
○ Sand, Gravel	GP-GM	

Project No.: J92214
Project: Meadows Pond Dam
○ Location: TP-18
K = Coefficient of Permeability = 2.0 X 10^{-3} cm/s;
γ_d = 121.8 PCF.
Date: September 29, 1992

Remarks:
L293-92
S-1

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Fig. No. 1

TOPOGRAPHIC WORKSHEET
OF THE
ALTON DAM SITE
ROUTE 140, ALTON, NH
FOR
GEI CONSULTANTS, INC.
CONCORD, NH
BY
EASTERN TOPOGRAPHICS
WOLFEBORO, NH

SCALE: 1"= 40'   CONTOUR INTERVAL: 2'

PHOTO DATE: 19 MAR 96 (1: 4800)
COMPILATION DATE: 25 APR 96

GROUND CONTROL BY: CIVIL CONSULTANTS
S. BERWICK, ME

ANY USER SHOULD DETERMINE THE SUITABILITY OF THIS AERIAL MAPPING FOR HIS INTENDED USE AND ASSUME ALL RISK AND LIABILITY IN CONNECTION THEREWITH.

NOTE: BUILDING CORNERS AS SHOWN REPRESENT ROOF LINES AS COLLECTED FROM AERIAL PHOTOGRAPHY.

NOTE: ICE AND SNOW AT TIME OF PHOTOGRAPHY.

COMP	EDIT	PLOT	CHECK	QCC
BH	MH	MH	BH	--

SHEET 1 OF 2   Q11A/3176A

MAPPING CERTIFICATION

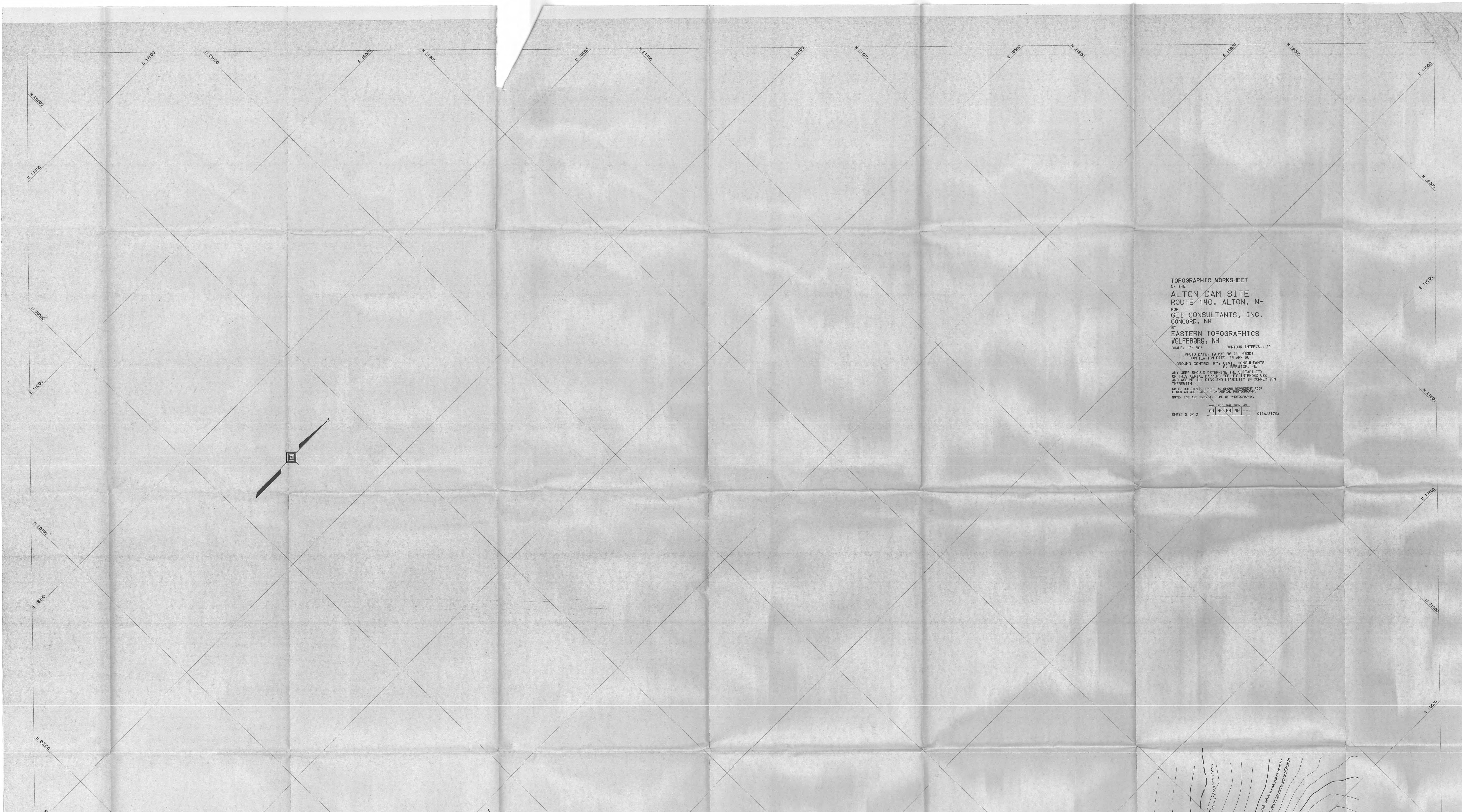
I HEREBY CERTIFY THAT THIS TOPOGRAPHIC MAPPING WAS COMPILED UNDER MY SUPERVISION AND DIRECTION BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY EXPOSED 19 MAR 96. THIS MAPPING CONFORMS TO NATIONAL MAP ACCURACY STANDARDS (NMAS).

22 May 96
DATE

Natalie M. Kelloway
NATALIE M. KELLOWAY
CERTIFIED PHOTOGRAMMETRIST
(ASPRS)

American Society for Photogrammetry and Remote Sensing
NATALIE M. KELLOWAY
CERTIFIED
PHOTOGRAMMETRIST
(ASPRS) No. 949
SEAL

SEAL



TOPOGRAPHIC WORKSHEET
OF THE
ALTON DAM SITE
ROUTE 140, ALTON, NH
FOR
GEI CONSULTANTS, INC.
CONCORD, NH
BY
EASTERN TOPOGRAPHICS
WOLFEBORO, NH
SCALE: 1"= 40'
CONTOUR INTERVAL: 2'
PHOTO DATE: 19 MAR 96 (1: 4800)
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NOTE: ICE AND SNOW AT TIME OF PHOTOGRAPHY.
COMP EDIT PLOT CHECK GCC
BH MH MH BH --
SHEET 2 OF 2
Q11A/3176A
ICE
700
690
680

APPENDIX C

EMBANKMENT CONSTRUCTION SPECIFICATIONS

I. GENERAL

A. **Work Included**
Provide all labor, materials, equipment and services and perform all operations required to complete the work as indicated on the drawings and specified herein.

B. **Subsurface Conditions**
Data indicated as subsurface conditions are not intended as representations or warranties of accuracy or continuity between test pits.

C. **Quality Control**
A qualified soils engineer shall be retained by the owner as needed during construction to perform necessary soil testing and observe compliance with the design intent.

D. **Tolerances**
The geometry of the embankment dam shall be constructed to within five percent tolerance to that indicated on the drawings.

E. **Borrow Areas**
Borrow areas should be quantified prior to construction to determine sufficient and consistent soil materials.

F. **Lay Out and Grades**
All lines and grades shall be laid out prior to and during construction. A permanent bench mark shall be established and replaced if destroyed.

G. **Samples and Testing**
Core materials shall be tested for approval for every 4,000 yards of material. Filter materials shall be tested for approval for every 1,000 yards of material. Samples should be at least 30 pounds in weight and submitted prior to use. Additional testing will be required if fill materials change as directed by the soils engineer.

H. **Inspection of Rock Surface**
The bedrock surface 20 feet from the upstream toe in the reservoir area shall be inspected for the presence of fractures, seams, fissures, joints, bedding planes or other anomalies which create seepage paths beneath the dam. The bedrock shall be pressure washed to obtain an unobstructed view of the surface.

I. Frost Protection

Soils which become frozen within the limits of the embankment dam shall be removed to the full depth of frost. Placed soils should be protected from frost should ambient air temperatures fall below freezing.

J. Dewatering

Excavated and fill areas shall be kept sufficiently dry from groundwater or surface water runoff so that it does not adversely affect construction procedures or cause excessive disturbance of borrow and fill areas. In no case should fill materials be placed if ponded or groundwater is observed.

K. Turbidity

Quantitatively measure turbidity of the water emanating from the embankment dam with a turbimeter in units of Nephelometric Turbidity Units (NTUs). Measurements should be accomplished daily during reservoir filling and one week upon attainment of full reservoir. Measurements shall be reported to the soils engineer within 24 hours. Measurements shall be taken on a weekly basis thereafter. Measurements shall be ceased once it can be demonstrated that the turbidity of the water is dissipating or at the discretion of the soils engineer.

II. MATERIALS

Fill materials shall be placed where indicated on the project drawings.

A. Core

Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Core materials shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	75 - 100
1 inch	65 - 95
3/8 inch	50 - 85
No. 4	40 - 80
No. 40	30 - 65
No. 200	20 - 40

The core materials shall possess as coefficient of permeability less than 10 E-5 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

B. **Filter Sand**

Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Filter sand shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
1.5 inch	100
3/8 inch	80 - 95
No. 4	60 - 85
No. 20	15 - 50
No. 40	0 - 30
No. 100	0 - 10

The filter sand should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

C. **Sand and Gravel**

Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Sand and gravel shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	70 - 100
1 inch	50 - 100
No. 4	30 - 80
No. 40	0 - 30
No. 100	0 - 10

The sand and gravel should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

D. **Rip-Rap**

Shall be sound, of approved quality, and free from structural defects. The maximum size by weight shall be 1,250 pounds. The stones shall be angular in shape and conform to the following gradation requirements:

Size by Weight	Percent By Weight
626-1,250 lbs.	40-40
50-625 lbs.	60-70
50 lbs.	0-10

E. **Topsoil**
Shall consist of fertile, friable, natural topsoil typical of the locality, without admixture of subsoil, and shall be obtained from a well drained arable site. It shall be such a mixture of sand, silt and clay particles as to exhibit sandy and clayey properties in about equal proportions. It shall be screened of all stones two inches or more in diameter, sticks, plants and other foreign materials. The topsoil shall contain not less than 4 percent, nor more than 20 percent organic matter as determined by the loss of ignition of oven-dried samples.

F. **Perforated Pipe**
Shall be an ADS (Advanced Drainage Systems, Inc.) four inch diameter continuous section wrapped in a nylon protective fabric or equivalent. The pipe shall be sloped a minimum of one percent throughout the entire length. The pipe should outlet at both the stream bed and abutment. The abutment outlet shall be capped with a split end cap. Installation should be in accordance with manufacturer's guidelines and specifications.

III. EXECUTION

A. **Clearing and Grubbing**
Remove topsoil and subsoil within the limits of the earthfill dam and in borrow areas. Exposed subgrade in which root structure or organic materials are encountered shall be overexcavated to the depth of the root line. Pile and store excavated materials in designated or approved locations where it will not interfere with construction operations.

B. **General Excavation**
Excavation within the limits of the embankment dam shall be excavated of all topsoil and subsoil to a depth greater than the root line.

C. **Placement**
Fill materials shall be placed and spread in a manner to minimize particle segregation. Care will be taken to not contaminate filter materials. Filter materials which become contaminated shall be removed and replaced. No fill materials shall be placed on uncompacted soil, wet/weaving soil, frozen soil or other soil conditions unacceptable to the soils engineer.

Surficial soils shall be uniformly distributed and evenly spread to compensate for shrinkage. Irregularities in the surface resulting from construction operations shall be corrected to prevent the formation of depressions where water will stand.

D. **Disking and Harrowing**
Each lift shall be uniformly disked or harrowed to a depth of at least two inches prior to the placement fill materials.

E. **Moisture Control**
The water content of fill materials shall be within -3 percent to +2 percent of the optimum moisture content determined by ASTM D-1557. Soils which are dry shall be uniformly wetted. Wet soils shall be aerated by blending, mixing or other satisfactory means until the moisture content is as specified. Borrow and fill areas should be protected from precipitation when necessary. Placed fill which does not conform to the specified moisture criteria shall be removed.

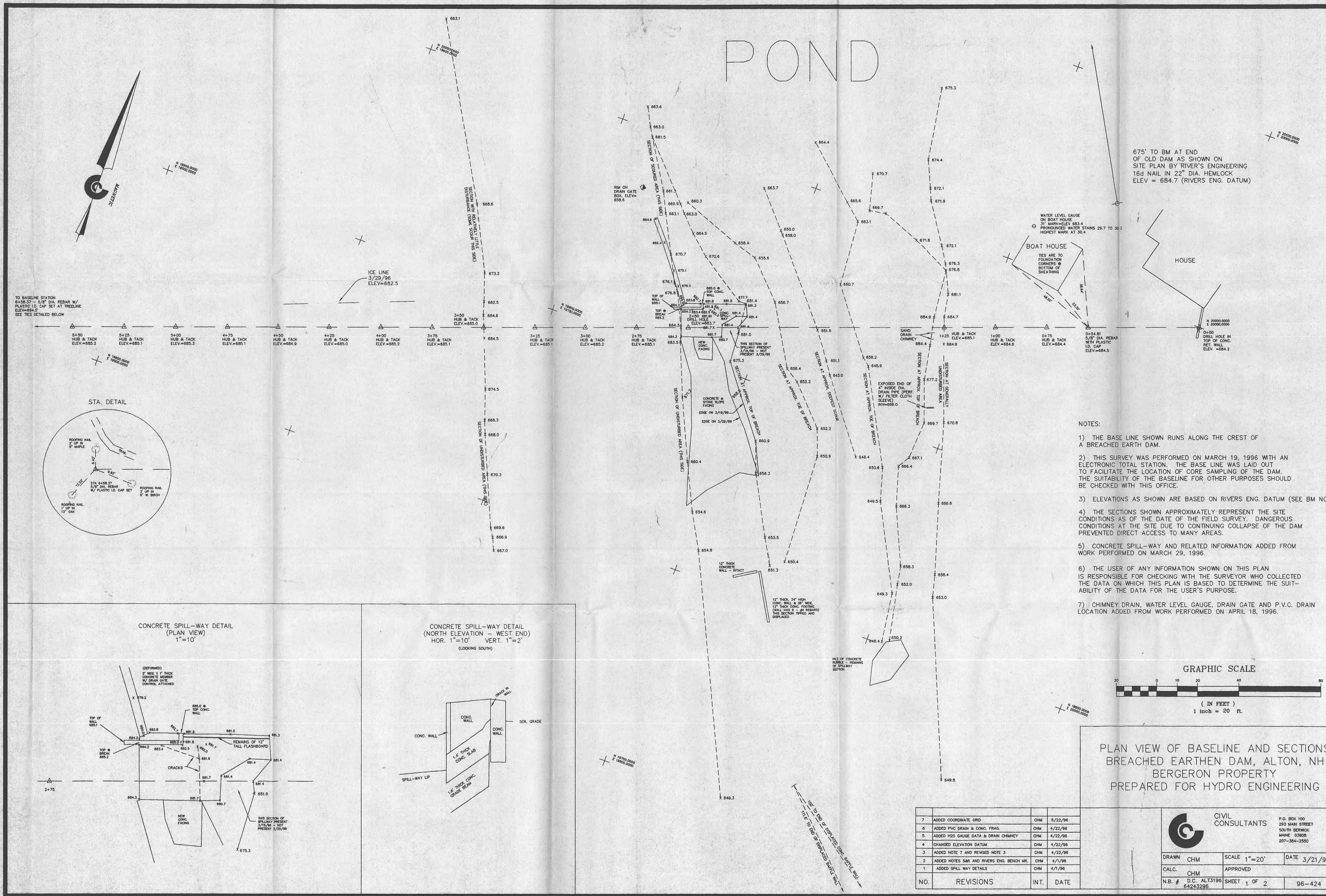
F. **Compaction**
Lift sizes should be limited to 18 inch loose lift thickness. Compact fill materials to 92 percent relative compaction as determined by ASTM D-1557. Field density tests shall be performed at 100 foot intervals for each lift. Soils which do not meet compaction requirements shall be recompacted or removed.

G. **Slush Grouting**
The bedrock surface should be exposed in the reservoir area at least 20 feet from the upstream toe of the dam. All open fractures, seams, joints or fissures shall be slush grouted as directed by the soils engineer with a lean sand and cement grout in which to establish an impermeable seam. The ratio of sand to cement shall not exceed two parts sand to one part cement. All areas to be slush grouted shall be thoroughly cleaned of all loose materials and shall be wetted prior the placement of the grout. Placement of slush grout shall be by brooming into all fractures, seams, joints or fissures with a stiff-bristled broom or other approved method. All fractures, seams, joints or fissures shall be chased at least 100 feet from the upstream toe and/or 30 feet into the embankment dam.

H. **Mulching**
Shall consist of hay or straw mulch loosely spread to a uniform depth over all grassed areas indicated on the plans. Mulch shall be spread following approval of the surficial soils by the soils engineer.

I. **Seeding**

Shall be performed early spring or late summer. Seed shall be evenly spread. Reseeding of bare spots and maintenance requirements shall be performed when necessary.



DRAWING F: \96424\96424 (ACAD12)

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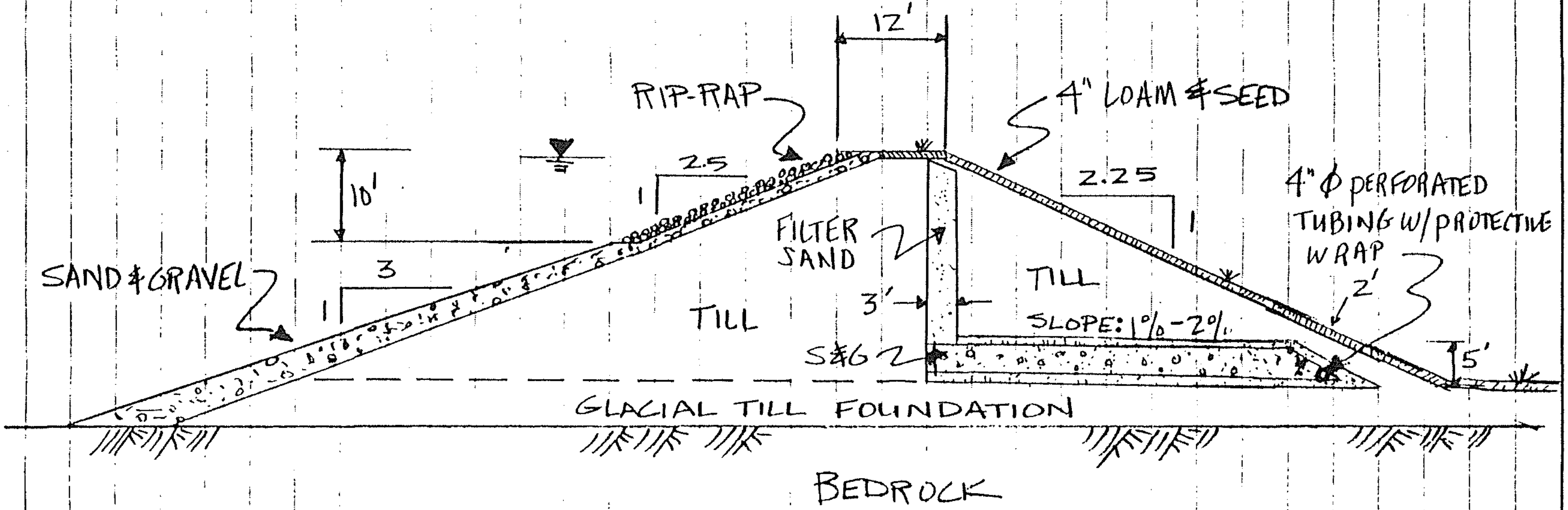
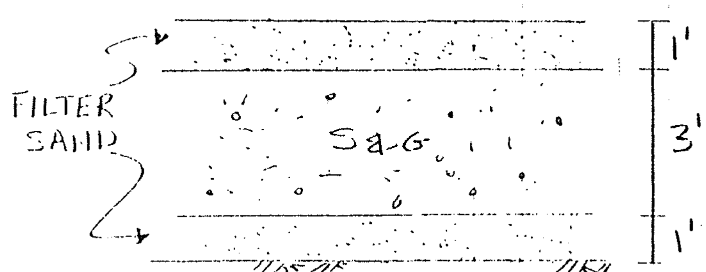
APPENDIX D

JAWORSKI GEOTECH, INC.
150 Zachary Road
Manchester, NH 03109
(603) 647-9700 • FAX 647-4432

Project MEADOW POND DAM
Project No. J92214
Sheet No. 1 Of 18
Calculated By KMM Date 10/7/92
Checked By TCC Date 10/[illegible]/92
Subject TYPICAL CROSS SECTION
Scale 1" = 20FT



NOTES:
1. RIP-RAP BLANKET TO BE AT LEAST 2FT NORMAL TO SLOPE
2. RIP-RAP BLANKET TO BE EITHER 10FT IN VERTICAL LENGTH OR AT LEAST 2FT BELOW LOW WATER ELEVATION - WHICHEVER IS GREATER
3. SAND & GRAVEL BLANKET TO BE 2 FEET NORMAL TO SLOPE EXCEPT UNDER RIP-RAP WHERE IS SHALL BE 12 INCHES NORMAL TO SLOPE
4. PERFORATED TUBING TO BE ADS 4 INCH DIAMETER PERFORATED TUBING WITH AN ADS DRAIN GUARD PROTECTIVE WRAP



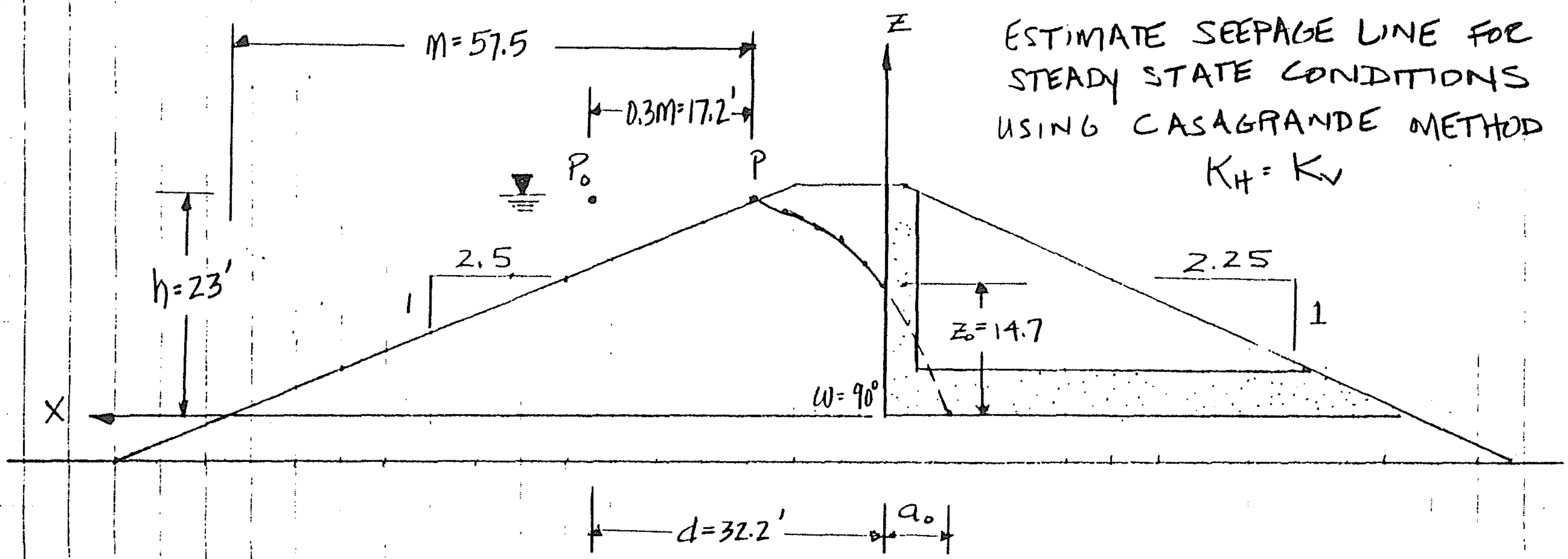
BLANKET DRAIN
NTS

JAWORSKI GEOTECH, INC.
(603) 647-9700 • FAX 647-4432
150 Zachary Road
Manchester, NH 03109

Project MEADOWS POND DAM — Project No. 92214
Sheet No. 2 — Of 18
Calculated By KMM — Date 10/6/92
Checked By TC — Date 10/20/93
Subject SEEPAGE (PHREATIC) LINE — Scale 1" = 20 FT

HOMOGENEOUS SECTION w/ CHIMNEY DRAIN

ESTIMATE SEEPAGE LINE FOR STEADY STATE CONDITIONS USING CASAGRANDE METHOD
$K_H = K_V$



$$a_0 = \frac{Z_0}{2} = \sqrt{d^2 + h^2} - d$$

$$a_0 = \sqrt{32.2^2 + 23^2} - 32.2 = 7.4$$

$$Z_0 = 2a_0 = 14.7'$$

$$X = \frac{Z^2 - Z_0^2}{2Z_0}$$

$$X = \frac{Z^2 + 14.7^2}{2(14.7)} = \frac{Z^2 - 216.1}{29.4}$$

X (FT)	Z (FT)
0	14.7 (Z_0)
2.5	17
4.9	19
7.6	21
10.6	23

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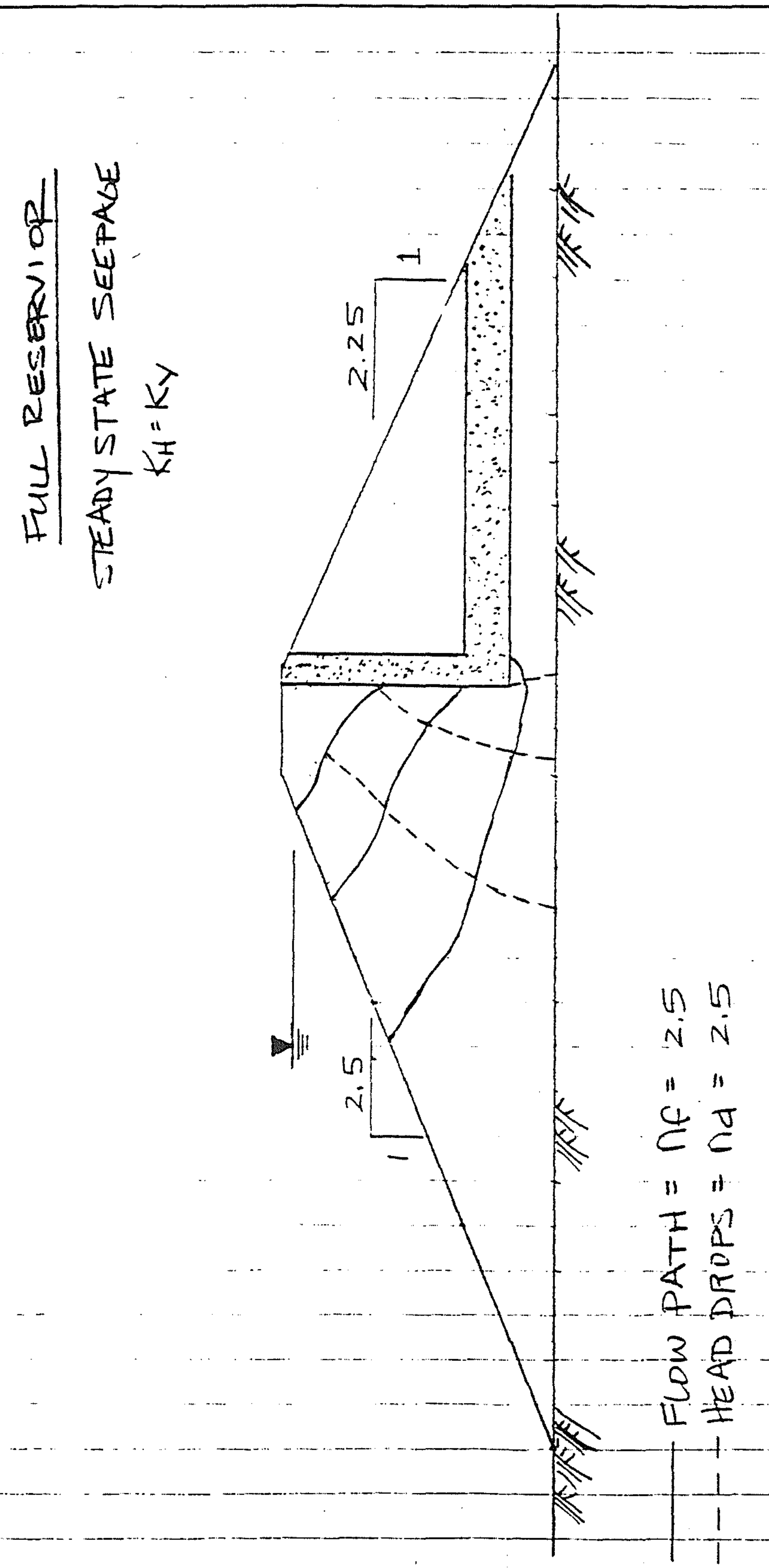
Manchester, NH 03109

Project MEADOWS POND DAM | Project No. J92214
Sheet No. 3 | Of 18
Calculated By KMM | Date 10/6/92
Checked By TCC | Date 10/30/92
Subject FLOW NET | Scale 1" = 20 FT



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Manchester, NH 03109
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FLOW RATE FROM CORE TO CHIMNEY DRAIN - ASSUMES 1FT SECTION AT MAX. HEIGHT

$q = K \cdot Z_o \cdot \sin^2 \omega$ WHERE $K = 1 \times 10^{-5} \frac{cm}{s} \simeq 2 \times 10^{-5}$ FT/MIN

$Z_o = 14.7'$

$\omega = 90°$

$q = \left(2 \times 10^{-5} \frac{FT}{MIN}\right)(14.7')(\sin^2 90°) = 3 \times 10^{-4}$ FT³/MIN/FT OF DAM

$\boxed{\therefore Q = 3 \times 10^{-4} \text{ FT}^3\text{/MIN/FT}}$

OR

$Q = K Z_o \frac{n_f}{n_d} = \left(2 \times 10^{-5} \frac{FT}{MIN}\right)(14.7')\left(\frac{2.5}{2.5}\right) = 3 \times 10^{-4} \frac{FT^3}{MIN}$ ✓

$\boxed{\therefore Q = 3 \times 10^{-4} \text{ FT}^3\text{/MIN/FT}}$

FLOW RATE THRU MAX. SECTION OF DAM VS. STREAM FLOW

Q_S = STREAM FLOW ≃ 0.5 CF/S (RIVERS ENGINEERING)

≃ 30 CF/MIN

MAX. DAM PROFILE: AREA ≃ 8,570 FT² (SEE SUBSURFACE PROFILE)

$K = 2 \times 10^{-5}$ FT/MIN

ASSUME HYDRAULIC GRADIENT $\left(\frac{h}{L}\right) = 1$

Q_D = FLOW THRU DAM ≃ KiA = $(2 \times 10^{-5}$ FT/MIN$)(1)(8,570$ FT²$) = 0.17$ FT³/MIN

$\boxed{Q_S \ggg Q_D}$

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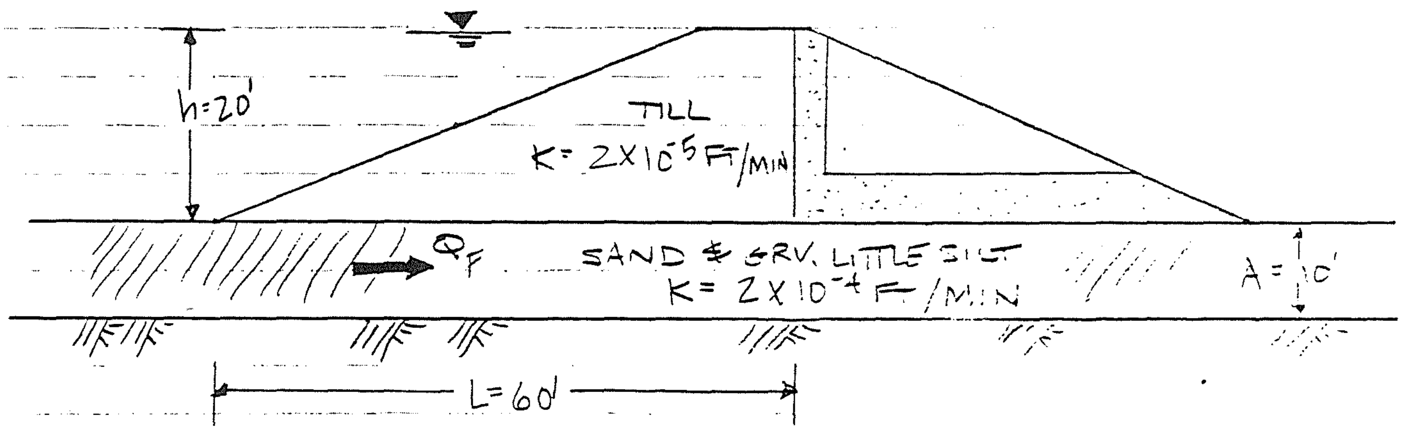
FLOW BENEATH DAM ALONG EASTERN ABUTMENT



$Q_F = KiA \qquad i = \frac{h}{L} = \frac{20'}{60'} = 0.33$

$Q_F = (0.0002\ FT/MIN)(0.33)(10\ FT^2) = 6.6 \times 10^{-4}\ FT^3/MIN/FT$

APPROXIMATELY 200FT (MEASURED ALONG ℄) OF S&G, SILT

$Q_F = 6.6 \times 10^{-4}\ CF/MIN/FT\ (200') = 0.13\ FT^3/MIN$

$\boxed{Q_{STREAM} \simeq 30\ CF/MIN \gg Q_F = 0.13\ FT^3/MIN}$

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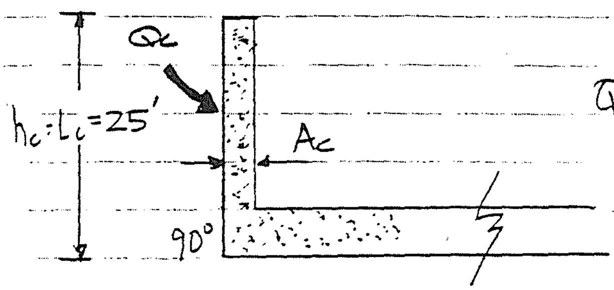
CHIMNEY DRAIN (VERTICAL) * ASSUME 1 FT SECTION AT MAX. HEIGHT

$Q_c = 3 \times 10^{-4}\ FT^3/MIN \simeq 0.43\ FT^3/DAY$

$\therefore$ Q_c INTO CHIMNEY = 0.43 FT^3/DAY



$Q_c = K\,i\,A_c$ WHERE A_c = AREA OF CHIMNEY DRAIN

$i = h_c / L_c = 1$

$Q_c = 0.43\ FT^3/DAY$

$K = 1 \times 10^{-3}\ cm/s = 2.84\ FT/DAY$

$\therefore A_c = \frac{Q_c}{Ki} = \frac{0.43\ FT^3/DAY}{2.84\ \frac{FT}{DAY} \cdot 1} = 0.15\ FT^2$

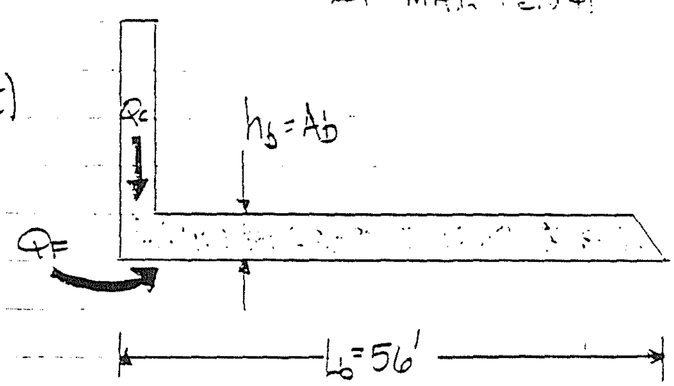
$\boxed{USE\ A_c = 3\ FT^2}$ - PRACTICAL LIMIT OF GOOD CONSTRUCTION

BLANKET DRAIN (HORIZONTAL) * ASSUME 1 FT SECTION AT MAX. HEIGHT

$Q_B = Q_C + Q_F$

ASSUME $Q_F = Q_c$ (CONSERVATIVE)

$Q_B = K\,i\,A_b$



$Q_B = 0.43 + 0.43 = 0.86\ FT^3/DAY$

$i = \frac{h_b}{L_b} = \frac{A_b}{56}$

$K = 2.84\ FT/DAY$

$Q_B = K\,i\,A_b = K \frac{A_b}{56} A_b$

NOTE: PITCH BLANKET AS MUCH AS possible TO INCREASE hydraulic gradient AND REDUCE AREA

$\therefore A_b^2 = \frac{56\,Q_B}{K} = \frac{56(0.86\ FT^3/DAY)}{2.84\ FT/DAY}$ $A_b = 4.1\ FT$ $\boxed{USE\ A_b = 5.0\ FT^2}$

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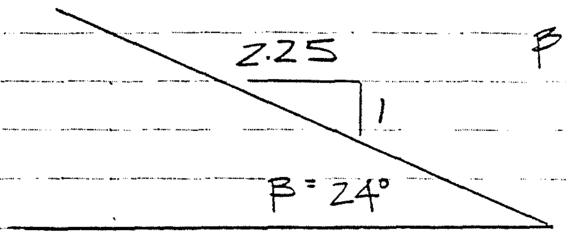
Project MEADOWS POND DAM | Project No. J92214
Sheet No. 7 | Of 18
Calculated By KMM | Date 10/6/92
Checked By TCC | Date 10/20/92
Subject SLOPE STABILITY | Scale
END-OF-CONSTRUCTION

TRANSLATIONAL

DOWNSTREAM

$\phi_{EST} = 35°$

$\beta = \tan^{-1} 1/2.25 = 24°$



$FS = \frac{\tan\phi}{\tan\beta} = \frac{\tan 35°}{\tan 24°} = 1.57$

$\boxed{FS_{EOC} = 1.57}$

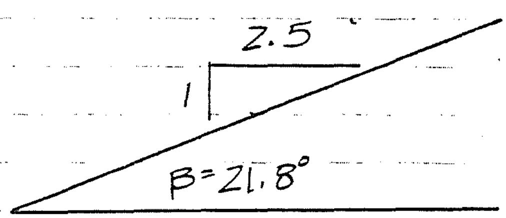
FS_{COE} = FS RECOMMENDED BY U.S. CORPS OF ENGINEERS

$\boxed{FS_{COE} = 1.3}$

UPSTREAM

$\phi_{EST} = 35°$

$\beta = \tan^{-1} 1/2.5 = 21.8°$



$FS_{EOC} = \frac{TAN\,\phi}{TAN\,\beta} = \frac{TAN\,35}{TAN\,21.8} = 1.75$

$\boxed{FS_{EOC} = 1.75}$

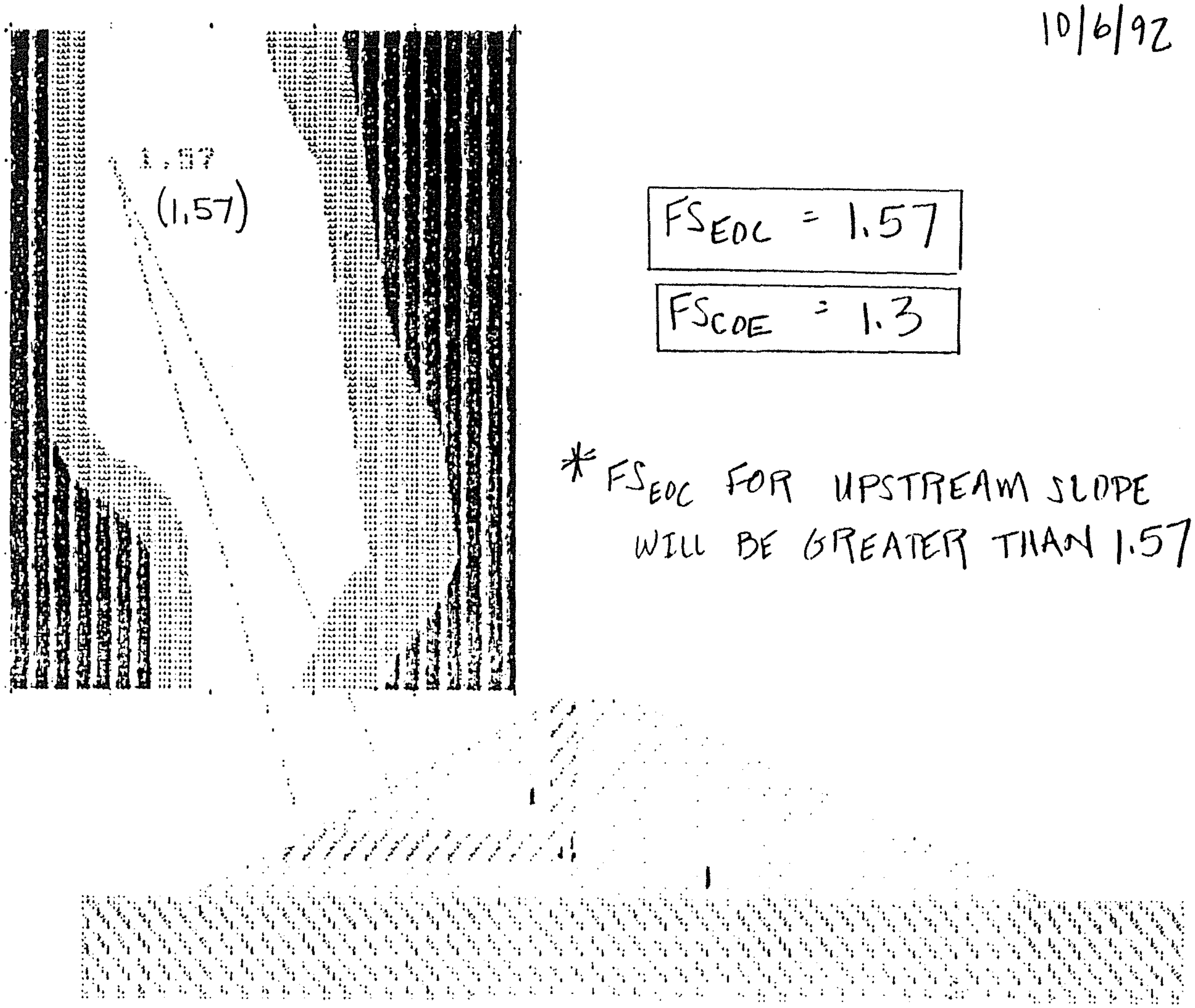
$\boxed{FS_{COE} = 1.3}$

ROTATIONAL SLOPE STABILITY – B HOP METHOD

DOWNSTREAM

END-OF-CONSTRUCTION

MEADOW'S POND DAM
ALTON, NH J92214
10/6/92

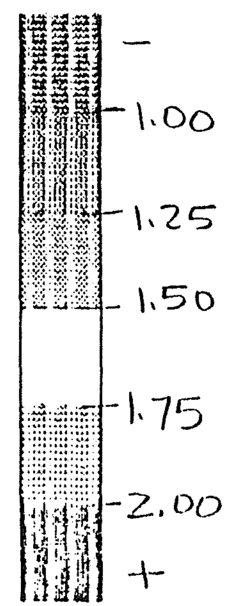


$\boxed{FS_{EOC} = 1.57}$

$\boxed{FS_{COE} = 1.3}$

* FS_{EOC} FOR UPSTREAM SLOPE WILL BE GREATER THAN 1.57

SAFETY FACTOR CONTOUR



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TCC

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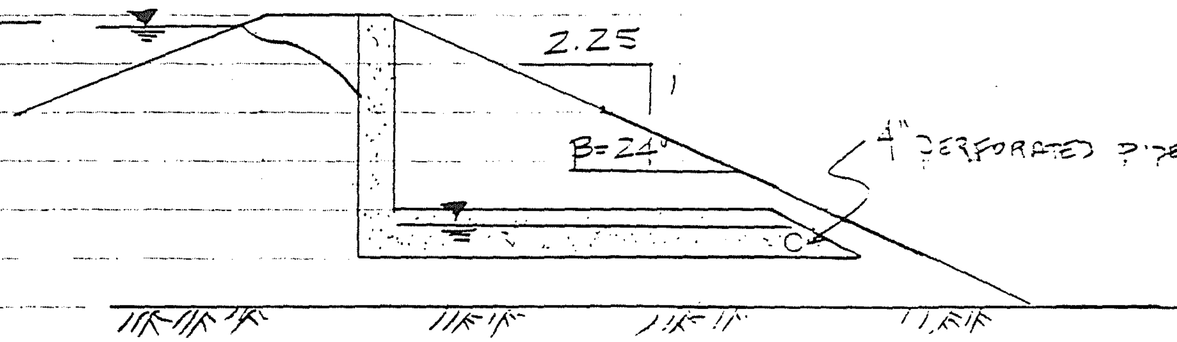
Project MEADOW'S POND DAM Project No. J92214
Sheet No. 9 Of 18
Calculated By KMM Date 10/7/92
Checked By TCC Date 10/20/92
Subject SLOPE STABILITY Scale
STEADY STATE SEEPAGE

TRANSLATIONAL

DOWNSTREAM

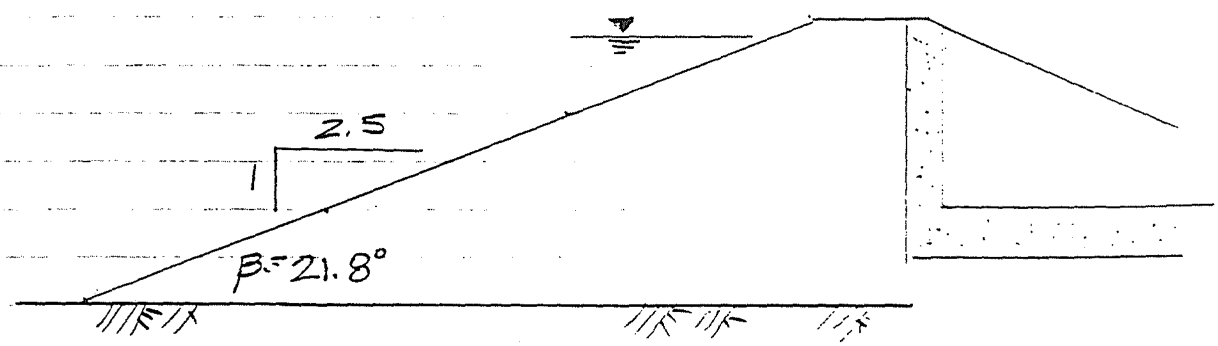


$\phi_{EST} = 35°$
$\beta = 24°$

$$\boxed{FS_{SS} = \frac{\tan \phi}{\tan \beta} = \frac{\tan 35}{\tan 24} = 1.57}$$

$$\boxed{FS_{COE} = 1.5}$$

UPSTREAM



$\phi_{EST} = 35°$
$\beta = 24°$

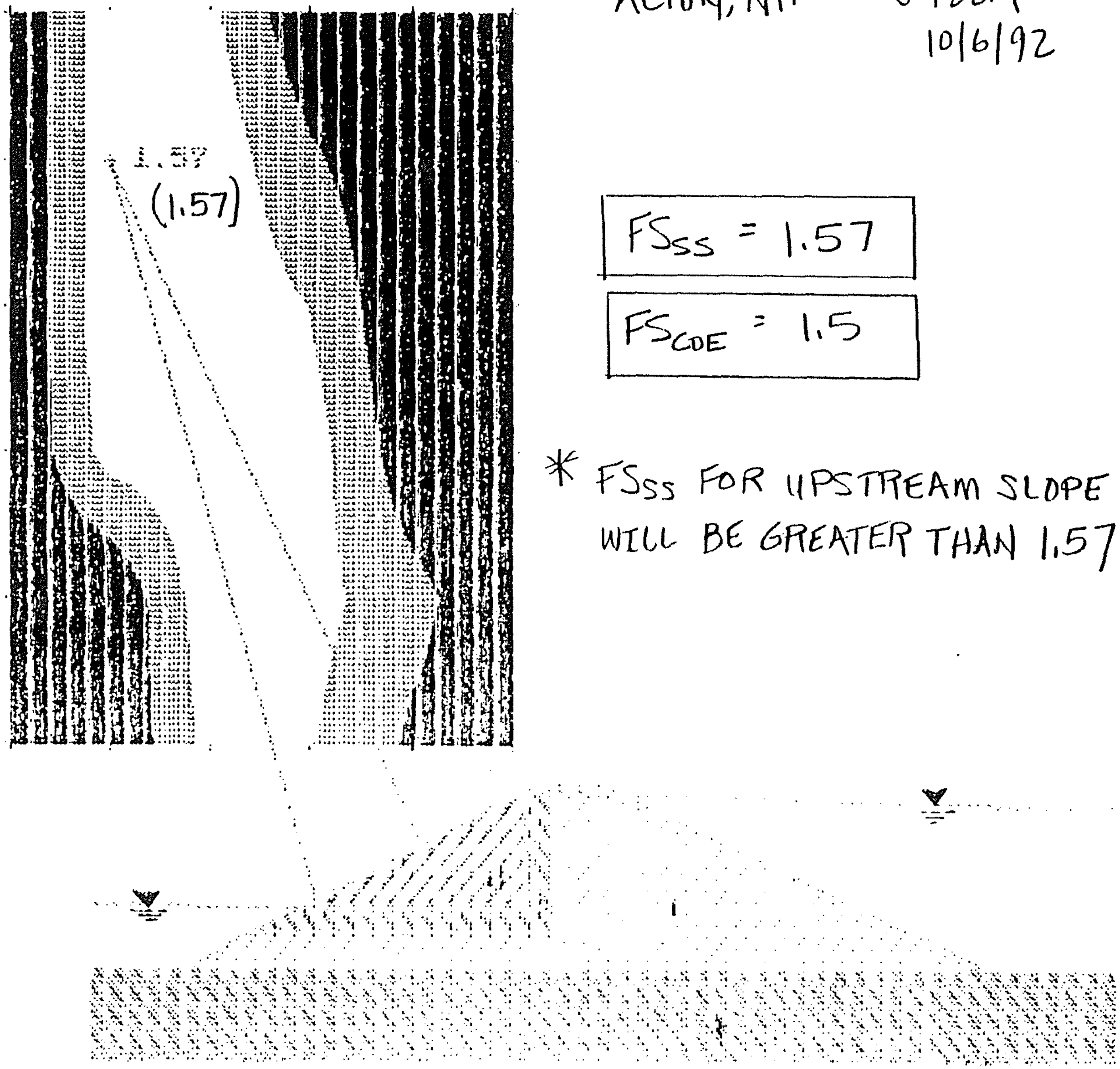
$$\boxed{FS_{SS} = \frac{\tan \phi}{\tan \beta} = \frac{\tan 35}{\tan 21.8} = 1.75}$$

$$\boxed{FS_{COE} = 1.5}$$

DOWNSTREAM

STEADY STATE SEEPAGE

MEADOW'S POND DAM
ALTON, NH J92214
10/6/92

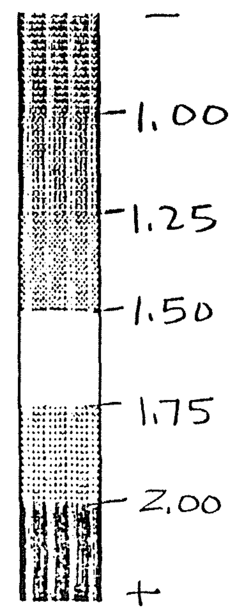


$FS_{SS} = 1.57$

$FS_{COE} = 1.5$

* FS_{SS} FOR UPSTREAM SLOPE WILL BE GREATER THAN 1.57

SAFETY FACTOR CONTOUR



KMM 10/18

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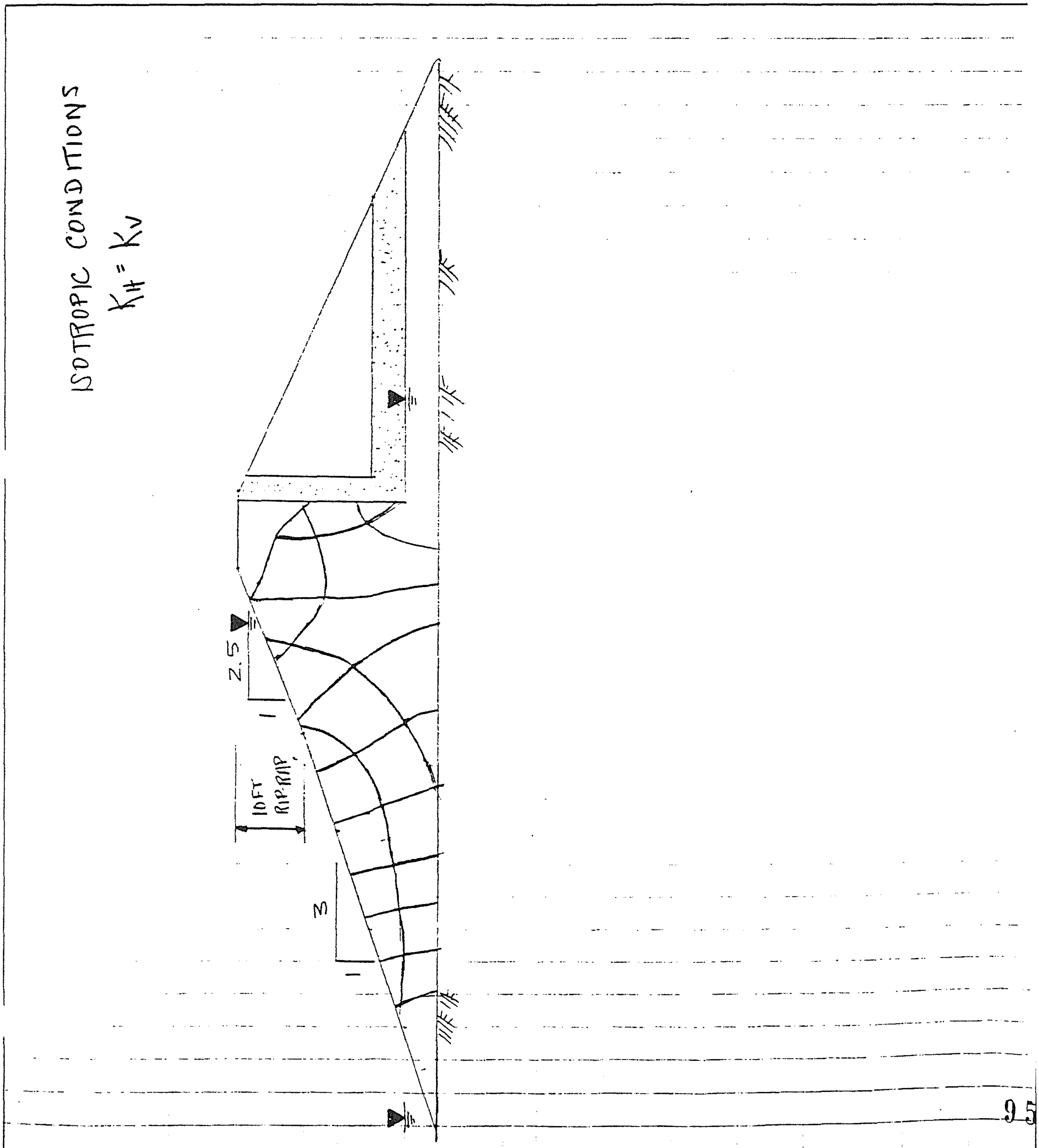
Project	MEADOW POND DAM	Project No.	192214
Sheet No.	11	Of	18
Calculated By	KMM	Date	10/7/92
Checked By	TCC	Date	10/20/92
Subject	FLOW NET - RAPID DRAWDOWN	Scale	1" : 20'



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150 Zachary Road
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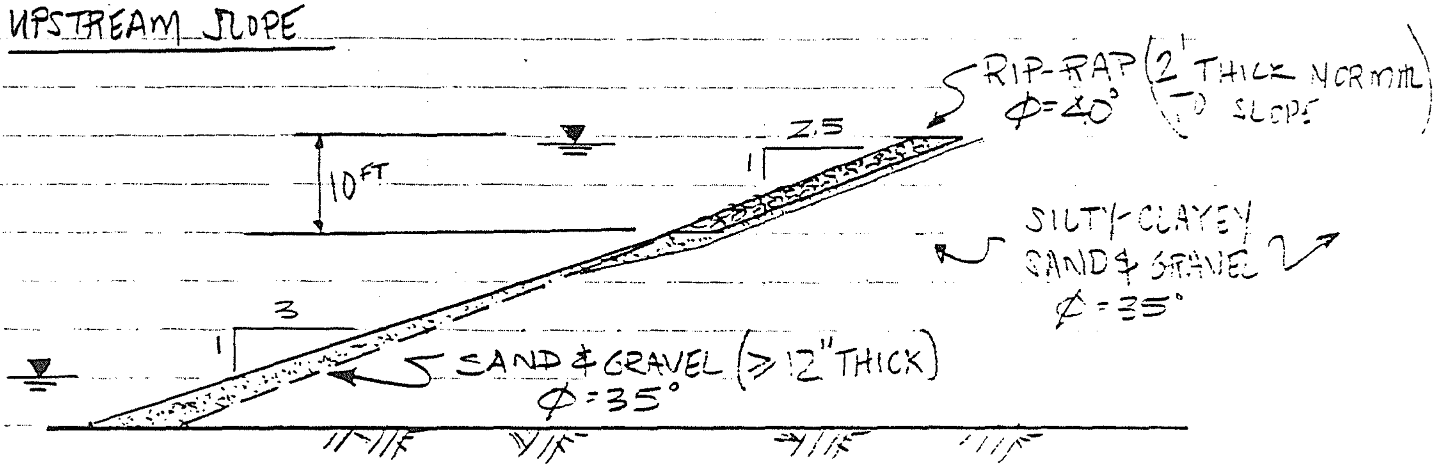
Project MEADOW'S POND DAM Project No. J92214
Sheet No. 12 Of 18
Calculated By KMM Date 10/7/92
Checked By TCC Date 10/20/92
Subject SLOPE STABILITY RAPID DRAWDOWN Scale

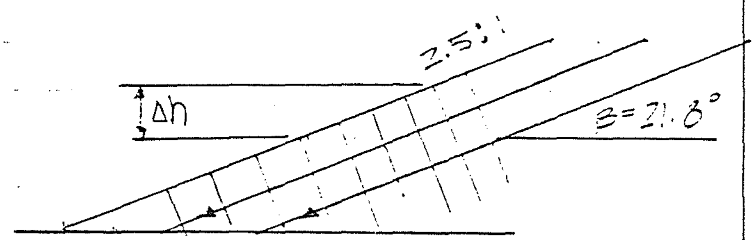
UPSTREAM SLOPE



FROM FLOW NET; FLOW PATHS IN UPPER 10 FT IS PARALLEL TO SLOPE

THEREFORE:

$$FS = \frac{\gamma_{sub}}{\gamma_{SAT}} \frac{\tan\phi}{\tan\beta}$$



RIP-RAP

$\phi_{EST} = 40°$

$\gamma_{SAT} \simeq 140 PCF$

$\gamma_{SUB} = 140 - 62.4 = 77.6 PCF$

$$\boxed{FS = \frac{77.6}{140} \frac{\tan 40°}{\tan 21.8°} = 1.16}$$

$$\boxed{FS_{COE} = 1.0}$$

SAND & GRAVEL / TILL

$\phi_{EST} = 35°$

$\gamma_d = 127.0 PCF$ (PROCTOR)

$G_{S\ EST} = 2.7$

$S = 100\%$

$\gamma_w = 62.4 PCF$

$\gamma_T = \gamma_{SAT} = 142.5 PCF$

$\gamma_{sub} = 80.1 PCF$

$$e = \frac{G_s \gamma_w}{\gamma_d} - 1 = \frac{(2.7)(62.4)}{127} - 1 = 0.33$$

$$w = \frac{e \cdot S}{G_s} = \frac{(0.33)(1.00)}{2.7} = 12.2\%$$

$$\therefore \gamma_T = \gamma_{SAT} = \gamma_d (1 + w_{SAT}) = 127(1.122) = 142.5 PCF$$

$$\gamma_{sub} = \gamma_T - \gamma_w = 142.5 - 62.4 = 80.1 PCF$$

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Project MEADOW POND DAM Project No. 192214
Sheet No. 13 Of 18
Calculated By KMM Date 10/7/92
Checked By TCC Date 10/20/92
Subject SLOPE STABILITY RAPID DRAWDOWN Scale

SEEPAGE PARALLEL TO UPPER SLOPE (2.5:1) FOR SAND+GRV/TILL

$$\boxed{FS = \frac{80.1}{142.5}\,\frac{\tan 35^\circ}{\tan 21.8} = 0.984 \simeq 1.0^{*}}$$

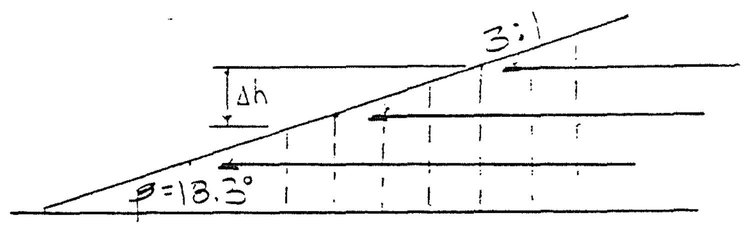
* NOTE: ADDITIONAL STABILITY PROVIDED BY RIP RAP OVERLYING THE SAND+GRV/TILL

$$\boxed{FS_{COE} = 1.0}$$

FROM FLOW NET: FLOW PATHS NEAR TOE ARE ~~APPROX HORIZ.~~ TO SLOPE

THEREFORE

$$FS = \frac{(\gamma_{sub} - \gamma_w \tan^2\beta)\tan\phi}{\gamma_T \tan\beta}$$



MATERIALS: SAND & GRV/TILL

$\gamma_{sub} = 80.1$ PCF
$\gamma_T = 142.5$ PCF

$$\boxed{FS = \frac{(80.1 - 62.4\tan^2 18.3)\tan 35}{142.5\tan 18.3} = 1.09 \simeq 1.0}$$

$$\boxed{FS_{COE} = 1.0}$$

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Project MEADOW POND DAM Project No. 92214
Sheet No. 14 Of 18
Calculated By KMM Date 10/5/92
Checked By TCC Date 10/20/92
Subject FILTER CRITERIA Scale

CORE MATERIAL REPRESENTITIVE OF L291-92, L294-92, & L210-92

$D_{85_{AVG}} = 1.0\ mm$
$D_{50_{AVG}} = 0.1\ mm$
$D_{15_{AVG}} = 0.02\ mm$
SEE GRAIN SIZE DISTRIBUTION TEST REPORT (BASED ON MINUS 3/4 INCH)

MIGRATION

$$\frac{D_{15}\ (FILTER)}{D_{85}\ (CORE)} = \frac{X}{1.0} \leq 5 \quad \therefore \quad X \leq 5mm\ (D_{15})$$

$$\frac{D_{50}\ (FILTER)}{D_{50}\ (CORE)} = \frac{X}{0.1} \leq 25 \quad \therefore \quad X \leq 2.5mm\ (D_{50})$$

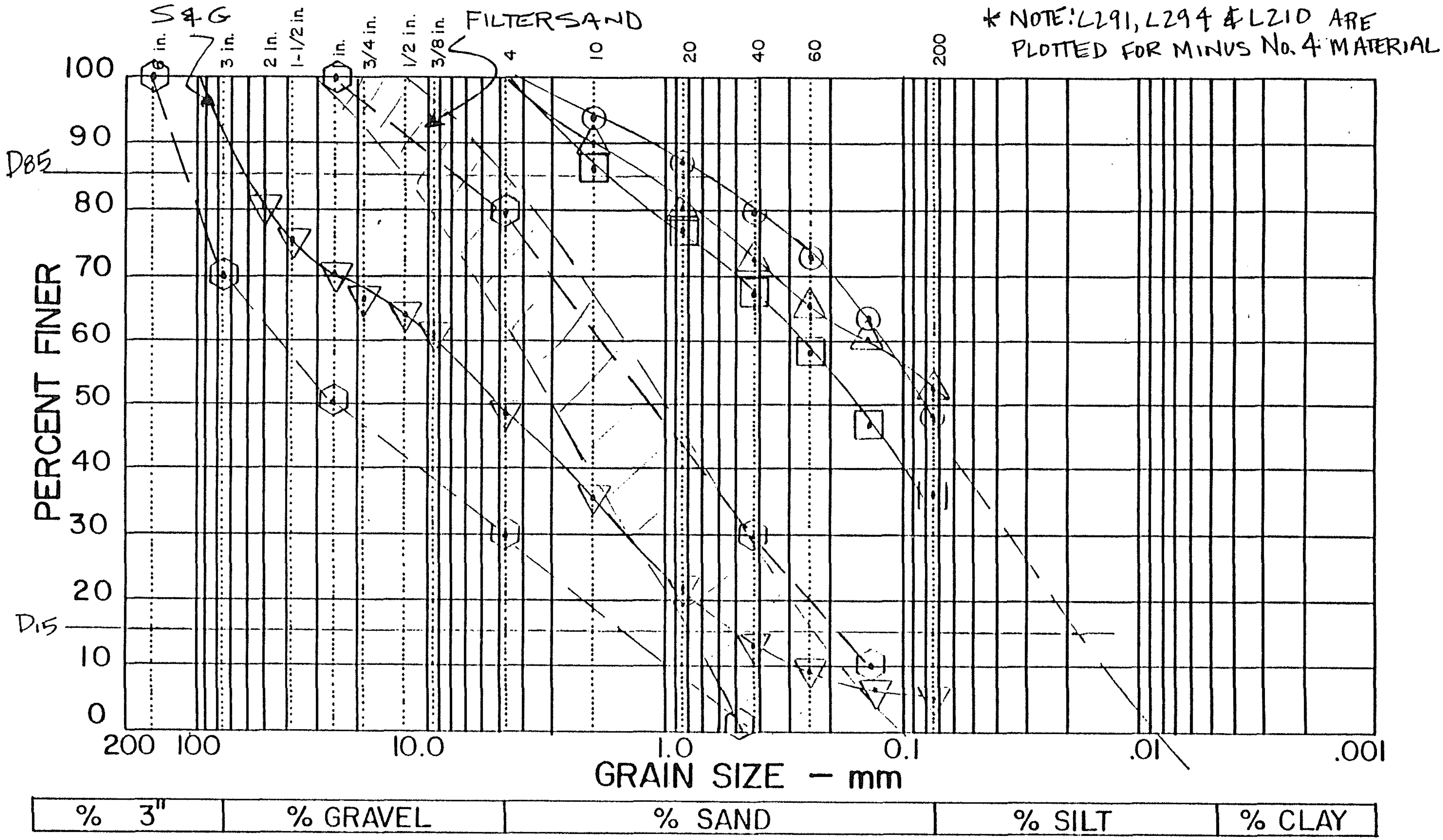
PERMEABILITY

$$\frac{D_{15}\ (FILTER)}{D_{15}\ (CORE)} = \frac{X}{0.02} \geq 5 \quad \therefore \quad X > 0.10\ mm\ (D_{15})$$

RECOMMENDED DESIGN CRITERIA $D_{15(FILTER)} \leq 0.7mm$

"FILTERS & LEAKAGE CONTROL IN EMBANKMENT DAMS" SHEPARD, J.L. & DUNNIGAN, L.P. ASCE - SEEPAGE AND LEAKAGE FROM DAMS and IMPOUNDMENTS - MAY 1985

GRAIN SIZE DISTRIBUTION TEST REPORT



JGI JAWORSKI GEOTECH, INC.	PREPARED FOR:	MEADOWS POND DAM	JP-5 L291-92 *
		FILTER SAND SPEC.	JP-4 L294-92 *
	DATE: Sept. 1992	SAND & GRV. SPEC.	TP-1 L210-92 *
	PROJECT NO. J92214	TP 18 L293-92	

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Project: ADAM'S POND DAM — Project No. J92214
Sheet No. 16 Of 18
Calculated By: KMM — Date: 10/4/92
Checked By: TCL — Date: 10/20/92
Subject: FILTER CRITERIA — Scale:

* FILTER SAND VS. SAND & GRAVEL (FOR USE OF S&G IN BLANKET DRAIN)

FILTER SAND $D_{15} = 0.3 - 0.8$ S&G $D_{15} = 0.25 - 1.7$
$D_{50} = 1 - 3$ $D_{50} = 1.0 - 25$
$D_{85} = 5 - 12$ $D_{85} = 7 - 100$

MIGRATION

$$\frac{D_{15}(S\&G)}{D_{85}(FS)} \leq 5 \quad \therefore \quad \frac{0.25 - 1.7}{5 - 12} \quad OK$$

$$\frac{D_{50}(S\&G)}{D_{50}(FS)} \leq 25 \quad \therefore \quad \frac{1.0 - 25}{1 - 3} \quad OK$$

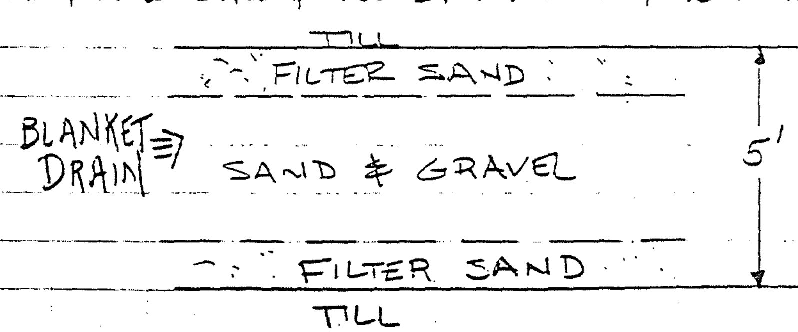
PERMEABILITY

$$\frac{D_{15}(S\&G)}{D_{15}(FS)} \geq 5 \quad \therefore \quad \frac{0.25 - 1.7}{0.3 - 0.8} = 0.3 - 5.7$$

∴ MUST DEMONSTRATE BY PERMEABILITY TESTING THAT $K_{S\&G} \geq K_{FS}$

* GRAVEL SPECIFICATION OUTLINED AND EVALUATED FOR USE WITHIN BLANKET DRAIN (SEE GRAIN SIZE DISTRIBUTION TEST REPORT)

SIEVE SIZE	% PASS
6 INCH	100
3 INCH	70-100
1 INCH	50-100
No. 4	30-80
No. 40	0-30
No. 100	0-10



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MATERIALS

CORE AND SHELL (GLACIAL TILL)

SIEVE SIZE	PERCENT PASSING BY WEIGHT
6"	100
3"	75-100
1"	65-95
3/8"	50-85
No. 4	40-80
No 40	30-65
No. 200	20-40

K = COEFFICIENT OF PERMEABILITY $\leq 1 \times 10^{-5}$ cm/s
WHEN COMPACTED TO 92% MDD PER ASTM D1557

FILTER SAND (CHIMNEY AND BLANKET DRAIN)

SIEVE SIZE	PERCENT PASSING BY WEIGHT
1½	100
3/8	80-95
No. 4	60-85
No. 20	15-50
No 40	0-30
No. 100	0-10

$K \geq 1 \times 10^{-3}$ cm/s

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SAND & GRAVEL (UPSTREAM BLANKET)

SIEVE SIZE	PERCENT PASSING BY WEIGHT
6 INCH	100
3 INCH	70-100
1 INCH	50-100
NO. 4	30-80
NO. 40	0-30
NO. 100	0-10

$K \geq 10^{-3}$ cm/s

RIP-RAP* (FOR FETCH ≤ 2.5 MILES)

SIZE BY WEIGHT	PERCENT BY WEIGHT
MAX. SIZE - 1,250 lbs.	
626 - 1,250 lbs.	30-40%
50 - 625 lbs.	60-70%
50 lbs.	0-10%

* REFERENCED FROM "DESIGN OF SMALL DAMS" - BUREAU OF RECLAMATION - 1973

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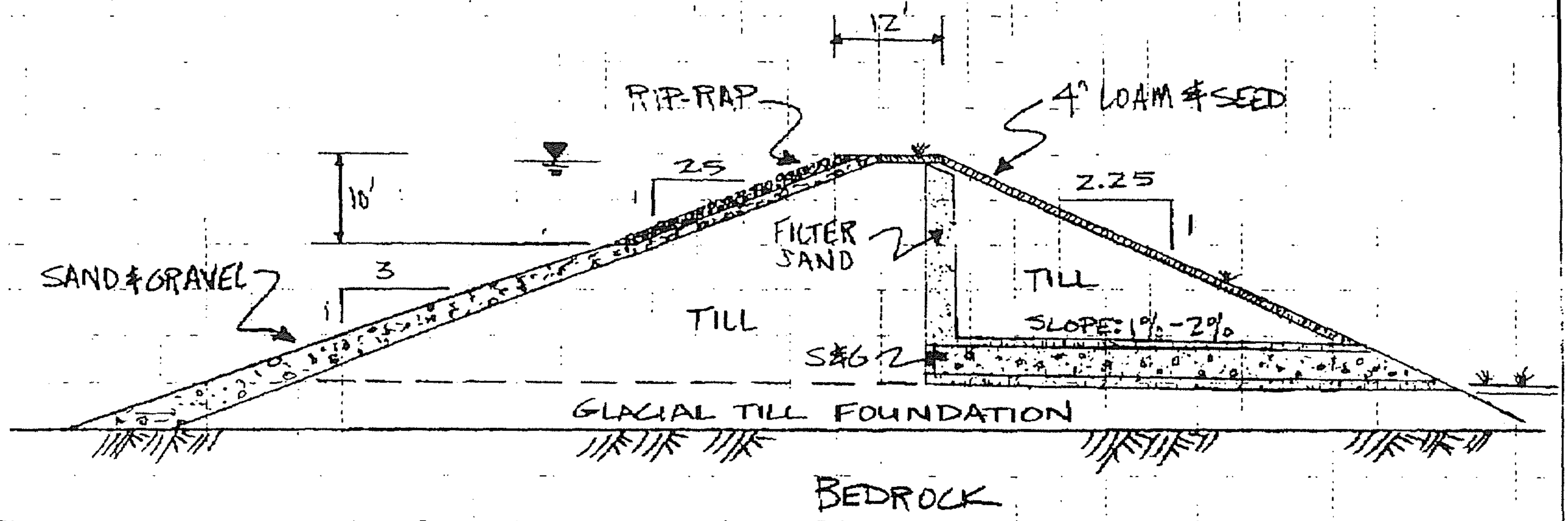
Project MEADOW POND DAM Project No. 92214
Sheet No. ____ Of ____
Calculated By KMM Date 10/7/92
Checked By ____ Date ____
Subject TYPICAL CROSS SECTION Scale 1" = 20FT



NOTES:
1. RIP-RAP BLANKET TO BE AT LEAST 3FT IN HORIZONTAL THICKNESS
2. RIP-RAP BLANKET TO BE EITHER 10FT IN VERTICAL LENGTH OR AT LEAST 2FT BELOW AVERAGE WATER ELEVATION - WHICHEVER IS GREATER
3. SAND & GRAVEL BLANKET TO BE 12 INCHES IN HORIZONTAL THICKNESS

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To Jim Dollard	From Kevin Martin
Co. RIVERS	Co. JGI
Dept.	Phone #
Fax # 647-4128	Fax #

CONSTRUCTION SPECIFICATIONS

I. GENERAL

A. Work Included
Provide all labor, materials, equipment and services and perform all operations required to complete the work as indicated on the drawings and specified herein.

B. Subsurface Conditions
Data indicated as subsurface conditions are not intended as representations or warranties of accuracy or continuity between test pits.

C. Quality Control
A qualified soils engineer should be retained by the owner as needed during construction to perform necessary soil testing and observe compliance with the design intent.

D. Tolerances
The geometry of the embankment dam shall be constructed to within 5 percent tolerance to that indicated on the drawings.

E. Borrow Areas
Borrow areas should be quantified prior to construction to determine sufficient and consistent soil materials.

F. Lay Out and Grades
All lines and grades shall be laid out prior to and during construction. A permanent bench mark shall be established and replaced if destroyed.

G. Samples and Testing
Core materials shall be tested for approval for every 4,000 yards of material. Filter materials shall be tested for approval for every 1,000 yards of material. Samples should be at least 30 pounds in weight and submitted prior to use. Additional testing will be required if fill materials change as directed by the soils engineer.

H. Inspection of Rock Surface
The bedrock surface 20 feet from the upstream toe in the reservoir area shall be inspected for the presence of fractures, seams, fissures, joints, bedding planes or other anomalies which create seepage paths beneath the dam. The bedrock shall be pressure washed to obtain an unobstructed view of the surface.

I. Frost Protection

Soils which become frozen within the limits of the embankment dam shall be removed to the full depth of frost. Placed soils should be protected from frost should ambient air temperatures fall below freezing.

J. Dewatering

Excavated and fill areas shall be kept sufficiently dry from groundwater or surface water runoff so that it does not adversely affect construction procedures or cause excessive disturbance of borrow and fill areas. In no case should fill materials be placed if ponded or groundwater is observed.

K. Turbidity

Quantitatively measure turbidity of the water emanating from the embankment dam with a turbimeter in units of Nephelometric Turbidity Units (NTUs). Measurements should be accomplished daily during reservoir filling and one week upon attainment of full reservoir. Measurements shall be reported to the soils engineer within 24 hours. Measurements shall be taken on a weekly basis thereafter. Measurements shall be ceased once it can be demonstrated that the turbidity of the water is dissipating or at the discretion of the soils engineer.

L. Erosion Control Measures

Temporary control consists of furnishing and placing temporary erosion and pollution control devices as specified by field engineer. All work regarding erosion and pollution control will be completed and properly installed in conformance with all federal, state and local permits and regulations.

M. Outlet structures

The outlet structures of the reservoir must have the capabilities to sufficiently pass the design flow as stated in local regulations for dam classification. The reservoir will also have the capabilities to be sufficiently drained without a sudden draw down of the water surface elevation.

II. MATERIALS

Materials shall be placed where indicated on the project drawings.

A. Core

Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Core materials shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	75 - 100
1 inch	65 - 95
3/8 inch	50 - 85
No. 4	40 - 80
No. 40	30 - 65
No. 200	20 - 40

The core materials shall possess as coefficient of permeability less than 10 E-5 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

B. **Filter Sand**
Shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Filter sand shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
1.5 inch	100
3/8 inch	80 - 95
No. 4	60 - 85
No. 20	15 - 50
No. 40	0 - 30
No. 100	0 - 10

The filter sand should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

C. **Sand and Gravel**
shall be free of snow and ice, roots, rubbish or other deleterious or organic matter. Sand and gravel shall conform to the following gradation requirements:

Sieve Size	Percent Finer By Weight
6 inch	100
3 inch	70 - 100
1 inch	50 - 100
No. 4	30 - 80
No. 40	0 - 30
No. 100	0 - 10

The sand and gravel should possess a coefficient of permeability greater than 10 E-3 cm/s when compacted to 92 percent of the maximum dry density per ASTM D-1557.

D. Rip-Rap

Shall be sound, of approved quality, and free from structural defects. The maximum size by weight shall be 1,250 pounds. The stones shall be angular in shape and shall conform to the following gradation requirements:

Size By Weight	Percent By Weight
626 - 1,250 lbs.	40 - 40
50 - 625 lbs.	60 - 70
50 lbs.	0 - 10

Rock available at the site may be used with permission from the field engineer. Stone used for riprap shall be durable, angular in shape; free from overburden, spoil , shale and organic material; and shall meet the gradation requirements specified.

Grouted angular riprap along spillway shall be minimum of 12" in diameter with angular face protruding one and a half inch above the surface of the grout.

Riprap at downstream end of spillway contained in baffle energy dissipator shall be angular with uniform diameter not to be less than 12" in diameter.

E. Topsoil

Shall consist of fertile, friable, natural topsoil typical of the locality, without admixture of subsoil, and shall be obtained from a well drained arable site. It shall be such a mixture of sand, silt and clay particles as to exhibit sandy and clayey properties in about equal proportions. It shall be screened of all stones two inches or more in diameter, sticks, plants and other foreign materials. The topsoil shall contain not less than 4% nor more than 20% organic matter as determined by the loss of ignition of oven-dried samples.

F. Reinforced Concrete

All concrete work shall be in accordance with the "Building Code Requirements for Reinforced Concrete (ACI 318)" with supplements and all pertinent specifications contained therein.

All concrete shall attain a minimum 28-day compressive strength of 4000 psi. Portland cement shall be type II in accordance with ASTM C-150. Concrete shall be air entrained with total air as a percent by volume of concrete equal to 5%. The air entraining admixture shall be Daravair, or as equal, conforming to ASTM C-260. The aggregates shall conform to ASTM C-33 and shall have a 3/4-inch maximum size.

Reinforcing steel shall be Grade 60 deformed billet steel bars conforming to ASTM A-615.

The minimum clear concrete cover for reinforcing shall be 3 inches for cast concrete cast against earth and 2 inches elsewhere, unless otherwise noted.

All grout shall be a portland cement based non-shrink grout, such as CG-86 construction grout as manufactured by W. R. Meadows, or equal. The grout shall be mixed and installed according to the manufacture's specifications.

The net allowable bearing capacity used for the foundation design is 4000 psf as provided in specifications by Jaworski Geotech Inc.

G. Slide Gate

Slide gate provided should be a model SC-5000 as manufactured by Waterman Industries or equal upon approval of Engineer. Compliance of specifications provided by manufacturer will be followed.

I. Perforated Pipe

Shall be an ADS (Advanced Drainage Systems, Inc.) four inch diameter continuous section wrapped in a nylon protective fabric or equivalent. The pipe shall be sloped a minimum of one percent throughout the entire length. The pipe should outlet at both the stream bed and abutment. The abutment outlet shall be capped with a split end cap. Installation should be in accordance with manufacturer's guidelines and specifications. Pipe shall also be placed along both sides of low level outlet.

III. EXECUTION

A. Clearing and Grubbing

Remove topsoil and subsoil within the limits of the earthfill dam and in borrow areas. Exposed subgrade in which root structure or organic materials are encountered shall be overexcavated to the depth of the root line. Pile and store excavated materials in designated or approved locations where it will not interfere with construction operations.

B. General Excavation:

Excavation within the limits of the embankment dam shall be excavated of all topsoil and subsoil to a depth greater than the root line.

C. Placement

Fill materials shall be placed and spread in a manner to minimize particle segregation. Care will be taken to not contaminate filter materials. Filter materials which become contaminated shall be removed and replaced. No fill materials shall be placed on uncompacted soil, wet/weaving soil, frozen soil or other soil conditions unacceptable to the soils engineer.

Surficial soils shall be uniformly distributed and evenly spread to compensate for shrinkage. Irregularities in the surface resulting from construction operations shall be corrected to prevent the formation of depressions where water will stand.

D. Disking and Harrowing

Each lift shall be uniformly disked or harrowed to a depth of at least 2 inches prior to the placement fill materials.

E. Moisture Control

The water content of fill materials shall be within -3 percent to +2 percent of the optimum moisture content determined by ASTM D-1557. Soils which are dry shall be uniformly wetted. Wet soils shall be aerated by blending, mixing or other satisfactory means until the moisture content is as specified. Borrow and fill areas should be protected from precipitation when necessary. Placed fill which exceeds the specified moisture shall be removed.

F. Compaction:

Lift sizes should be limited to 18 inch loose lift thickness. Compact fill materials to 92 percent relative compaction as determined by ASTM D1557. Field density tests shall be performed at 100 foot intervals for each lift. Soils which do not meet compaction requirements shall be recompacted or removed.

G. Slush Grouting

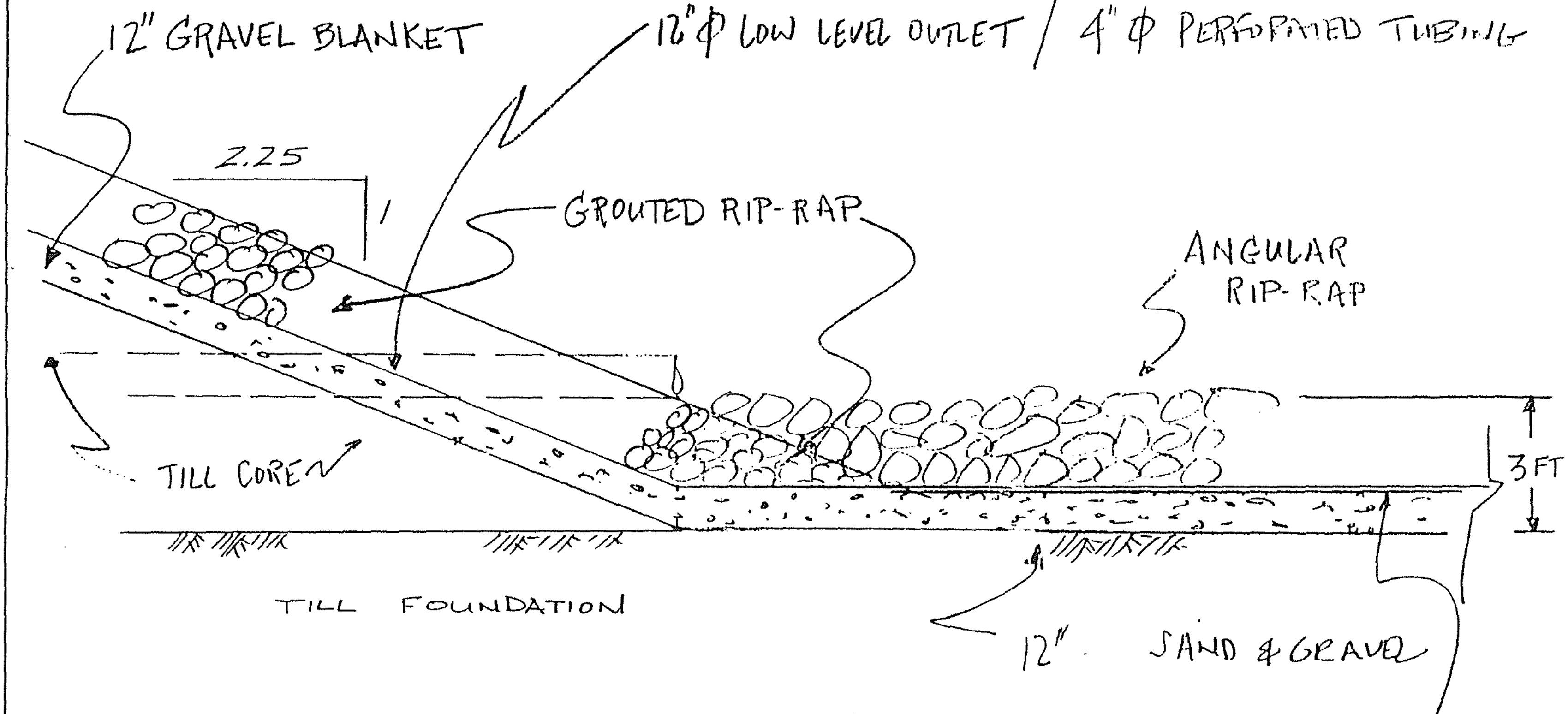
The bedrock surface should be exposed in the reservoir area at least 20 feet from the upstream toe of the dam. All fractures, seams, joints or fissures shall be slush grouted with a lean sand and cement grout in which to establish an impermeable seam. The ratio of sand to cement shall not exceed 2 parts sand to 1 part cement. All areas to be slush grouted shall be thoroughly cleaned of all loose materials and shall be wetted prior the placement of the grout. Placement of slush grout shall be by brooming into all fractures, seams, joints or fissures with a stiff-bristled broom or other approved method. All fractures, seams, joints or fissures shall be chased at least 100 feet from the upstream toe and/or 30 feet into the embankment dam.

H. **Mulching**
Shall consist of hay or straw mulch loosely spread to a uniform depth over all grassed areas indicated on the plans. Mulch shall be spread following approval of the surficial soils by the soils engineer.

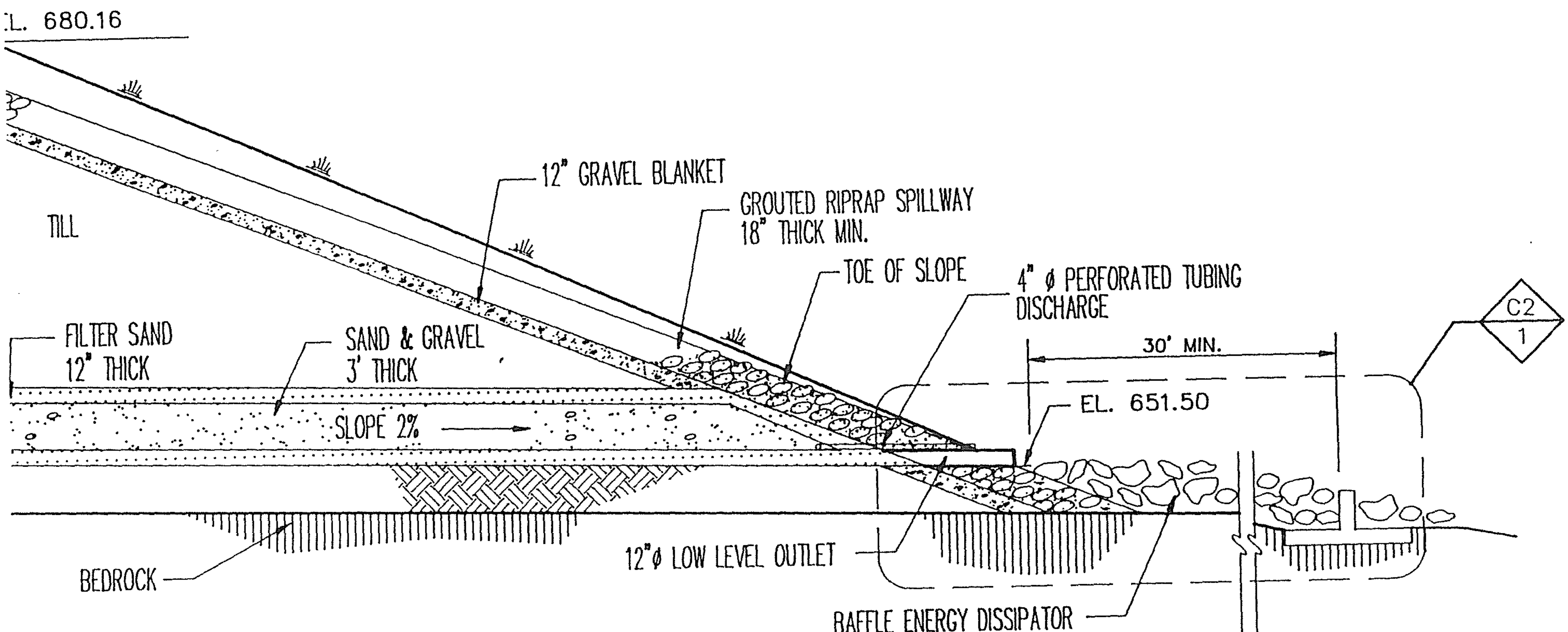
I. **Seeding**
Shall be performed early spring or late summer. Seed shall be evenly spread. Reseeding of bare spots and maintenance requirements shall be performed when necessary.

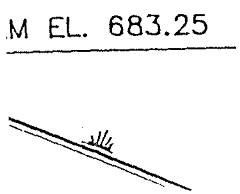
JGI
JAWORSKI GEOTECH, INC.
(603) 647-9700 • FAX 647-4432
150 Zachary Road
Manchester, NH 03109

Project MEADOW POND DAM
Project No. [illegible]
Sheet No. ____ Of ____
Calculated By KMM Date 11/12/92
Checked By GJ Date 11/12/92
Subject BAFFLE ENERGY DISSIPATOR
Scale 1" = 4FT



C2 / 1 BAFFLE ENERGY DISSIPATOR SECTION


L. 680.16
12" GRAVEL BLANKET
GROUTED RIPRAP SPILLWAY
18" THICK MIN.
TOE OF SLOPE
4" ø PERFORATED TUBING
DISCHARGE
TILL
FILTER SAND
12" THICK
SAND & GRAVEL
3' THICK
SLOPE 2%
30' MIN.
C2
1
EL. 651.50
12"ø LOW LEVEL OUTLET
BEDROCK
BAFFLE ENERGY DISSIPATOR

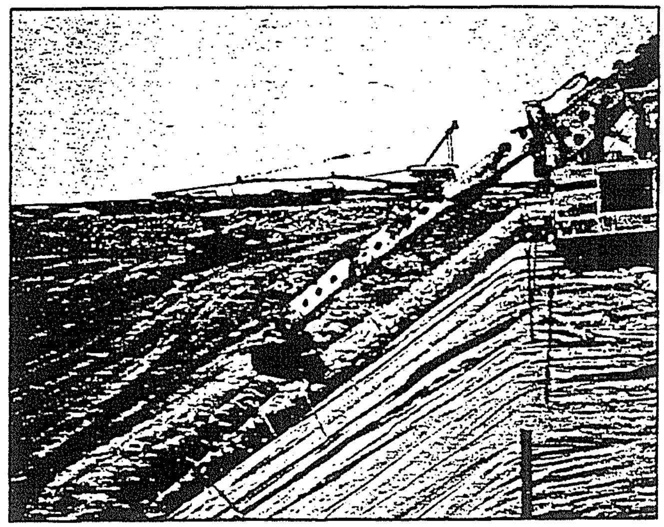

M EL. 683.25

MIRAFI®
700X

ARMORED EROSION CONTROL

Embankment Protection

Slope and embankment erosion, particularly along coastal shorelines and inland waterways, poses a serious environmental problem. The stability and performance of many civil engineering structures have been impaired or destroyed by unchecked erosion.

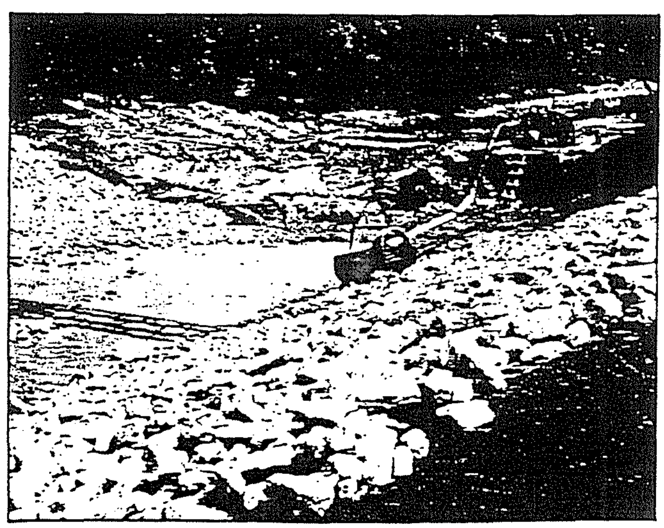


Armored protection systems are often used to guard against erosion caused by waves, tides, currents, surface run-off, and ground water seepage. Integral parts of an armored erosion protection system are energy dissipation and filtration materials.

Graded-aggregate systems (usually multilayered) have been traditionally used with limited success beneath armor both as energy dissipators and filters to prevent the washout of soil fines.

Such aggregate filters are difficult to source, install, and inspect, and even when installed properly, they are susceptible to erosive forces.

Mirafi **700X** erosion control fabric provides an effective, cost-efficient alternative to graded aggregate systems.



Among its performance features are:

- Acts as an energy dissipator by shielding the slope from the erosive forces of moving water;
- Allows adequate ground water to pass from the protected slopes while retaining underlying soil particles;
- Withstands armorment installation stresses because of its exceptional strength;
- Provides excellent clogging resistance and filtration properties;
- Does not wash out from beneath the armor, thus providing a reliable filtration and energy dissipation system.

In addition to its outstanding performance advantages, Mirafi **700X** has a significantly lower installed cost than multilayered or even single-layered aggregate systems.

APPENDIX B

Post Failure Topographic Plan by Eastern Topographics

APPENDIX C

Post Failure Survey Drawings by Civil Consultants

APPENDIX D

Daily Field Observation Reports

FIELD OBSERVATION REPORT INTRODUCTION

Presented in this appendix are the field observation reports for:

- site visits conducted on March 19 and 22, 1996 and,
- field investigations conducted on March 20 and April 1 through 5, 1996.

The soil descriptions contained in the field observation reports are based on visual classification and were not modified to reflect subsequent laboratory testing.

The convention of "left" and "right" used in the field observation reports is from the point of view of standing upstream facing the dam (looking downstream). Left is to the east of the breach and right is to the west of the breach.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: March 19, 1996
Client:	NHDES, Water Resources Division	Report No. 1
Contractor:		

6) We examined the right side of the breach and remnants of the chimney drain. The interface between the embankment fill and the chimney drain was smooth and uniform. At approximately 13' below the dam crest, the chimney drain "stepped" downstream. The upper and lower portions of the chimney drain overlapped by about 0.8'. The chimney drain was measured to be approximately 3' wide. (The dimensions of the chimney drain are investigated in more detail on March 20, 1996.)

7) A large pile of concrete rubble was observed downstream of the dam. This rubble appeared to contain portions of the spillway structure (cut-off wall and slab). Observations of the underside of a concrete slab showed that the reinforcing steel was not embedded in the concrete, possibly indicating that the steel had been placed on the subgrade prior to casting. Similar conditions were observed under portions of the spillway crest slab that had fallen into the breached section of the dam.

8) NHDES personnel placed tarps over the exposed sidewalls of the breached portion of the dam to protect it from rain, which is expected tonight and tomorrow.

9) NHDES personnel indicated the insurance company for the site owner has hired a consultant who plans to conduct excavation tomorrow. GEI will be on-site to observe the excavation.

Four soil samples were collected from the site as follows:

Sample No.	**Baseline Station**	**Offset**	**Description**
SS1	1+48	8' DS	Fine to medium sand with trace fine to coarse gravel (10%) (Chimney drain, left side of breach)
SS2	1+47	1' DS	Silty sand with gravel (embankment core fill upstream of chimney drain, left side of breach)
SS3	1+47	1' DS	Dry clods of silty clay from core fill (left side of breach)
SS4	2+42	5' DS	Fine to medium sand from pocket near crest of dam (possibly top of chimney drain, right side of breach)

Notes:

Stationing along baseline established in the field by Civil Consultants on March 19, 1996.
DS indicates downstream of baseline.

GEI Consultants Inc.
by William J. Hassell
App'd by GAW

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: March 20, 1996
Client:	NHDES, Water Resources Division	Report No. 2
Contractor:	J.R. Olson Excavating Contractor	Page 2 of 4

1250 hrs.: Limited excavation was conducted on the right side of the breach to expose the blanket drain. The sideslopes of the excavation were not sloped to allow the excavation to be entered and measurements to be taken. The excavation was approximately at station 2+30, 9' downstream of the baseline. A change in soil type was observed approximately 24' below the crest of the dam. The change in soil type was assumed to be the blanket drain.

A portion of the concrete spillway slab and cutoff wall observed on the slope of the right side of the breach was measured. The dimensions are shown in Figure 3. Observations of the spillway slab and cutoff wall are as follows:

- Although not shown in Figure 3, flash boards attached to this section of the spillway measured 13 7/8" tall.
- Longitudinal reinforcing steel was not observed at any of the four exposed ends of the cutoff wall. Vertical reinforcing steel was observed to protrude beyond the bottom of the 57" long section of cutoff wall at approximately 2' on center.
- The fractured faces of the concrete were observed to be either blue-grey or white in color. The color of the fractured faces, where observed, are noted in Figure 3.
- A splintered-off section of concrete approximately 8" long was collected from the bottom side of the spillway slab.

Additional excavation was conducted on the right side of the breach at approximately station 2+30. The following observations were made:

- The chimney drain was observed from 6'8" and 9'8" downstream of the baseline.
- At about 15' below the spillway slab, a wedge shaped layer of sand was observed to extend from either side of the chimney drain with the dimensions shown in Figure 4. This configuration may be the result of the technique used to construct the chimney drain (place core material over entire width of dam, excavate a trench and backfill it with sand to create the chimney drain).
- Glacial till foundation soil was observed beneath the fill at a depth of about 22.3' below the concrete spillway slab, about 10' to 15' upstream of the chimney drain.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: March 20, 1996
Client:	NHDES, Water Resources Division	Report No. 2
Contractor:	J.R. Olson Excavating Contractor	Page 3 of 4

The following is a list of soil samples collected from the dam:

Sample No.	Baseline Station	Offset	Description
SS5	1+28	NM	Sand with silt and gravel, from 3'6" to 4'4" below dam crest, part of core
SS6	1+28	NM	Chimney drain, fine to medium sand, 4" below dam crest
SS7	1+28	NM	Silty sand, is very soft, part of core, 7'4" below dam crest
SS8	1+28	NM	Grey silty sand, 11'8" below dam crest, part of core
SS9	1+28	NM	Silty sand, 8' below dam crest, part of core
SS10	1+33	9' DS	Brown silty gravel with sand and silt from blanket drain, 20' below dam crest, beneath chimney drain
SS11	1+33	20' DS	Fine to medium sand with gravel, tan, 21' below dam crest, filter sand
SS12	1+33	20' DS	Gravel with silt and sand, 21'6" below dam crest, blanket drain
SS13	1+33	32' DS	Brown gravel with silt and sand, 20.5' below dam crest, blanket drain
SS14	1+33	41' DS	Brown gravel with silt and sand, from about 1' above the toe drain
SS15	2+30	NM	Fine to medium sand from chimney drain, 18' below the spillway
SS16	NM	20' DS	Silty sand and gravel beneath the grouted riprap, right side of spillway at edge of breach
SS17	2+30	NM	Core material beneath cutoff wall

NM = Not measured
Stationing along baseline established in the field by Civil Consultants on March 19, 1996.
DS indicates downstream of baseline.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: March 20, 1996
Client:	NHDES, Water Resources Division	Report No. 2
Contractor:	J.R. Olson Excavating Contractor	Page 4 of 4

At the conclusion of field investigations (about 1630 hrs.), a meeting was conducted at the Alton Town Hall. The meeting was attended by:

Joyce Tucker / Acadia Insurance
Nathan Whetten / Haley & Aldrich
David Thompson / Haley & Aldrich
John Lavigne / Rivers Engineering
Andrew Pretzer / Douglas G. Peterson & Associates
Richard Doherty / Hydro Environmental Technologies
Gary Jaworski / Jaworski Geotech
Steve Doyon / NHDES
Jim Leung / NHDES
Hank McCourt / Aetna Insurance
Paul Aldinger / P.B. Aldinger & Associates, Inc.
John Halvatzes / Connie's Septic Service, Inc.
Michael Lenehan / Ransmcier & Spellman
W. Allen Marr / GeoTesting Express
Joseph Tomei / GeoTesting Express

It was agreed that additional field work should be conducted next week (scheduled start date of Wednesday, March 27, 1996). Field investigations would be conducted to investigate the following areas:

- The void on the right side of the concrete spillway. The spillway will need to be sawcut to facilitate it's removal and observations of the slab subgrade.

- Uncover the inlet to the low level outlet pipe.

- Collect concrete core samples for possible strength testing.

- Excavate into the right side of the breach so that the soil profile can be logged, density tests may be performed, and samples can be collected.

Joyce Tucker of Acadia Insurance agreed to try and locate other interested parties by Friday, March 22, 1996. She will attempt to contact the concrete supplier and contractor responsible for the concrete work.

Craig Ward will draft a scope of work for the field investigations and distribute it to all interested parties by Friday, March 22, 1996.

A list of key contacts with phone and fax numbers was created and distributed (attached).

The meeting concluded at 1710 hrs.

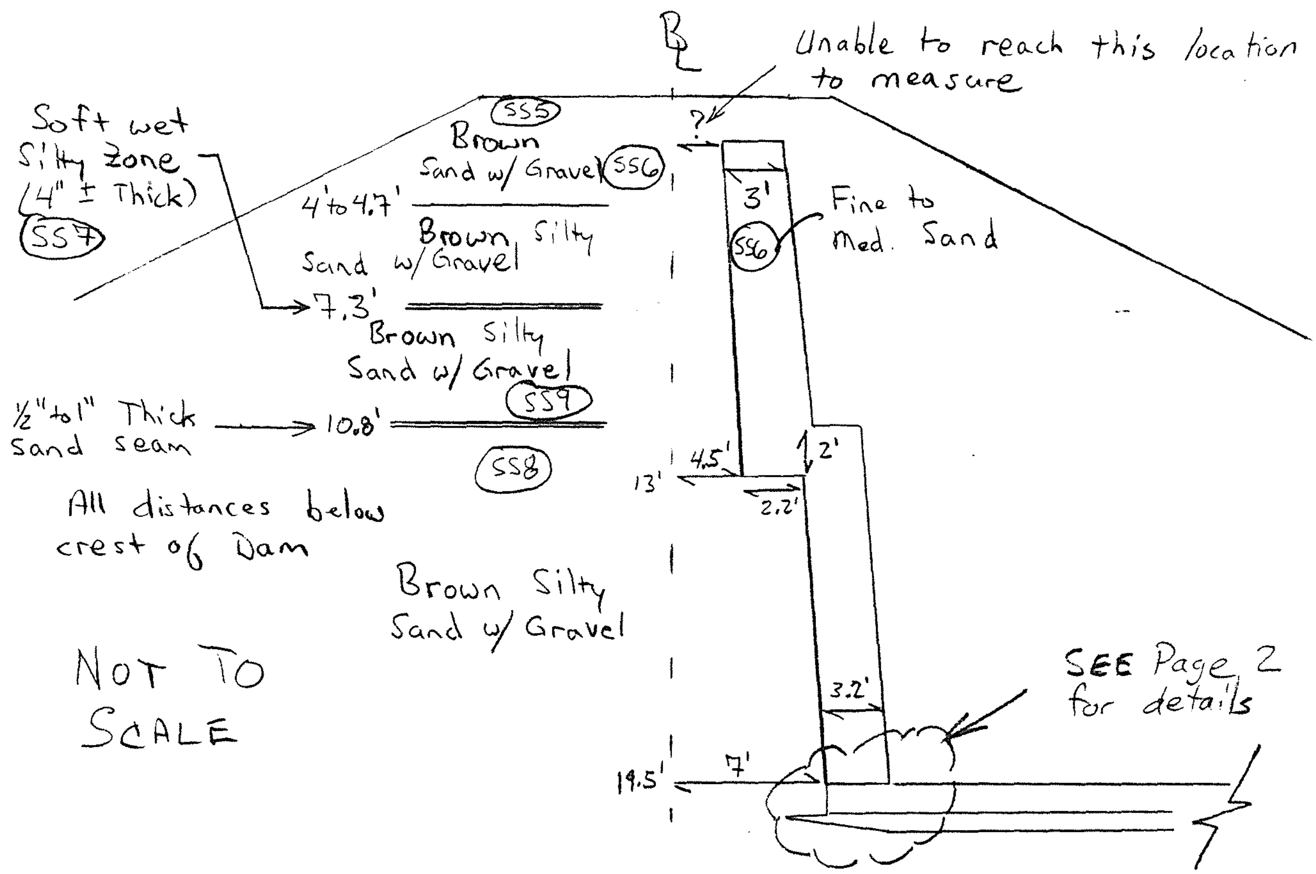
GEI Consultants Inc.
by William L. Hassell
App'd by CW

GEI Consultants, Inc.

FIG. 1

Project	96069	Page	1
Client NHDES- WRD	Date 4/9/96	By	WJH
Subject FIELD OBSERVATION REPORT 3/20/96	Checked	By	
	Approved	By	

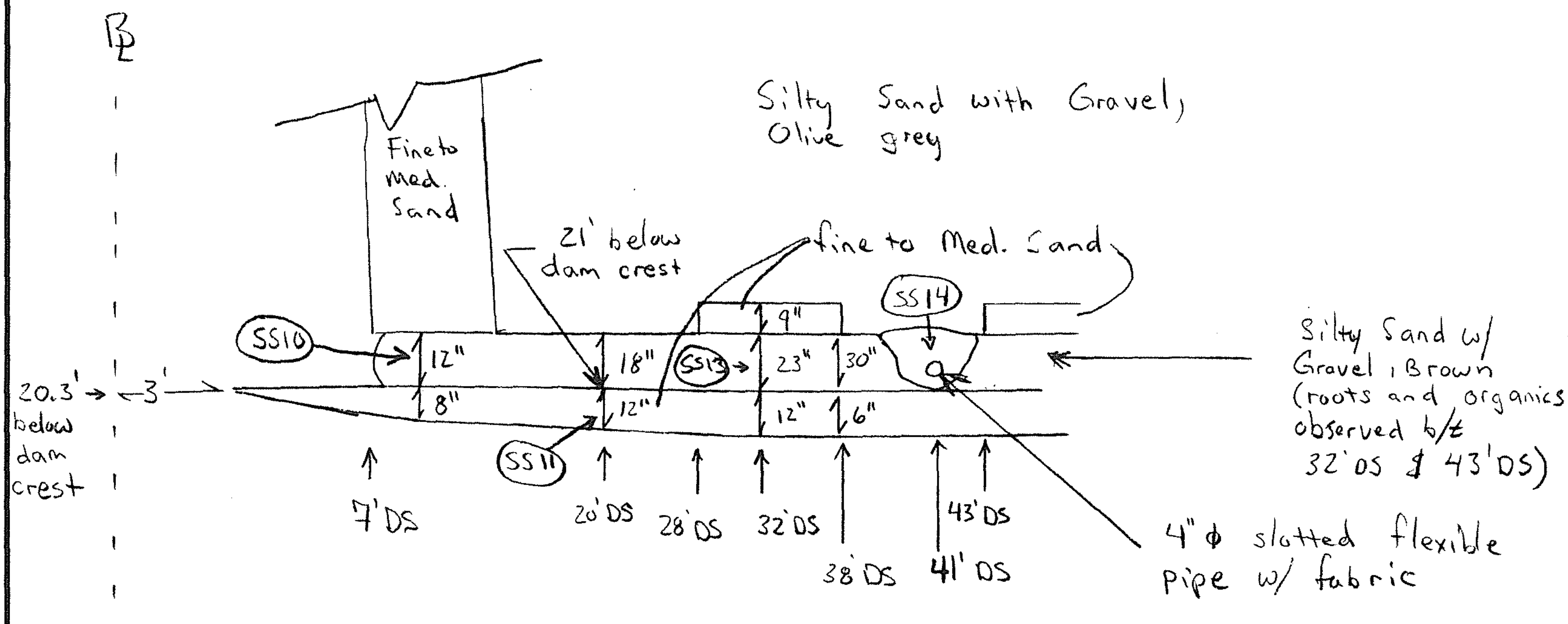
SOIL PROFILE
LEFT SIDE OF BREACH
Approximately Stat 1+28



SS 5 - 4' Below Crest - Brown Sand with Gravel
SS 6 - 4' Below Crest - Fine to Med. Sand (Chimney drain)
SS 7 - 7.3' Below Crest - Soft, wet Silty Zone
SS 8 - 11.7' Below Crest - Silty Sand
SS 9 - 8' Below Crest - Silty Sand

BL is Base Line Stationing Established by Civil Consultants

SOIL PROFILE
LEFT SIDE OF BREACH
Approximately Stat 1+28



Profile not logged beyond 44' DS

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Client: NHDES - WRD
Subject: MEADOW POND DAM - FOR 3/20/96
Project: 96069 Page:
Date: 4/9/96 By: WJH
Checked: By:
Approved: By:

FIG. 2

Figs. 3 & 4

GEI Consultants, Inc.

Project	96069	Page	3
Client NHDES - WRD			
Date	4/10/96	By	WJH
Subject Meadow Pond Dam - FOR 3/20/96			
Checked		By	
Approved		By	

FIGURE 3

Looking Downstream at section of Cut-off wall in breach of dam

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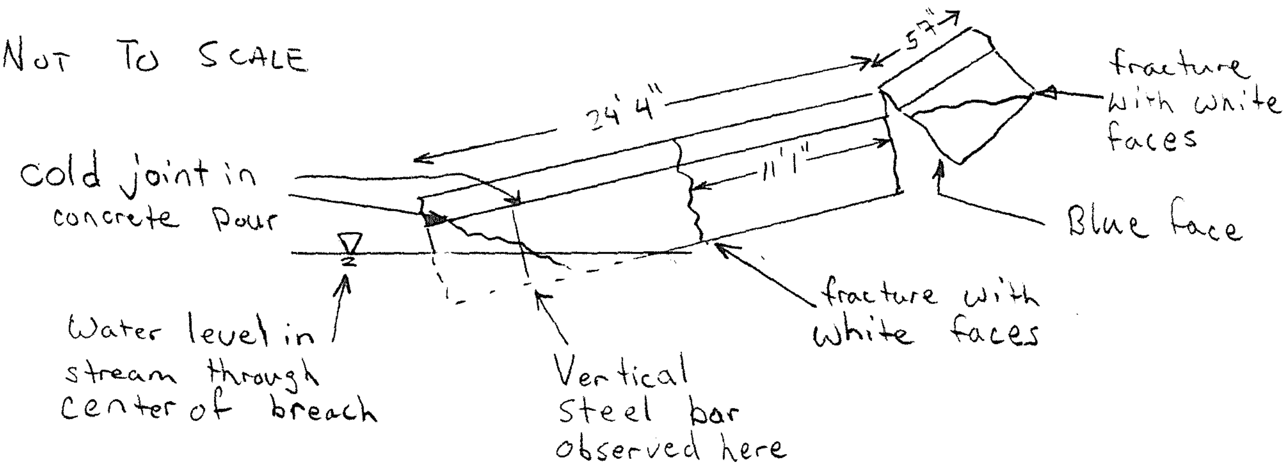
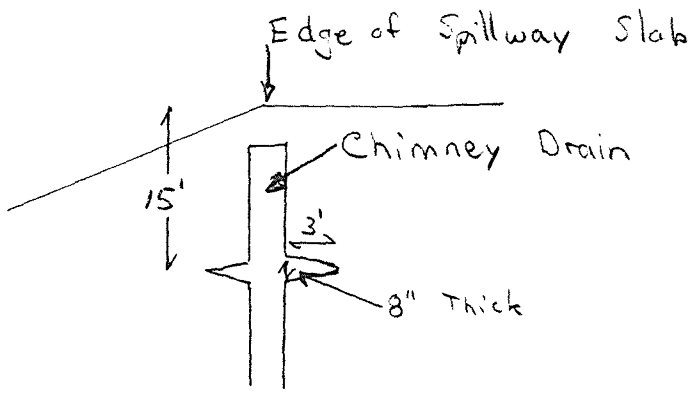


FIGURE 4

Right Side of Breach Approximately Stat. 2+30



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Joyce Tucker *	fax 603-627-9488 800-224-8850	Acadia Ins.
Nathan Whetten	207-883-4411 (207) 883-2438 fax	Haley + Aldrich
John Lavigne *	603-647-8700 647-4128 (fax)	RIVERS ENG'G
ANDREW PRETZER	401/785-2690 FAX NO! 461-9360	DOUGLAS G PETERSON
Richard Doherty *	508-263-4044 FAX 635-0980	Hydro-Environmenta
Gary Jaworski *	603-647-9700 fax 647-4482	Jaworski Geotech
David Thompson *	617/494-4910 fax 577-8142	Haley + Aldrich
Craig Ward *	(603) 224 7979 fax 224-7990	GEI for - State of NH
Bill HASWELL	(603) 224-7979	GEI - for State of NH
Steve N Dayon * (H) 783-0128	(603) 271-3406 FAX 271-7894	NHDES
JIM LEUNG	(603) 271-3406	NHDES
Hank McCourt	(800) 422-3340 x540	Aetna Ins.
Paul B Aldinger	(401) 435-5570 (fax 5569)	PB Aldinger & Assoc Inc for Acadia
John Waluntzes Jr.	(603)-889-2980 (889-8666)	CSSI *
Michael Lenehan	603-228-0477	Ransmeier + Spellman
DR. W. Allen Marr *	508.635.0424 / 508.635.0266	GeoTesting
JOSEPH TOMEI	508-635-0424	GEOTESTING
Tom Varney *		Varney Engineer

FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: March 22, 1996
Client: NHDES, Water Resources Division	Report No. 3
Contractor:	Page 1 of 2

Time of Arrival: 1215 hours	Departure: 1400 hours
Weather: Not recorded	
Persons Contacted/Company None	**GEI Representatives** Craig Ward Gonzalo Castro

The purpose of this site visit was to provide Gonzalo Castro an opportunity to view the site. Gonzalo Castro and I made observations, measured dimensions on the intact section of the spillway at the right side of the breach, and measured elevations of the intact section of the spillway and the ice adhered to the riprap on the upstream face of the embankment.

Relative elevations of various points on the intact section of the spillway and ice adhered to riprap were measured. Relative elevations (with top of right end of concrete abutment wall at assumed elevation 100') are indicated below:

Elevation	Location
97.88'	Ice on upstream face of dam upstream of station 3+20 (Civil Consultants' baseline)
97.51'	Ice on upstream face of dam upstream of station 3+30
100' (Assumed)	Top of westernmost portion of concrete abutment wall, right side of spillway (see location 3 on Figure 1)
96.66'	Horizontal spillway slab upstream of station 2+42 (see location 4 on Figure 1)
99.87'	Top of easternmost portion of the concrete abutment wall, right side of (see location 5 on Figure 1)

The results of the survey data indicate that ice at stations 3+20 and 3+30 was between 0.85' and 1.22' higher than the spillway.

The dimensions of the concrete spillway were measured and are shown on Figure 1.

The following features were observed:

- The void at the right end of the cutoff wall.

FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: March 22, 1996
Client: NHDES, Water Resources Division	Report No. 3
Contractor:	Page 2 of 2

- Chimney drain on the right and left side of the breach.
- The blanket drain and filter layers on the left side of the breach.
- The broken sections of the concrete spillway slab and cutoff wall, some with a blue hue, and others with a gray color.
- Dark brown sand and gravel layer (with significant silt content) under intact spillway slab at right side of the breach.
- Light brown sand and gravel (with significant silt content) under the grouted riprap along the right side of the breach.
- Sloughed soil and riprap along the upstream face of the right embankment.

During our Site visit USGS personnel were surveying the area downstream of the breach.

GEI Consultants Inc.

by [signature]

App'd by [signature] for Gonzalo Castro

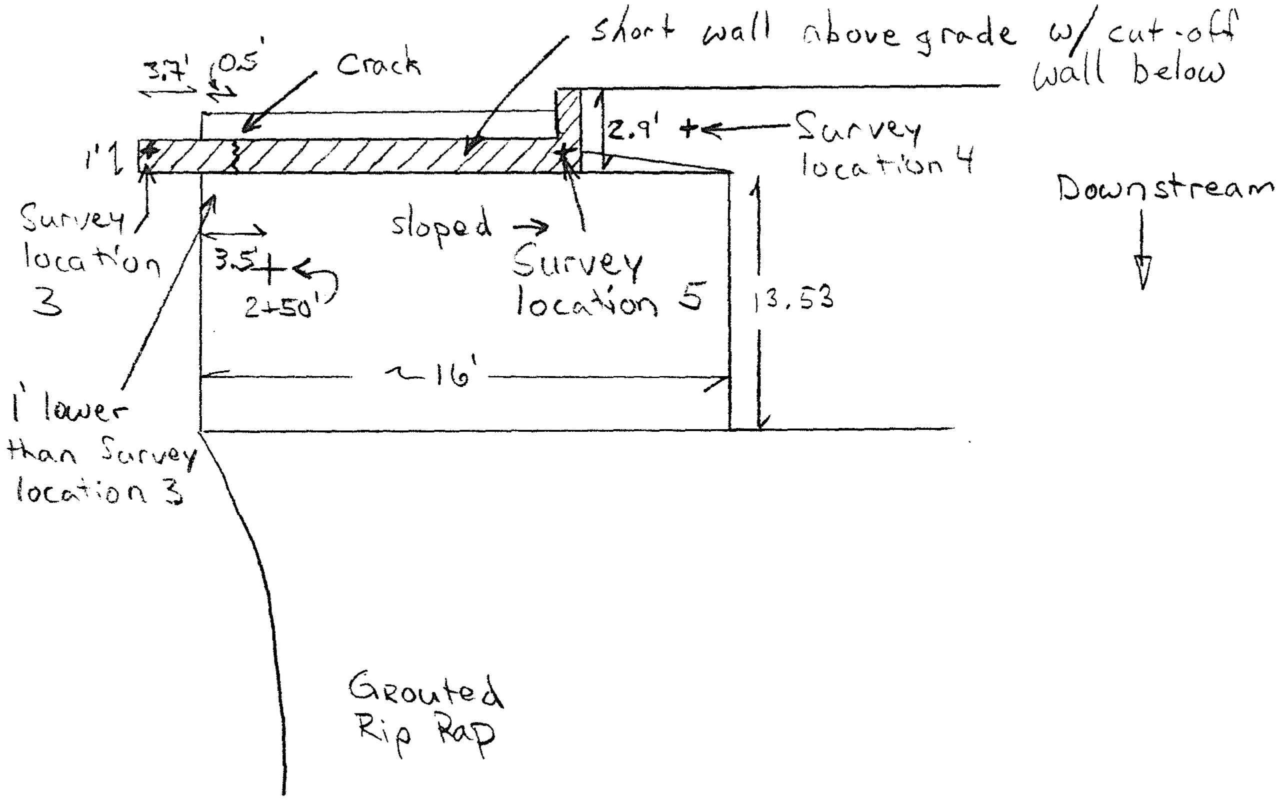
FOR-03.322

GEI Consultants, Inc.

Figure 1

		Project 96069	Page 1
Client NHDES - WRD		Date 4/10/96	By WJH
Subject Meadow Pond Dam	FOR 3/22/96	Checked	By
		Approved	By

Right side of Spillway



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FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: April 1, 1996
Client: NHDES, Water Resources Division	Report No. 4
Contractor: J.R. Olson Excavating Contractor	

Time of Arrival: 0745 hours	Departure: 1655 hours
Weather: Sunny, temperature in the 30's°F, light wind	
Persons Contacted/Company See attached attendance sheet distributed by Richard Doherty of Hydro Environmental Technologies, Inc.	**GEI Representatives** William Haswell Craig Ward

0810 hrs. The excavator was in place to untangle the pile of concrete (a section of the spillway) located downstream of the breached section of the dam.

0830 hrs. Allen Marr held a brief meeting and outlined the following agenda for field investigations to be conducted during the week (listed in order of how tasks will be performed):

- Untangle the portion of the cutoff wall located downstream of the breach.
- Saw cut the spillway slab and remove it.
- Investigate the void at the right side of the existing portion of the cutoff wall.
- Excavate the right side of the breach in a series of benches.

0900 hrs. (approximately). The concrete sawing contractor arrived on-site.

0950 hrs. The excavator began to untangle the pile of concrete. However, the excavator was unable to untangle the concrete and work was stopped to obtain equipment to cut the reinforcing steel to allow the pieces of concrete to be separated.

The grouted riprap on the right side of the breach was measured to be between 0.8' and 1.4' thick. The grouted riprap is generally one layer of stone thick. I observed an area of different color concrete on the grouted riprap slope from the downstream edge of the concrete spillway slab to about 14' downstream that appeared to indicate grout repair.

Measurements of the spillway slab are shown in Figure 1. The cracks in the concrete spillway were mapped and are shown in Figure 2.

A concrete saw was used to cut the spillway slab into "blocks" which could be lifted by the excavator. Core holes were drilled in the slab so that a chain could be attached which would allow the excavator to pick each block up. Water was applied to the concrete saw blade during and core hole bit cutting. The saw cut

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 1, 1996
Client:	NHDES, Water Resources Division	Report No. 4
Contractor:	J.R. Olson Excavating Contractor	Page 2 of 2

locations, dimensions of the blocks, core hole locations, and thicknesses of the blocks sawed today are shown in Figures 3 through 5. Core W15 (not shown in the Figure) was obtained from the grouted riprap spillway.

Blocks 1 and 2 of the concrete spillway slab were removed. The slab subgrade was observed to be smooth fine to medium sand.

After block 3 was removed, a void was observed beneath portions of the remaining spillway slab to the right. The locations of the voids are shown in Figure 6 and identified as void 1 and void 2.

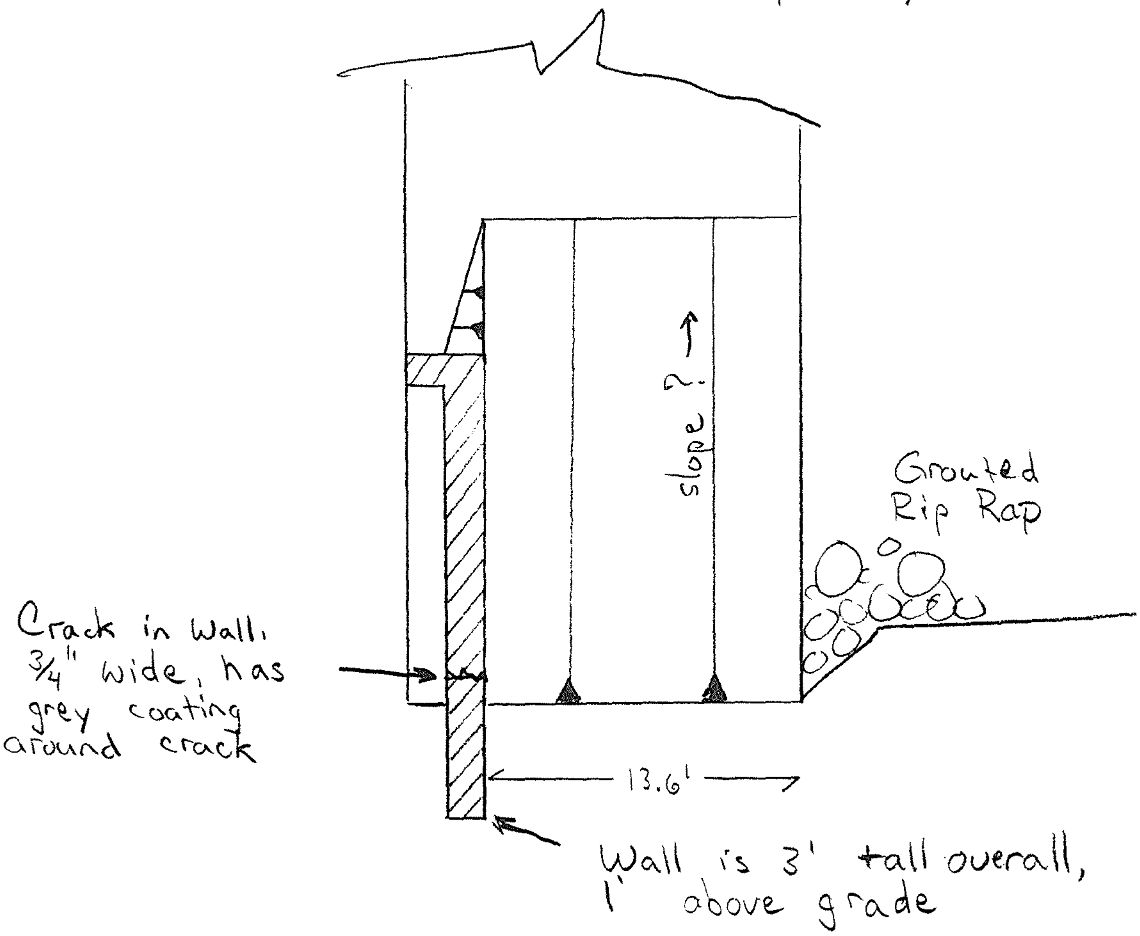
GEI Consultants Inc.
by William L. Haswell
App'd by

Figure 1

GEI Consultants, Inc.

		Project 96069	Page 1
Client NHDES- WRD		Date 4/10/96	By WJN
Subject Meadow Pond Dam	FOR 4/1/96	Checked	By
		Approved	By

Right side of concrete spillway



NOT TO SCALE

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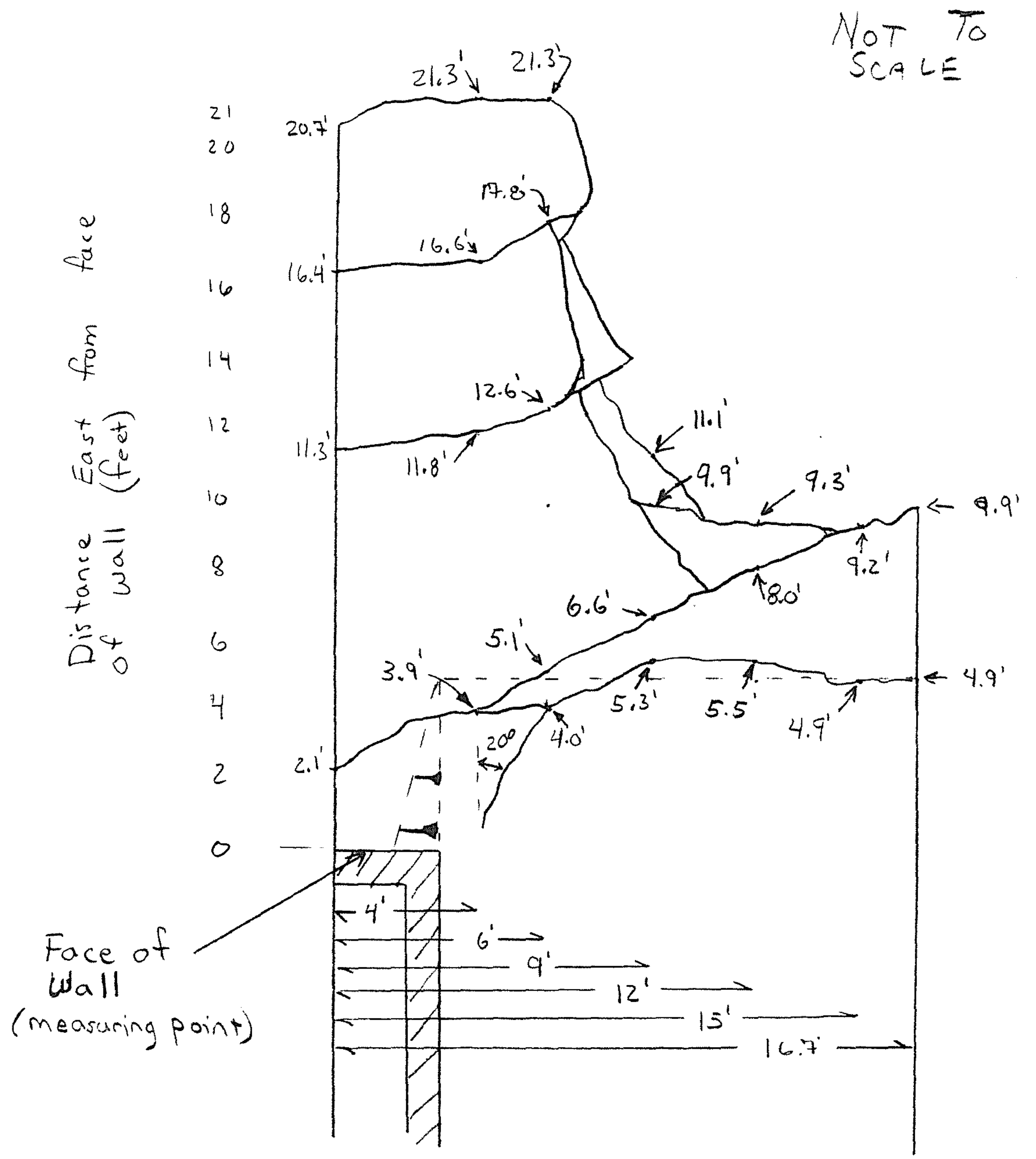
Figure 2

Project	96069	Page	1
Date	4/10/96	By	WJH
Checked		By	
Approved		By	

Client NHDES- WRD

Subject Meadow Pond Dam - FOR 4/1/96

Crack Mapping
Right side of concrete spillway



All unspecified measurements are a distance east from face of wall (measuring point) at off-sets shown.

Figure 3

Φ GEI Consultants, Inc.

		Project 96069	Page
Client	NHDES - WRD	Date 4/11/96	By WJH
Subject	Meadow Pond Dam - FOR 4/1/96	Checked	By
		Approved	By

Concrete Core Locations
Right side of Concrete Spillway

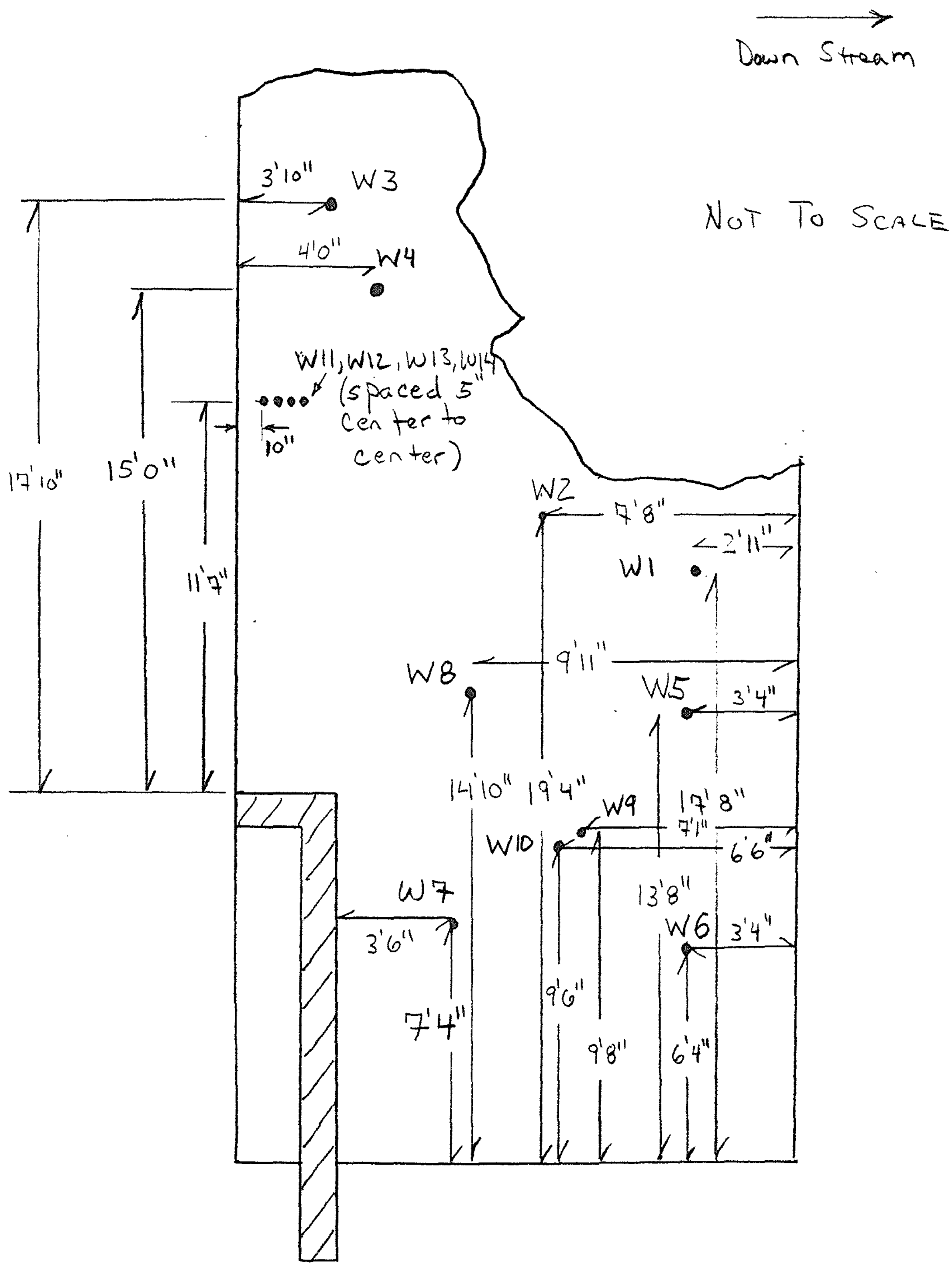


Figure 4

GEI Consultants, Inc.

Client	NHDES-WRD	Project 96069	Page
		Date 4/10/96	By WJH
Subject	Meadow Pond Dam - FOR 4/1/96	Checked	By
		Approved	By

CONCRETE SAW CUT LOCATIONS & BLOCK No.
Right Side of Concrete Spillway

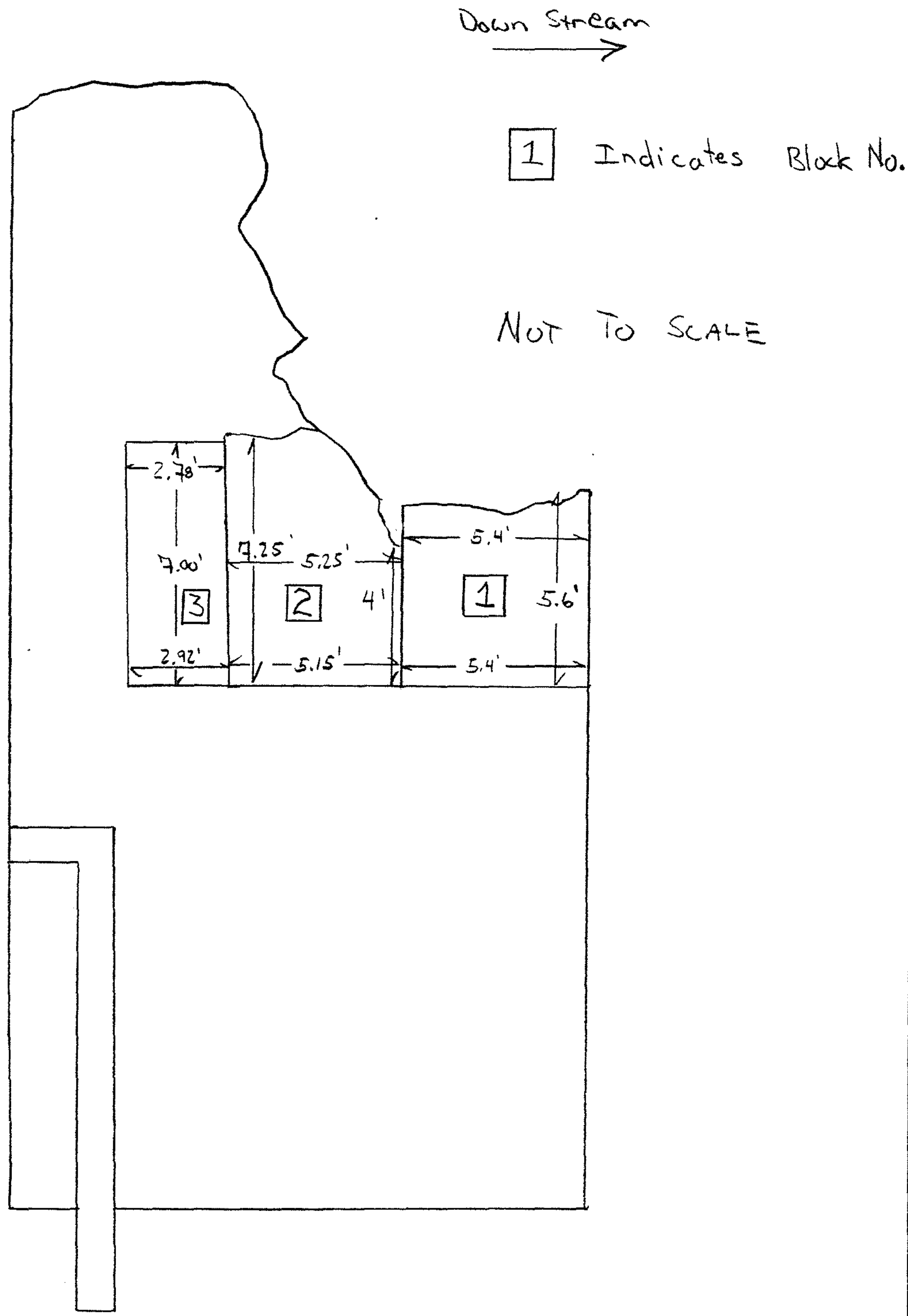
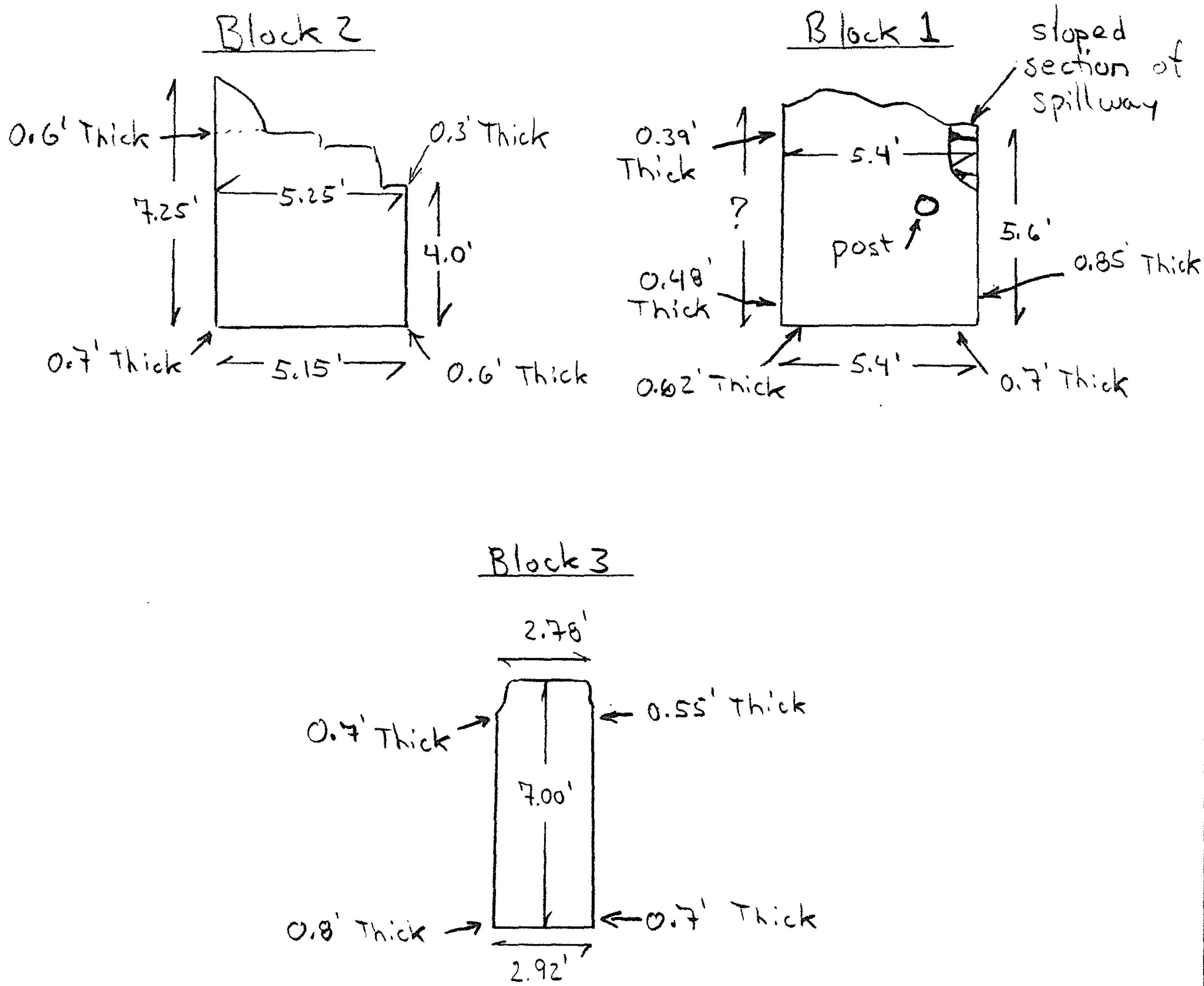


Figure 5

GEI Consultants, Inc.

Client	NHDES - WRD	Project 96069	Page
Subject	Meadow Pond Dam - FOR 4/1/96	Date 4/11/96	By WJH
		Checked	By
		Approved	By

Concrete Block Section Details
Right side of Concrete Spillway



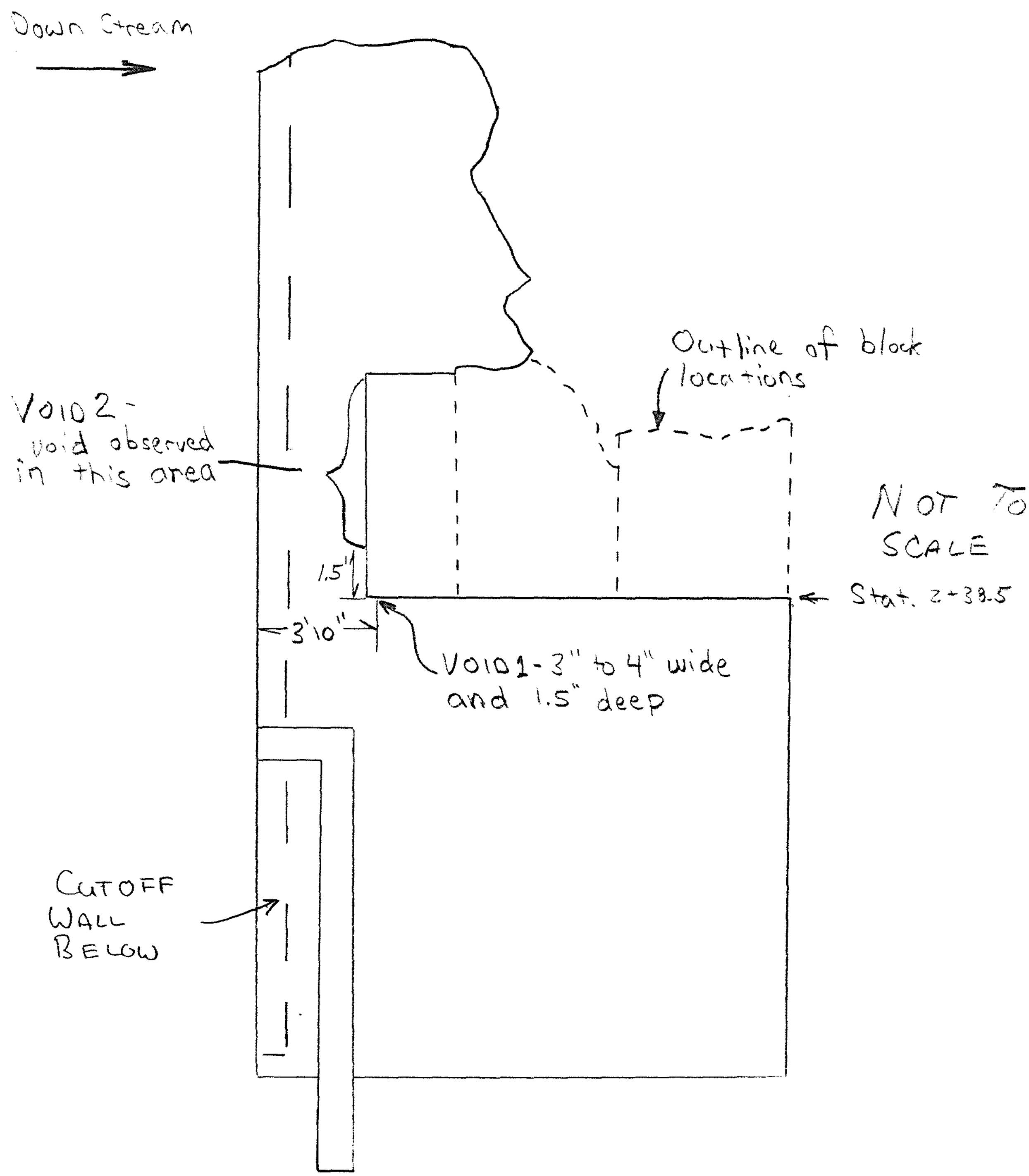
NOT TO SCALE

GEI Consultants, Inc.

Figure 6

Project	96069	Page	
Client	NHDES - WRD		
Date	4/16/96	By	WJH
Subject	Meadow Pond Dam FOR 4/1/96		
Checked		By	
Approved		By	

CONCRETE SPILLWAY
RIGHT SIDE OF BREACH



SIGN-IN SHEET

Bergeron Dam

Alton, New Hampshire

Date: April 1, 1996

The undersigned agree that they are responsible for their own safety while on the Bergeron property, and agree to idemnify and hold harmless the property owners for any and all claims arising out of their activities or the activities of their employees while on the property.

Signature	Printed Name	Company
[signature]	Richard Doherty	Hydro-Environmental
[signature]	DONALD O DUSENBERRY	Simpson Gumpertz & Heger
[signature]	William O. Hoodtte	Brox Concrete
[signature]	CRAIG WARD	GEI
[signature]	Lizetta M Brown	Haley + Aldrich.
[signature]	Ed McSweeney	Haley & Aldrich
Nathan Whetten	[signature]	Haley + Aldrich
[signature]	William Haswell	GEI
[signature]	HARRI KYTOMAA	FAILURE ANALYSIS ASSOC.
[signature]	Marlin J. Cook	[illegible] Ins. Co.
[signature]	JOSEPH TOMEI	GEO-TESTING EXPRESS
W. Allen Marr	W. Allen Marr	Geo-Testing Express
[signature]	MICHAEL C. PENNEY	GEOINSIGHT, INC.
[signature]	JONATHAN C. BARRETT	GEO INSIGHT INC.
[signature]	PAUL B ALDINGER	DG. PETERSON, Inc.
[signature]	C A PRETZER	"
[signature]	TIMOTHY S FREESE	ACADIA INS.
GARY JAWORSKI	[signature]	JGI
CHRIS COOLEY	[signature]	HTE
ROD STARK	[signature]	STARK LAW FIRM (RIVERS)
[signature]	JOHN LAVIGNE	RIVERS ENG'ING
[signature]	JIMMY LEUNG	NHDES
[signature]	LOUIS FOISY	LEGAL EVIDENCE PHOTO (FOISY PHOTO)
Bill Zoino		Zoino-Hebert Inc
JACK MACKSEY	[signature]	CONCRETE BORING Co.
[signature]	BILL HARTWICK	CONCRETE CORING Co.

(BergFrm.doc)

Bergeron Dam
Alton, New Hampshire

Date: April 1, 1996

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Signature	***Printed Name***	***Company***
[illegible]	MARK MALLORY	Baird - Malley
[illegible]	KEVIN MARTIN	FOR JGI
Tom Vanney	Tom Vanney	VANNOY ENG.
Michael M Peters	Michael M Peters	" "
Michael Lenehan	MICHAEL LENEHAN	Ransacier + Spellman
Bill Konicki	Bill Konicki	GEI
Jayce Tucker	Jayce Tucker	Acadia
Pete Cowan	Pete Cowan	Sheehan Plumbing
Albert Palasca	Albert Palasca	DPIC
Gonzalo Castro	Gonzalo Castro	GEI Consultants Inc
[illegible]	WILL WRIGHT	GEI Consultants Inc
[illegible]	Peter Spaulding	NH Exec Council
Ken Nash	Ken Nash	← " —

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 2, 1996
Client:	NHDES, Water Resources Division	Report No. 5
Contractor:	J.R. Olson Excavating Contractor	Page 1 of 3

Time of Arrival: 0750 hours	Departure: 1700 hours
Weather: Light rain and snow, temperature in the low 30's°F	
Persons Contacted/Company See attached attendance sheet distributed by Richard Doherty of Hydro Environmental Technologies, Inc.	**GEI Representatives** William Haswell Craig Ward

The remaining portions of the spillway slab were saw cut in the morning. While the slab was being cut, I walked downstream of the dam and observed several pieces of concrete. The following data was collected:

- A section of the baffle wall was observed several hundred feet downstream of the dam. The footing was 1' thick. The wall was 1.8' tall. The overall length of the baffle wall was measured to be 19.4'.

- A short section of partially buried concrete was observed. The sides of the concrete were curved and rough, similar to that observed in the intact section of the cutoff wall. The exposed portion was 2.8' long and 4.3' deep.

- A section of concrete with smooth formed tapered sides and grey painted surface similar to the far right section of the intact concrete spillway abutment wall was observed. The concrete was 1.1' tall at one end and 2.4' tall at the other end. The length of the concrete was 9.8'.

- A partially buried section of concrete with rough poured surfaces was observed. The concrete was approximately 5' long and 2.6' wide. The exposed end of the concrete is formed at an angle and measures 1.7' thick (thickness measured at an angle).

The remainder of the spillway slab was removed today. The locations and dimensions of the blocks are provided in Figures 1 and 2. The blocks were removed in numerical order. Observations made during the removal of the spillway slab follow:

- <u>1000 hrs.</u> Block 4 was removed from the spillway slab. The subgrade beneath block 4 was smooth with no evidence of erosion.

- Block 5 was removed from the spillway slab. An area of protruding gravel was observed on the subgrade at the location shown in Figure 3. The remaining portion of the subgrade was a smooth surface of fine to medium sand. An approximately 7" tall by 2.5' wide void was observed at the location shown in Figure 3.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 2, 1996
Client:	NHDES, Water Resources Division	Report No. 5
Contractor:	J.R. Olson Excavating Contractor	Page 2 of 3

- Block 6 was removed from the spillway. The subgrade was observed to be a smooth surface of fine to medium sand.

- Block 7 was removed from the spillway slab. An area of protruding gravel was observed on the subgrade beneath the upstream edge of the block (see Figure 4). An area of protruding gravel approximately 2" wide was observed to cross the subgrade beneath block 7 as shown in Figure 4. The corresponding area on the bottom of the slab was observed to be dry while the remainder of the slab bottom was damp. A void was observed along the upstream edge of block 7 subgrade. Protruding gravel was also observed along the surface of soil beneath the void. The void at right end of the upstream side of the cutoff wall (standing upstream of the cutoff wall) was observed to be connected to the void observed at the upstream edge of the block 7 subgrade (see Figure 5). The remainder of the subgrade was smooth fine to medium sand.

An area was prepared by Haley & Aldrich (H&A) to conduct density testing (nuclear density gauge) on the slab subgrade. Field Density test FD1 was conducted on the subgrade beneath the sloping spillway slab. Four density tests (FD1-H&A,S, FD1-H&A,E, FD1-H&A,N and FD1-H&A,W)were conducted by H&A at this location by rotating the instrument about the probe location (at front of the instrument) at 90° intervals. GEI conducted one density test at this location (FD1-GEI,W). An area adjacent to FD1 was prepared (a level surface) for density testing by H&A using nuclear methods and a sand cone (FD1a-H&A). The results of the density testing are summarized in a table at the end of this field observation report.

A test pit was excavated parallel to the crest of the dam, 4' downstream from the spillway wall on the right side of the breach. The location of the excavation and a soil profile are shown in Figure 6. After increasing the length and width of the excavation, the second soil profile was logged at five locations, as shown in Figure 7.

Field density test FD2 was conducted by H&A on embankment core fill. The test results are summarized in the table at the end of this field observation report.

The thickness of the grouted riprap immediately downstream of the spillway was measured to be between 10" and 14" thick.

Soil sample SS20 was collected from beneath the grouted riprap at station 2+42, 12' downstream (elevation not measured). This soil is a silty sand, not sand and gravel as specified in the design drawings. Discontinuous pockets of sand were observed beneath some portions of the grouted riprap in the area of sample SS20.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 2, 1996
Client:	NHDES, Water Resources Division	Report No. 5
Contractor:	J.R. Olson Excavating Contractor	

The following table summarizes the soil samples collected today:

Sample No.	Station	Offset	Description
SS19	2+41	2' US	Silty sand with gravel, part of embankment core, 3.5' below slab subgrade.
SS20	2+42	12' DS	Silty sand - from beneath grouted riprap.

Note: US and DS indicate upstream and downstream, respectively, of baseline stationing established in the field by Civil Consultants on March 19, 1996.

Field Density Testing Results
Nuclear Method

Test No.	Station	Off-set	El. (ft)	Wet Density (pcf)	Dry Density (pcf)	Water Content (%)
FD1-H&A, S	2+48	5' US	682.0	133.2	119.8	11.2
FD1-H&A,E	2+48	5' US	682.0	133.3	121.1	10.0
FD1-H&A,N	2+48	5' US	682.0	136.7	123.2	11.0
FD1-H&A,W	2+48	5' US	682.0	136.6	123.8	10.3
FD1-GEI, W	2+48	5' US	682.0	137.6	125.2	9.9
FD1a-H&A	2+48	5' US	682.0	131.5	117.5	12.0
FD2-H&A	2+48	4' US	678.0	135.2	119.7	13.0

Notes: Samples were collected from the locations of FD1 and FD2 for laboratory analysis.
US and DS indicate upstream and downstream respectively, of baseline stationing. Elevations referenced to "Rivers Datum". Baseline stationing with elevation control established in the field by Civil Consultants on March 19, 1996.

GEI Consultants Inc.
by William J. Haswell
App'd by GW

Figure 1

GEI Consultants, Inc.

		Project 96069	**Page**
Client NHDES-WRD		**Date** 4/11/96	**By** WJH
Subject Meadow Pond Dam FOR 4/2/96		**Checked**	**By**
		Approved	**By**

Concrete Saw Cut Locations
Right side of Concrete spillway

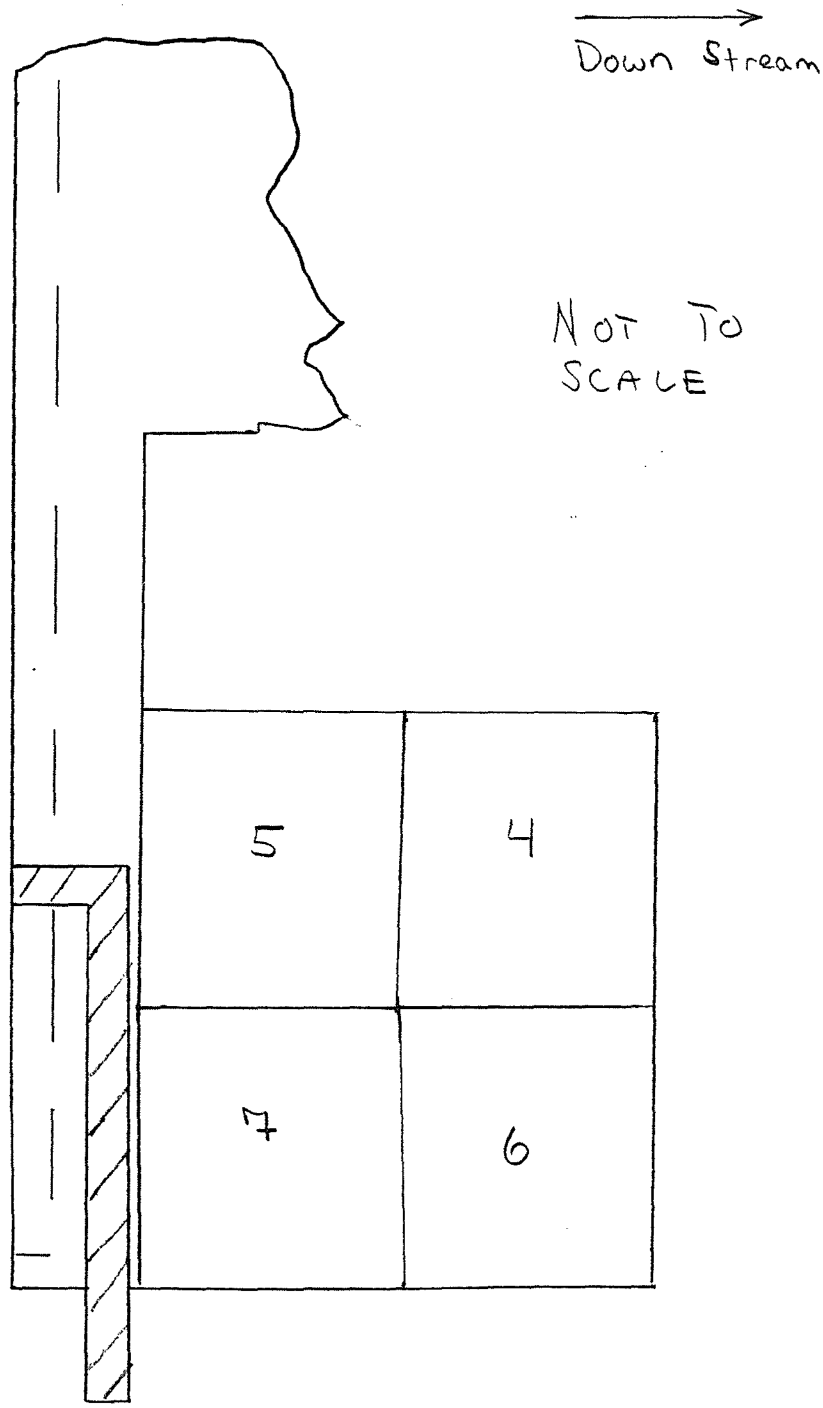


Figure 2

GEI Consultants, Inc.

		Project 96069	Page
Client NHDES-WRD		Date 4/11/96	By
Subject Meadow Pond Dam - FOR 4/2/96		Checked	By
		Approved	By

Concrete Slab Section Details
Right Side of Concrete Spillway

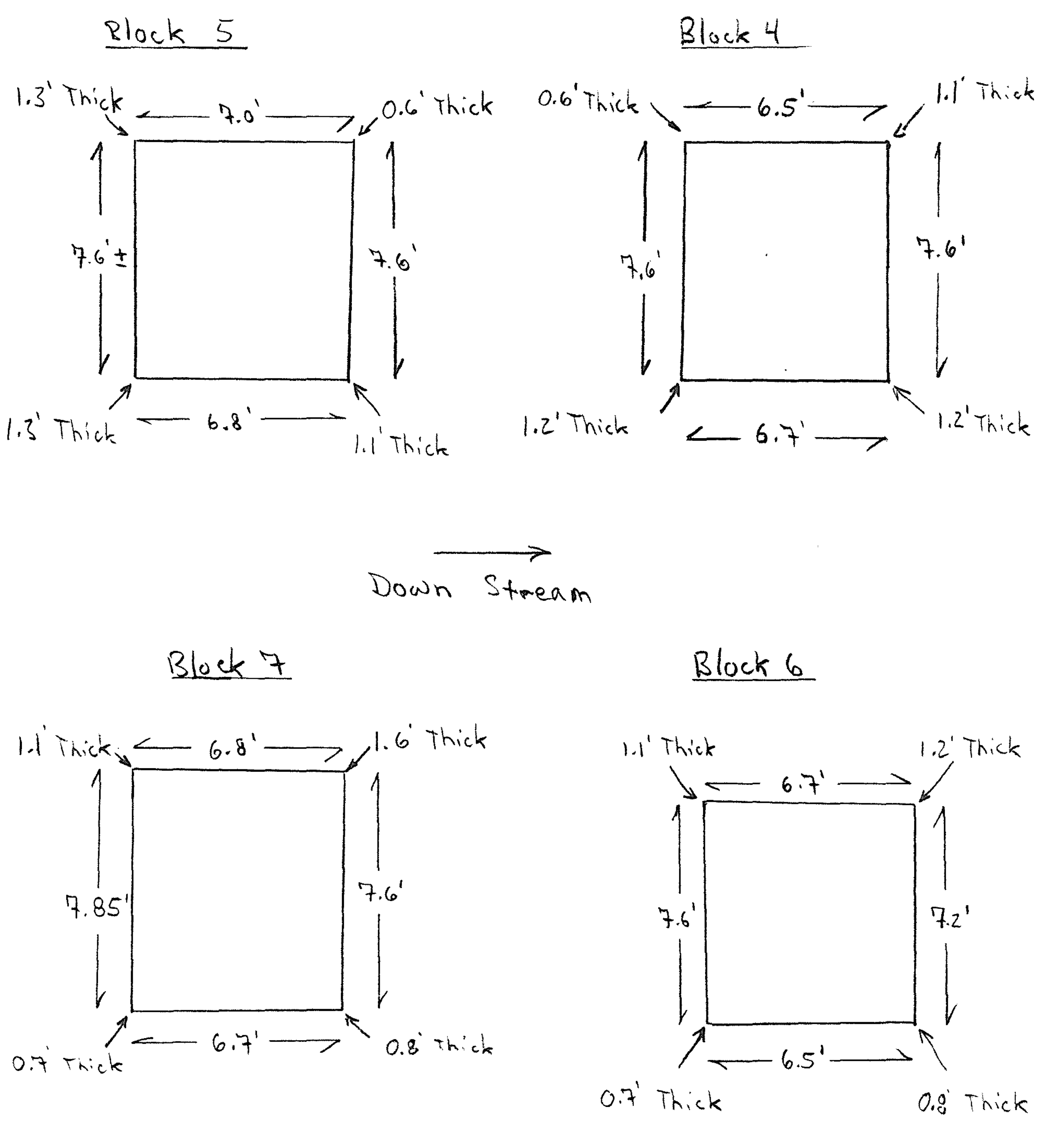
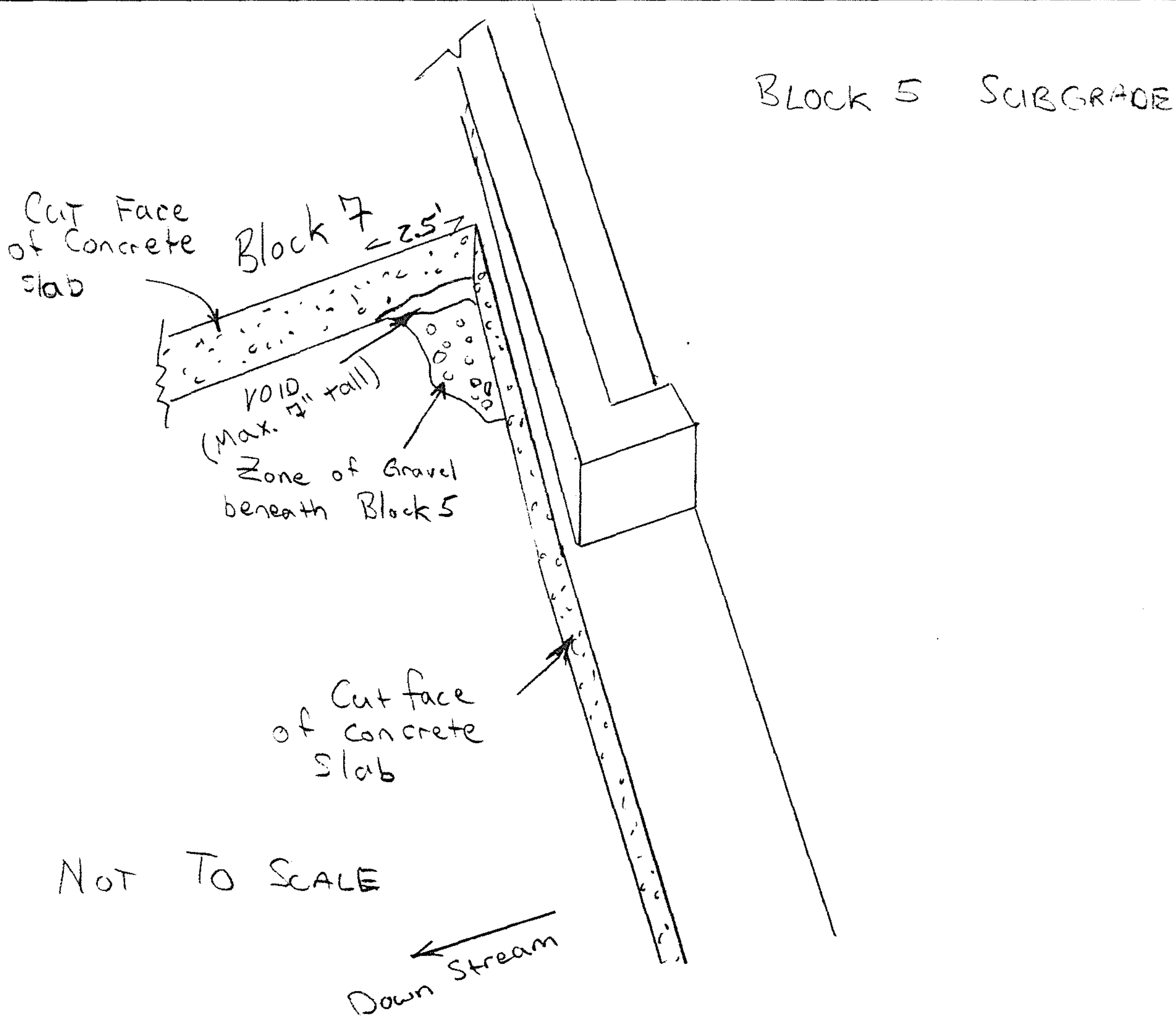


Figure 3

Φ GEI Consultants, Inc.

		Project 96069	Page
Client NHDES-WRD		Date 4/11/96	By WJH
Subject Meadow Pond Dam	FOR 4/2/96	Checked	By
		Approved	By



An area of gravel was observed beneath the sloped portion of the spillway slab (beneath Block 5). The surface of the remaining subgrade was fine to medium sand (no protruding gravel)

FIGURE

GEI Consultants, Inc.

Project	96069	Page	
Date	4/11/96	By	WJH
Checked		By	
Approved		By	

Client: NHDES-WRD

Subject: Meadow Pond Dam FOR 4/2/96

OBSERVATIONS OF SPILLWAY SLAB SUBGRADE
RIGHT SIDE OF CONCRETE SPILLWAY

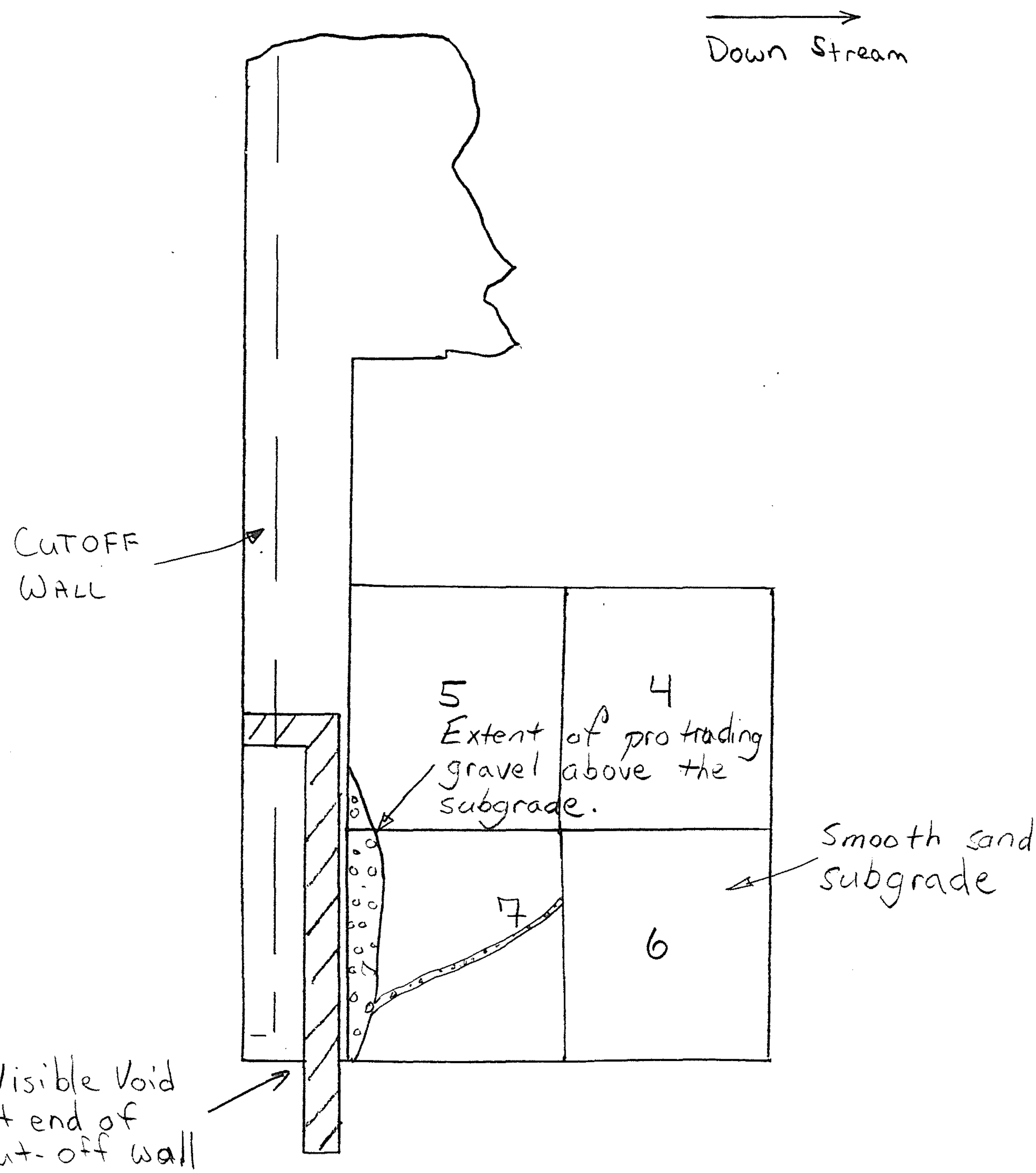
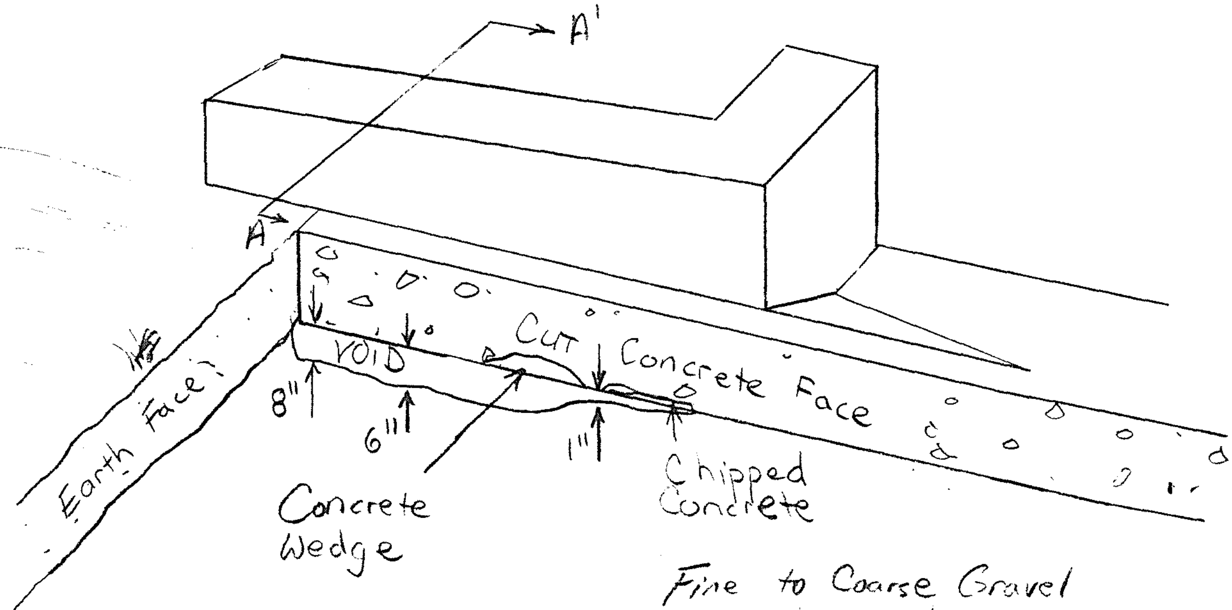


FIGURE 5

GEI Consultants, Inc.

		Project 96069	Page
Client	NHDES - WRD	Date 4/11/96	By WJH
Subject	Meadow Pond Dam FOR 4/7/96	Checked	By
		Approved	By

OBSERVATIONS OF SPILLWAY SLAB SUBGRADE
RIGHT SIDE OF CONCRETE SPILLWAY



Fine to Coarse Gravel was observed on the surface of the void

SECTION A-A'

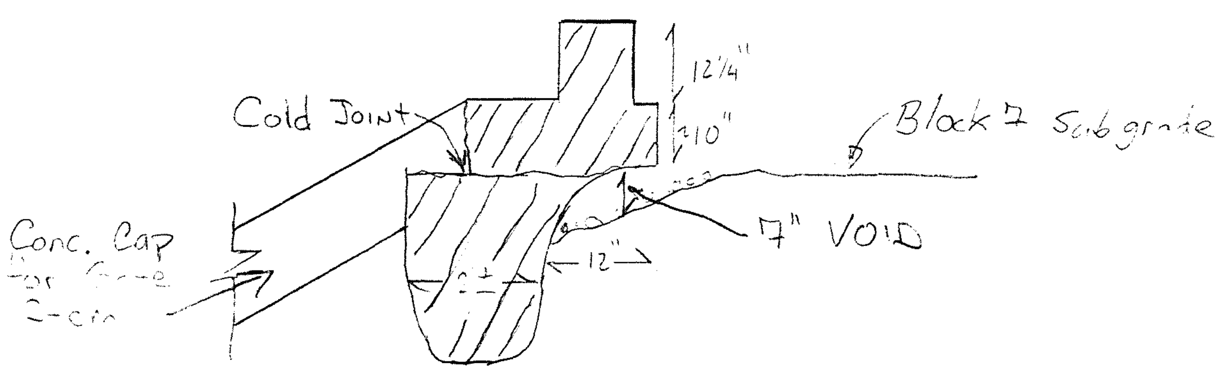


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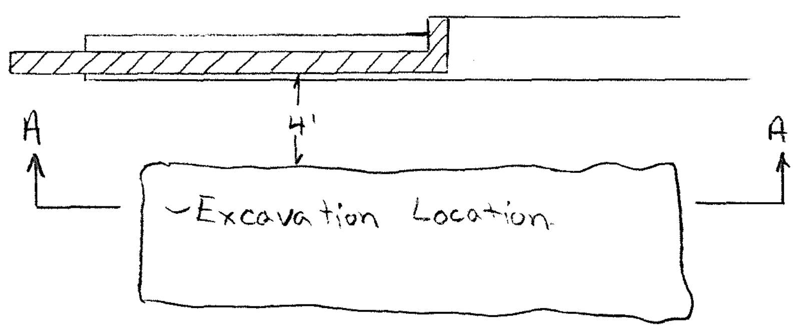
FIGURE 6

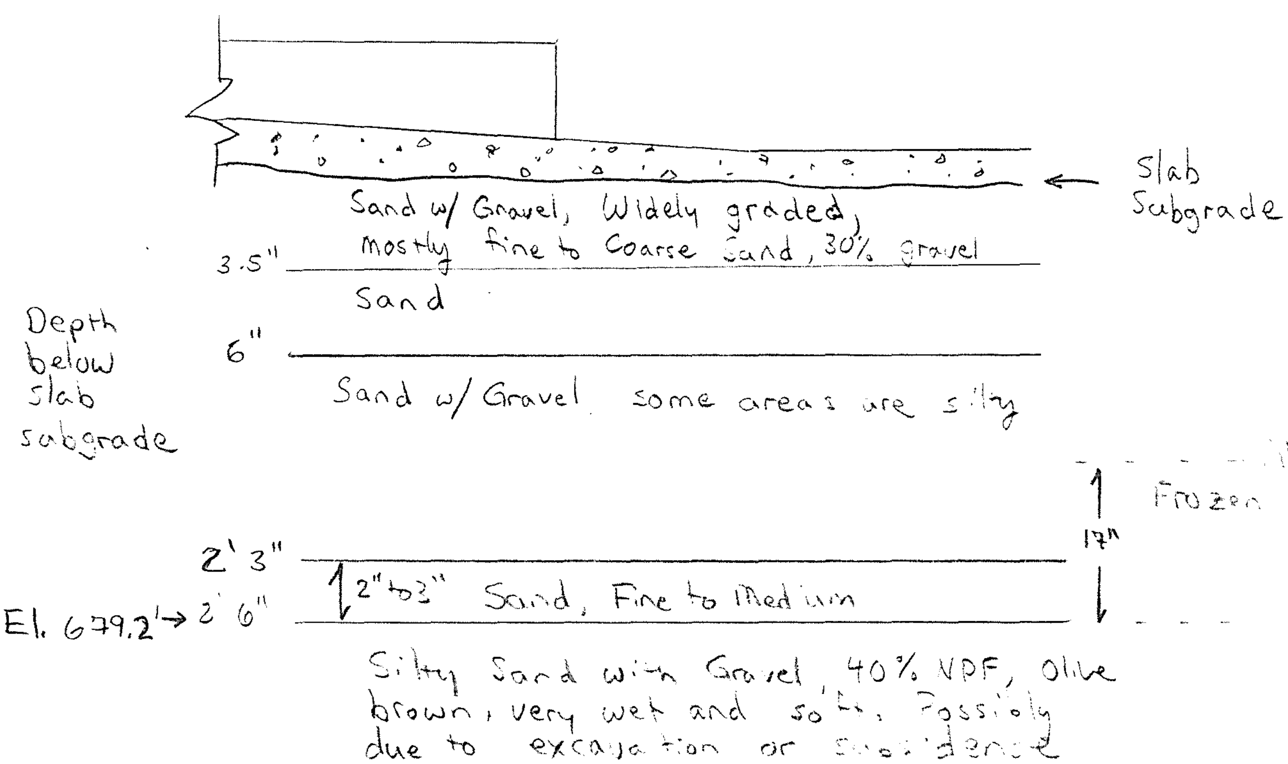
Client	NHDES - WRD	Project 96069	Page
Subject	Meadow Pond Dam FOR 4/2/96	Date 4/18/96	By WJH
		Checked	By
		Approved	By

EXCAVATION LOCATION

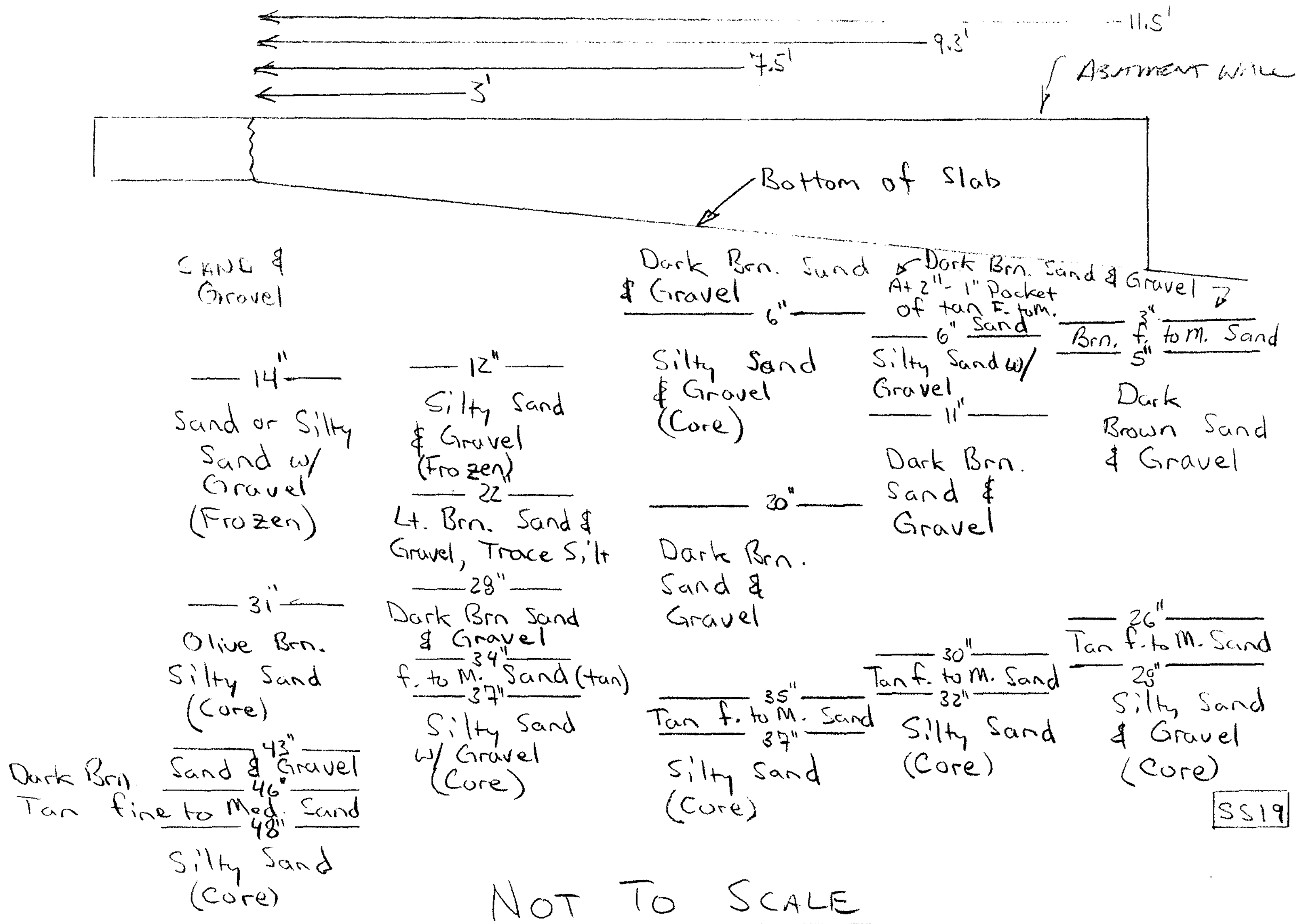


SOIL PROFILE

SECTION AA



SOIL PROFILE
3.5' Down Stream of Abutment WALL



NOT TO SCALE

(LOOKING UPSTREAM)

GEI Consultants, Inc.

Client NHDES - WRD

Subject Meadow Pond Dam FOR 4/2/96

FIGURE 7

Project 96069 Page

Date 4/11/96 By WJH

Checked By

Approved By

SIGN IN SHEET

Bergeron Dam
Alton, New Hampshire

Date: April 2, 1996

The undersigned agree that they are responsible for their own safety while on the Bergeron property, and agree to idemnify and hold harmless the property owners for any and all claims arising out of their activities or the activities of their employees while on the property.

Signature	Printed Name	Company
[illegible]	William O. Hodo III	Brox Contrctg
[illegible]	Richard Doherty	Hydro Environmental
[illegible]	Joseph Tomei	GeoTesting Express
[illegible]	Jonathan C. Brackett	Geo Insight Inc.
[illegible]	Chris Cooley	HTE
[illegible]	Nathan Whetten	Haley + Aldrich
W. Allen Marr	Marr	GeoTesting Express
[illegible]	Donald O Dusenberry	Simpson Gumpertz & Heger
William J. Harnack	William J. Harnack	GEI
[illegible]	Tim Freese	Acadia Ins.
[illegible]	Jimmy Lenny	DES
Harri Kytomaa	Harri Kytomaa	FaAA
Jon Wren	Jon Wren	FaAA
[illegible]	Marlies J. Cook	[illegible]
Richard A Mitchell	[illegible]	Sullivan & Gregg
Louis Foisy	[illegible]	Foisy Photo
John Lavigne	[illegible]	Rivers Eng'g
Craig F. Ward	Craig Ward	GEI
Ed McSweeney	Ed McSweeney	Haley & Aldrich
[illegible]	Lizette M Brown	Haley & Aldrich
[illegible]	Gary Jaworski	J GI
[illegible]	Bill Hartwick	Concrete Coring Co.
[illegible]	Jack Maciejczyk	Concrete Coring Co.
Tom Varney	Tom Varney	Varney Eng
Paul B. Aldinger	Paul B. Aldinger	D.G. Peterson & Assoc.
D. Thompson	Dave Thompson	Haley & Aldrich
Steve Dellamusso	Steve Dellamusso	SG & H

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FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: April 3, 1996
Client: NHDES, Water Resources Division	Report No. 6
Contractor: J.R. Olson Excavating Contractor	Page 1 of 2

Time of Arrival: 0730 hours	Departure: 1705 hours
Weather: Sunny, very windy, temperatures in the 40's° F	
Persons Contacted/Company See attached attendance sheet distributed by Richard Doherty of Hydro Environmental Technologies, Inc.	**GEI Representatives** William Haswell Craig Ward

The excavation begun on the previous day beneath the spillway slab was continued. The lower sand layer observed in the soil profiles logged previously (Figures 6 and 7 of Field Observation Report 5) continued 14' downstream. The excavation proceeded upstream to within approximately 2' of cutoff wall. The soil profile is shown in Figure 1.

Additional excavation was conducted by hand to the downstream side of the cutoff wall. The location of the hand excavation and soil profile is shown in Figure 2. An approximate 1" thick void was observed on the east side of the hand excavated notch directly beneath the slab. The soil at the base of the void was lined with fine to coarse gravel. It appears that soil around the gravel had been eroded away, leaving the gravel. Upper portions of the soil beneath the slab was thinly stratified (approximately 1/32") with fine sand and silt, possibly indicating water movement along the bottom of the wall and soil deposition, or silt and fine sand zones left behind by the melting of ice lenses. The distance from the top of the slab to the bottom of the core wall was measured to be 51" (see Figure 2, bottom half). The soil was tight against the bottom of the core wall at this location.

An attempt was made by the excavator to uncover the low level outlet on the upstream side of the dam. The soils in the area of the low level outlet were very loose, and saturated. Due to the soil conditions, the excavator was unable to uncover the low level outlet, however, the steel trash rack which covered the outlet valve was removed.

A sample of hard, dry silt (SS21) was collected from 4'2" below the slab subgrade.

The westernmost portion of the spillway abutment wall easily and cleanly broke free from the remainder of the wall at the location of the "crack" (see Figure 2). Five pieces of reinforcing steel protruded approximately 5" from the end of the short section which was removed. The reinforcement steel pulled cleanly out of the main section of the wall. The end of the main section of the wall was a smooth formed surface. The short section of wall was added after the main section of the wall had been poured and cured. The subgrade at the base of the wall was sand and gravel.

As shown in Figure 3, excavation below the slab subgrade continued. The excavation proceeded in benches of 3 to 5' in height, stepping down toward the breach, to provide vertical surfaces for logging and horizontal surfaces for density testing, and to maintain excavation stability. Field density testing was generally conducted at each bench on the core material upstream and downstream of the chimney drain, and in the chimney drain. The field density data are summarized at the end of this field observation report. Soil samples for one point compaction tests were collected at each field density test location except FD5 and FD6.

FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: April 3, 1996
Client: NHDES, Water Resources Division	Report No. 6
Contractor: J.R. Olson Excavating Contractor	Page 2 of 2

Field Density Testing Results
Nuclear Method

Test No.	Station	Off-set	El. (ft)	Wet Density (pcf)	Dry Density (pcf)	Water Content (%)	Notes
FD3-H&A	2+47	5' DS	678.9	113.9	106.8	6.6	Chimney drain
FD3-GEI	2+47	5' DS	678.9	114.4	108.0	5.9	Chimney drain
FD4-H&A	2+57	0' DS	678.8	124.6	110.9	12.4	Silty sand with gravel, core
FD4-GEI	2+57	0' DS	678.8	124.9	111.2	12.4	Silty sand with gravel, core
FD5-H&A	2+53	4' DS	676.2	106.7	101.4	8.1	Chimney drain
FD6-H&A	2+51	1' DS	676.2	137.1	123.1	11.4	Core, US of chimney drain
FD7-H&A	2+63	10' DS	675.9	134.9	119.1	13.3	Core, DS of CD
FD8-H&A	2+63	5' DS	675.9	99.1	93.0	6.6	Chimney drain
FD9-H&A	2+63	2.5' US	675.9	136.1	122.1	11.4	Core, US of CD
FD10-H&A	2+56	1' DS	671.2	138.4	122.6	12.9	Core, US of CD
FD11-H&A	2+56	6' DS	671.2	100.5	95.6	5.2	Chimney drain
FD12-H&A	2+56	10.5' DS	671.2	134.7	120.2	12.1	Core, DS of CD

Notes: Soil samples collected at all test locations except FD5-H&A and FD6-H&A.

US and DS indicate upstream and downstream of respectively, of baseline stationing. Baseline stationing with elevation control established in the field by Civil Consultants on March 19, 1996. Elevations referenced to "Rivers Datum".

GEI Consultants Inc.
by William J. Haswell
App'd by [illegible]

GEI Consultants, Inc.

FIGURE 1

Client

Subject

Project

Page

Date

By

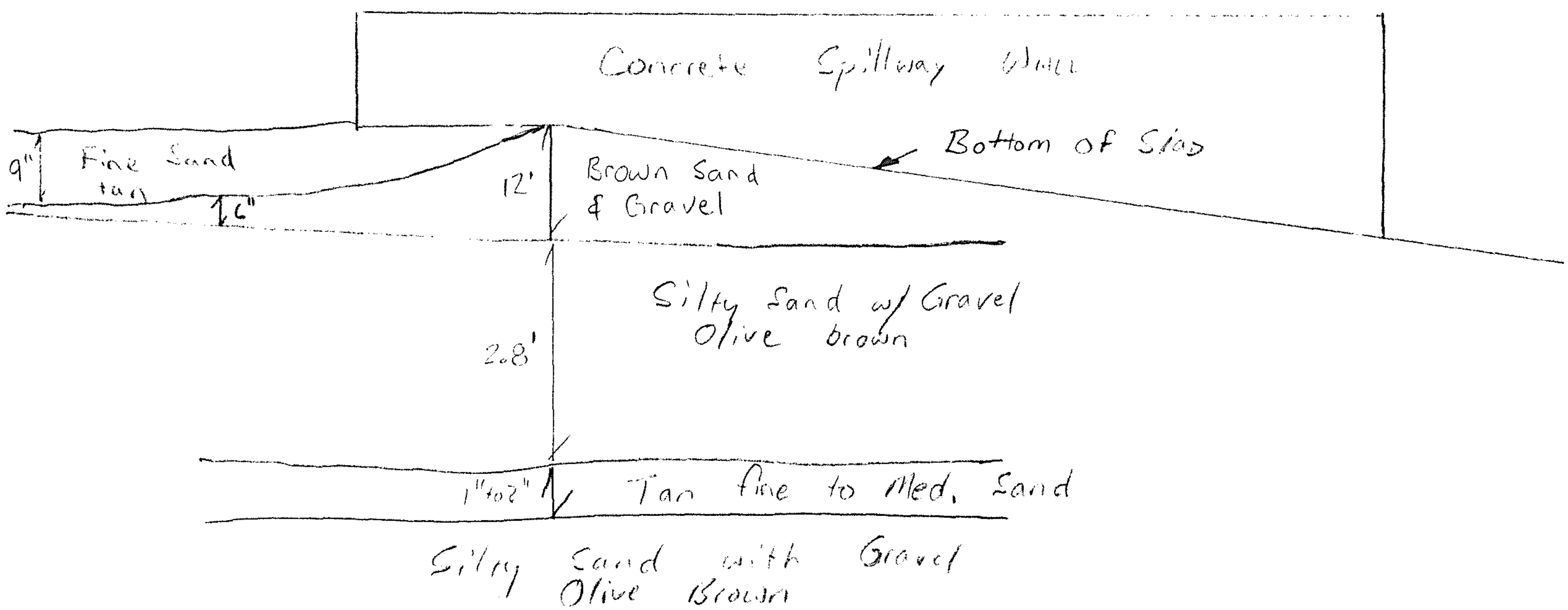
Checked

By

Approved

By

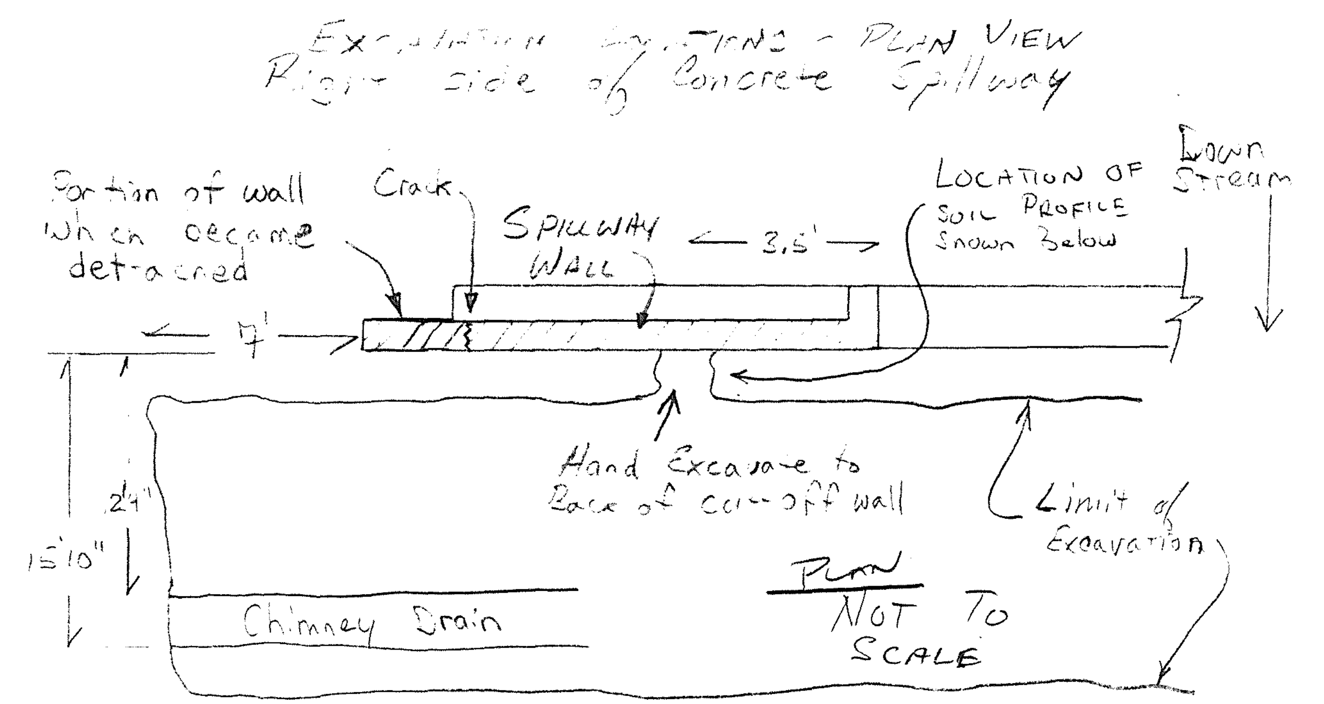
SOIL PROFILE
2' DOWN STREAM of ABUTMENT WALL

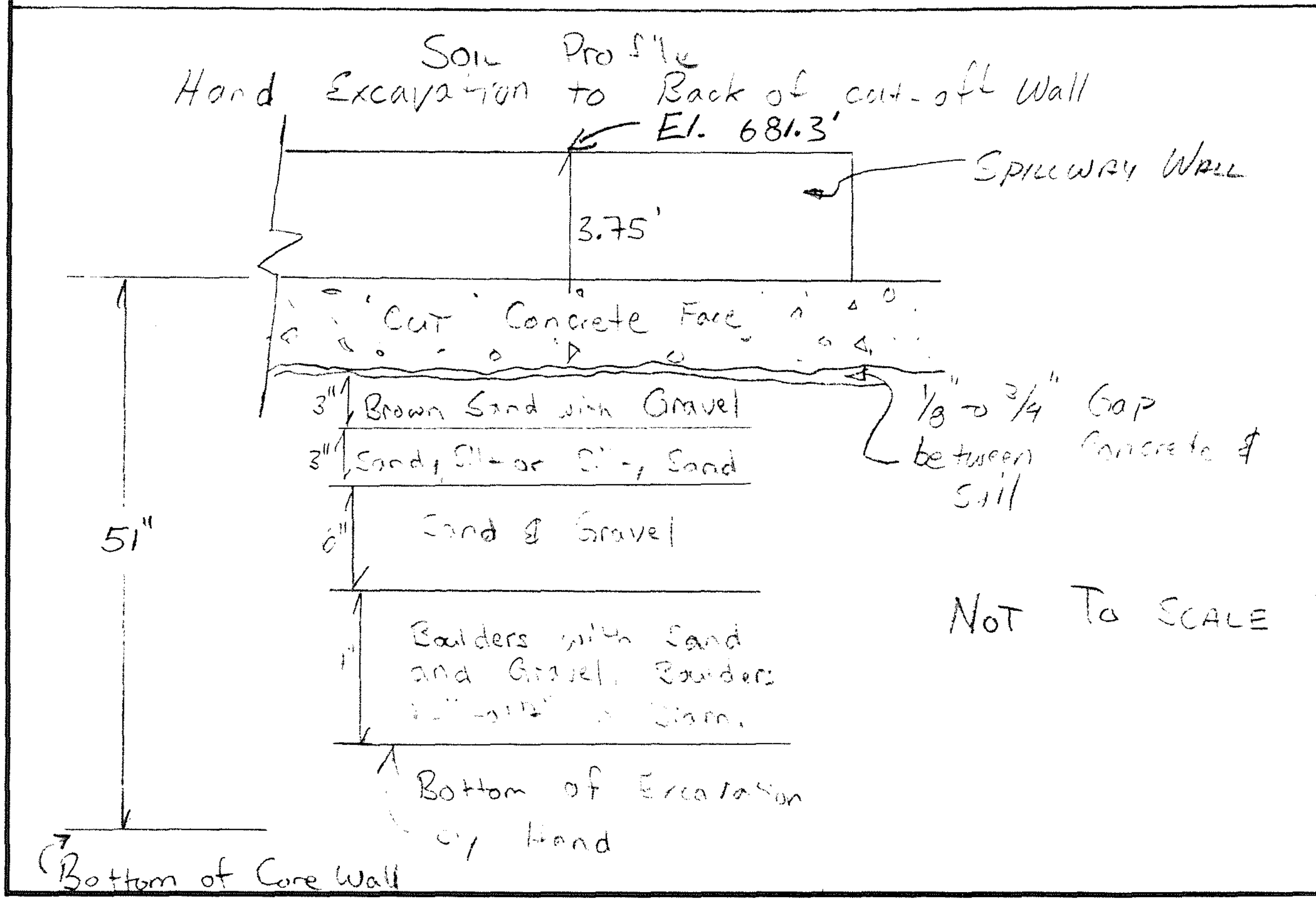


GEI Consultants, Inc.

FIGURE 2

Client		Project	Page
Subject 4/2/96		Date	By
		Checked	By
		Approved	By



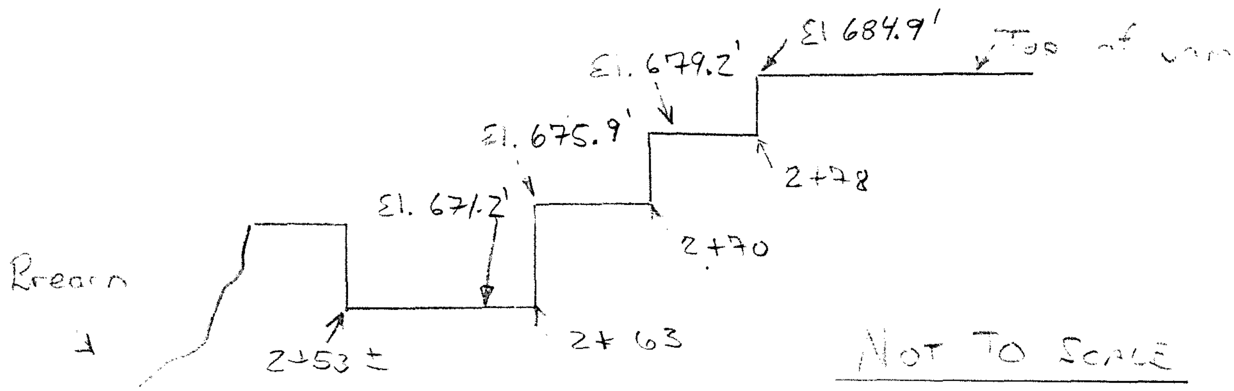


GEI Consultants, Inc.

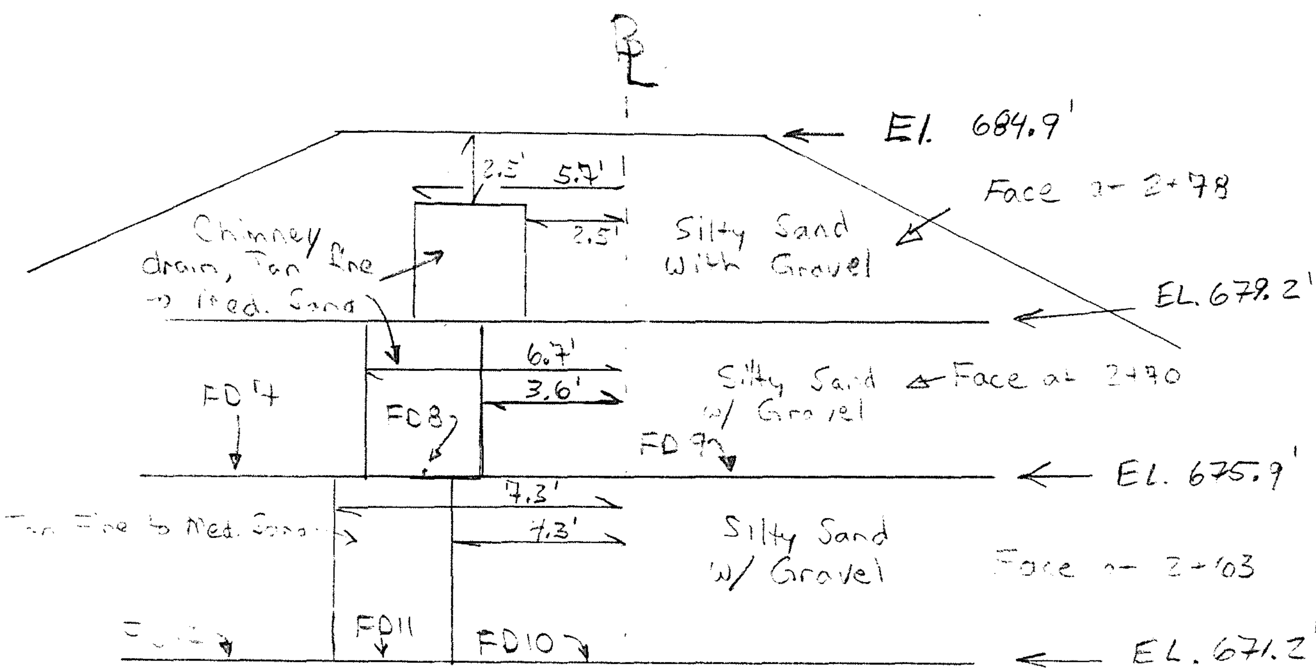
FIGURE 3

Client		Project 96069	Page
		Date 4/12/96	By
Subject		Checked	By
		Approved	By

Excavation Profile (Looking Downstream)



Excavation Section



A change in Chimney drain soil was observed opposite the 3rd bench (Sta. 2+53±). The soil below el. 673.0' was Tan Med. to Coarse Sand with Gravel.

SIGN-IN SHEET
Bergeron Dam
Alton, New Hampshire

Date: April 3, 1996

The undersigned agree that they are responsible for their own safety while on the Bergeron property, and agree to idemnify and hold harmless the property owners for any and all claims arising out of their activities or the activities of their employees while on the property.

Signature	Printed Name	Company
[signature]	Richard Doherty	Hydro Environmental
[signature]	ED McSWEENEY	HALEY & ALDRICH
[signature]	Nathan Whetten	HALEY + ALDRICH
[signature]	Lizette M Brown	Haley & Aldrich
[signature]	LOUIS H FOISY	FOISY PHOTO
[signature]	WILLIAM J. HASWELL	GEI
[signature]	CRAIG WARD	GEI
[signature]	JOSEPH TOMEI	GEOTESTING EXPRESS
W. Allen Marr	W. Allen Marr	GeoTesting Express
[signature]	JONATHAN C BRACKETT	GeoInsight Inc
[signature]	MICHAEL C. PENNEY	GEOINSIGHT, INC.
[signature]	TOM VARNEY	VARNEY ENG.
[signature]	Jon Wren	FAAA
[signature]	CHRIS COOLEY	HTE
[signature]	TIM FREESE	ACADIA
[signature]	Steve DelloRusso	SGH
[signature]	JOHN LAVIGNE	RIVERS ENG'ING
[signature]	ANDREW PRETZER	Douglas G Peterson
Bill Zoino		Zoino-Hebert
[signature]		Acadia Ins.
[signature]	JIMMY LEUNG	NHDES
[signature]	DONALD O DUSENBERRY	SGH
[signature]	Peter M. Gerbino	—
[signature]	Gary Jaworski	JGI

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FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 4, 1996
Client:	NHDES, Water Resources Division	Report No. 7
Contractor:	J.R. Olson Excavating Contractor	Page 1 of 3

Time of Arrival: 0725 hours	Departure: 1700 hours
Weather: Sunny, light to moderate wind, temperatures in the 20's° F	
Persons Contacted/Company See attached attendance sheet distributed by Richard Doherty of Hydro Environmental Technologies, Inc.	**GEI Representatives** William Haswell Craig Ward

The thickness of the grouted riprap and gravel blanket were measured at two locations along the edge of the right side of the breach. At about station 2+30, offset 29' downstream of the baseline, the grouted riprap was about 0.5' (grout thickness between stones) and the gravel blanket was about 2' thick. The gravel blanket at this location consisted of sand and gravel with cobbles and trace silt. At about station 2+23, offset 50' downstream, the grouted riprap was about 1.2' thick and the gravel blanket was about 1.3' thick. The gravel blanket at this location consisted of sand and gravel with cobbles.

0835 hrs. The excavator was digging on the upstream side of the cutoff wall at the right side of the breach and a section of the cutoff wall approximately 8' to 10' long broke off and fell into the breach. The break occurred at the location concrete cores W11 through W14. A void was observed near the bottom of the downstream side of the newly exposed end section of the cutoff wall (looking west along the crest of the dam). The section of the cutoff wall at the break is sketched in Figure 1. The void was approximately 1/2" by 1" in size and located approximately 5.1' from the top of the slab. The overall height of the wall and slab was 5.7'. The color of the concrete at the face of the core wall changed from white (top) to blue (bottom) at 4.2' below the top of the slab. The crack had been previously patched at the surface of the slab. Evidence of water movement was observed 1' below the slab subgrade on the downstream side of the cutoff wall. The remaining portion of the cutoff wall was pushed upstream by the excavator. Most of the soil adjacent to the upstream side of the cutoff wall was observed to be smooth as though it had been in contact with the cutoff wall. However, the soil was somewhat disturbed from the cutoff wall being pushed over.

Excavation of the benches in the embankment along the right side of the breach continued. The soil profile logged at each bench is shown in Figure 2. The results of the field density testing conducted at each bench are summarized at the end of this report. The field density testing was generally conducted in the core upstream of the chimney drain, in the chimney drain, and in the core down stream of the chimney drain. A soil sample was not collected from the location of FD18 because the test was found to be conducted within two different types of soils (filter sand from chimney drain and core material).

The chimney drain was observed to be discontinuous at the faces of benches at stations 2+48, 2+41, and 2+37 (see Figure 4). The discontinuities were zones about 3' to 4' high in which silty sand with gravel core material were in place of the filter sand in the chimney drain. It appears as though the trench excavated for the chimney drain had partially caved in at these locations during backfilling with filter sand.

FIELD OBSERVATION REPORT

Project: Project No.	Meadow Pond Dam 96069	Date: April 4, 1996
Client:	NHDES, Water Resources Division	Report No. 7
Contractor:	J.R. Olson Excavating Contractor	Page 2 of 3

The chimney drain was observed to connect to the blanket drain at the excavated face at about station 2+26 (looking left) (Figure 4). However, on the face of the excavation at station 2+37 (looking right), the bottom of the chimney drain was observed at less than one foot above the glacial till foundation soils in the bottom of the excavation, but the blanket drain was not observed.

The face at 2+41 was deepened by excavation of the bench at 2+37. As shown in Figure 3, the blanket drain was observed below and downstream of the bottom of the chimney drain. The upstream edge of the blanket drain was located about 4.3' downstream of the downstream side of the chimney drain. The top of the sand and gravel layer in the blanket drain was about 3.7' lower than the bottom of the chimney drain.

As shown in Figure 4, the layers in the blanket drain on the face at station 2+26 were irregular and varied in thickness. The upper filter layer was absent from the downstream side of the chimney drain to about 8.8' downstream the downstream side of the chimney drain (16.3' downstream of the baseline). Where observed, the thickness of the upper filter sand layer was about 0.2'. The sand and gravel layer ranged from about 0 to 1.7' thick and consisted of brown sand and gravel similar to that observed along the left side of the breach. The lower filter sand layer ranged in thickness from about 0.8 to 2.75'. The bottom of the blanket drain was underlain by the glacial till foundation soils, consisting of silty sand with gravel. Numerous cobbles and boulders were observed on the surface of the till. In some locations, thin pockets of organic soils were observed between the cobbles and boulders.

A summary of the soil samples collected today is provided below:

Sample No.	Station	Off-set	El. (ft)	Sample Description	Notes
SS22	2+30	29' DS	NM	Sand and gravel, possible silt	Below grouted riprap
SS23	2+23	50' DS	NM	Sand and gravel	Below grouted riprap
SS24	2+26	16.4' DS	655	Organics	From dam foundation
SS25	2+41	5' DS	655.4	Silty sand with gravel, olive brown	Core soil
SS26	2+26	6' DS	655	Sand	Chimney drain
SS27	2+26	12' DS	NM	Brown sand with gravel	Blanket drain

Notes: NM indicates data not measured.

US and DS indicate upstream and downstream respectively, of baseline stationing. Elevations referenced to "Rivers Datum". Baseline stationing with elevation control established in the field by Civil Consultants on March 19, 1996.

FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No. 96069	Date: April 4, 1996
Client: NHDES, Water Resources Division	Report No. 7
Contractor: J.R. Olson Excavating Contractor	Page 3 of 3

Field Density Testing Results
Nuclear Method

Test No.	Station	Off-set	El. (ft)	Wet Density (pcf)	Dry Density (pcf)	Water Content (%)	Notes
FD13-H&A	2+50	5' DS	667.1	121.7	113.5	7.2	Chimney drain
FD14-H&A	2+50	11' DS	667.1	138.0	125.3	10.1	Core, trench offsets used as follows: Moisture 9 Density 197
FD15-H&A	2+41	0' DS	663.6	132.0	117.3	12.5	US of CD
FD16-H&A	2+41	6.5' DS	662.8	108.3	102.1	6.2	Chimney Drain
FD17-H&A	2+41	13.5' DS	662.3	140.4	124.0	13.2	Core DS of CD
FD18-H&A	2+32	3' DS	657.8	123.9	109.6	13.1	Test conducted on two layers, no one point sample collected
FD19-H&A	2+32	12' DS	657.8	136.3	125.8	8.3	Core DS of CD

Notes:

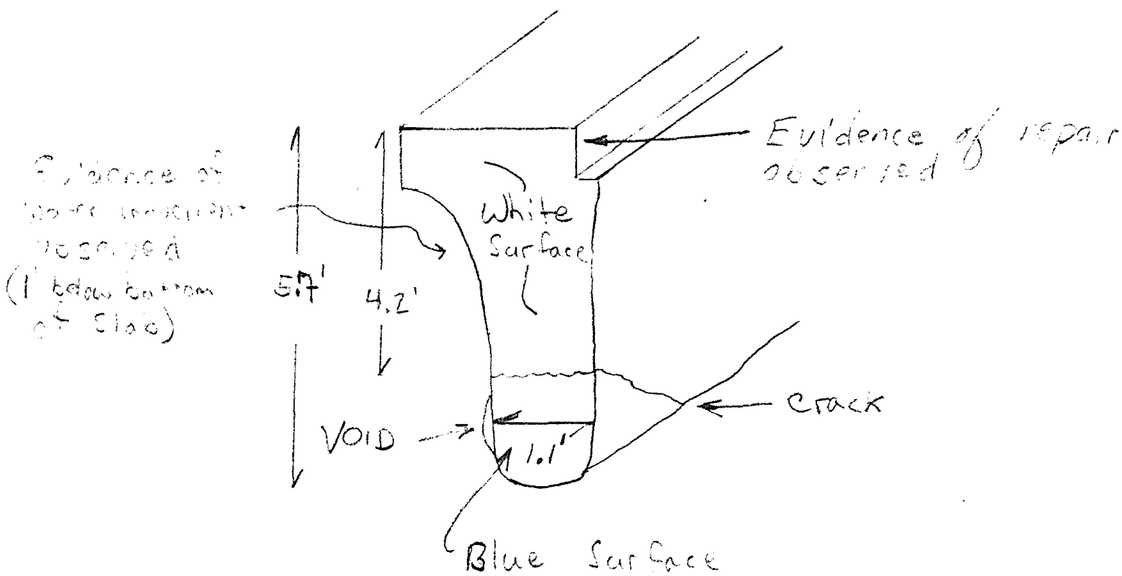
Soil samples collected at all test locations except FD18-H&A, which was conducted within two soil layers (filter sand and core materials.)
US and DS indicate upstream and downstream respectively, of baseline stationing. Elevations referenced to "Rivers Datum". Baseline stationing with elevation control established in the field by Civil Consultants on March 19, 1996.

GEI Consultants Inc.
by William J. Haswell
App'd by CW

Φ GEI Consultants, Inc.

FIGURE 1

		Project	Page
Client	[illegible]	Date 4/12/96	By WJH
Subject	[illegible] Pond Dam FOR [illegible]	Checked	By
		Approved	By



VOID – ½"x1", 5.1' from top of slab

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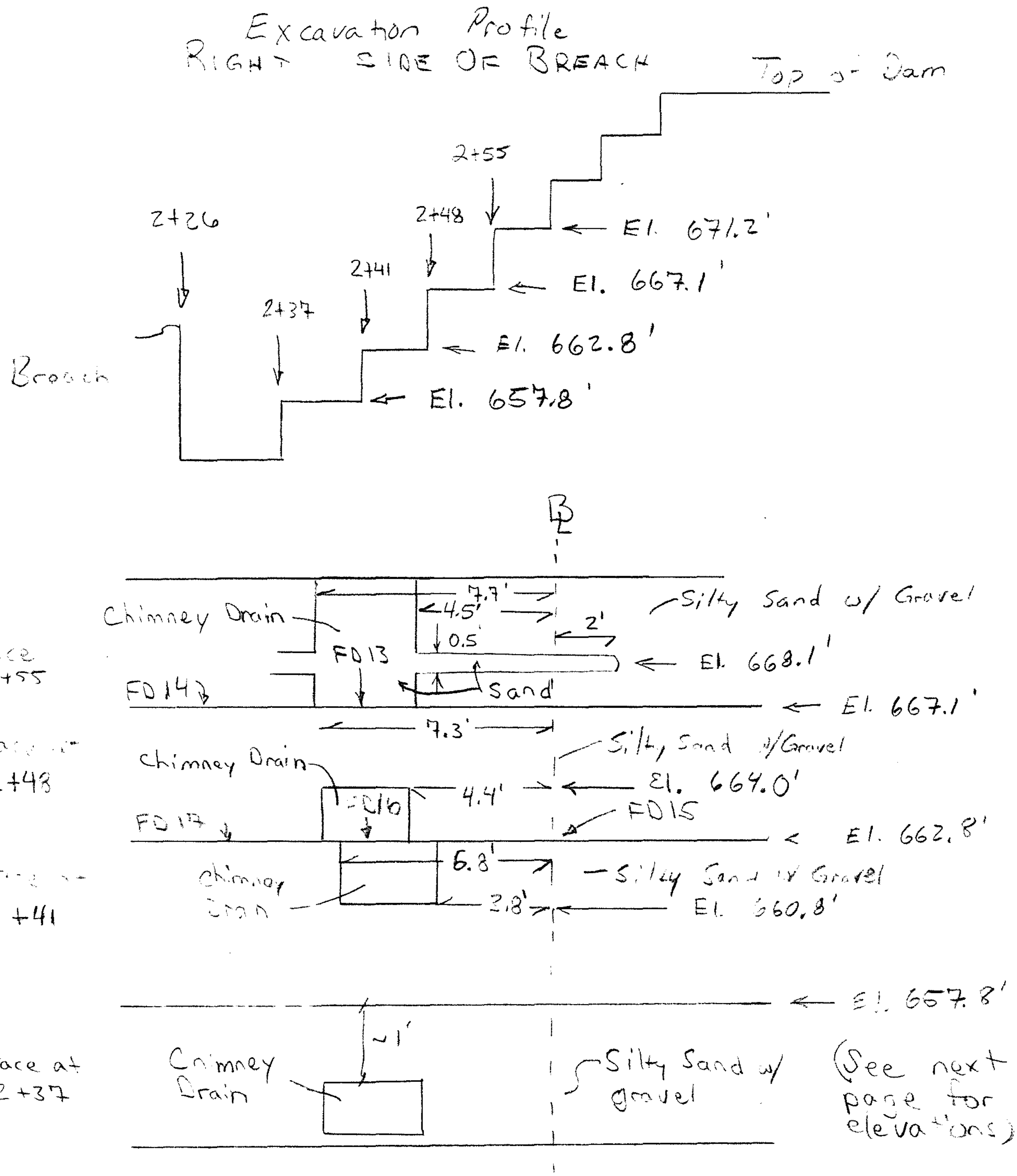
FIGURE 2

Project	96067	Page	
Client	NHDES- WRD	Date	4/15/96	By	WJH
Subject	Meadow Pond Dam FOR 4/4/96	Checked		By	
		Approved		By	

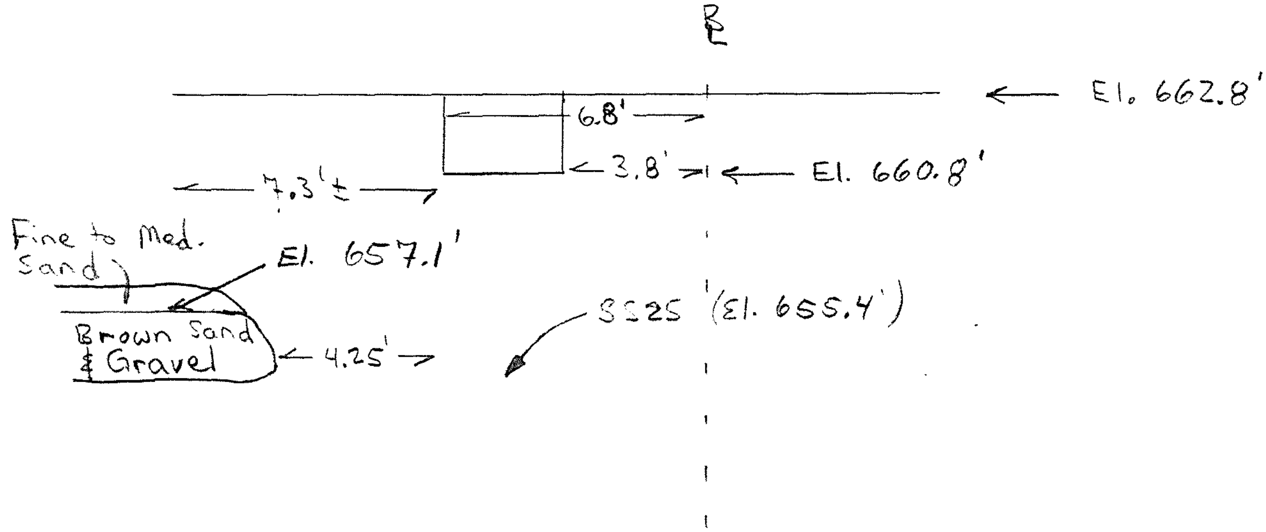


GEI Consultants, Inc.

FIGURE 3

Client	NHDES - WRD	Project 96067	Page
		Date 4/15/96	By WJH
Subject	Meadow Pond Dam FOR 4/4/96	Checked	By
		Approved	By

CROSS SECTION
Station 2+41



Deepened Face At 2+41
by excavating bench At 2+37

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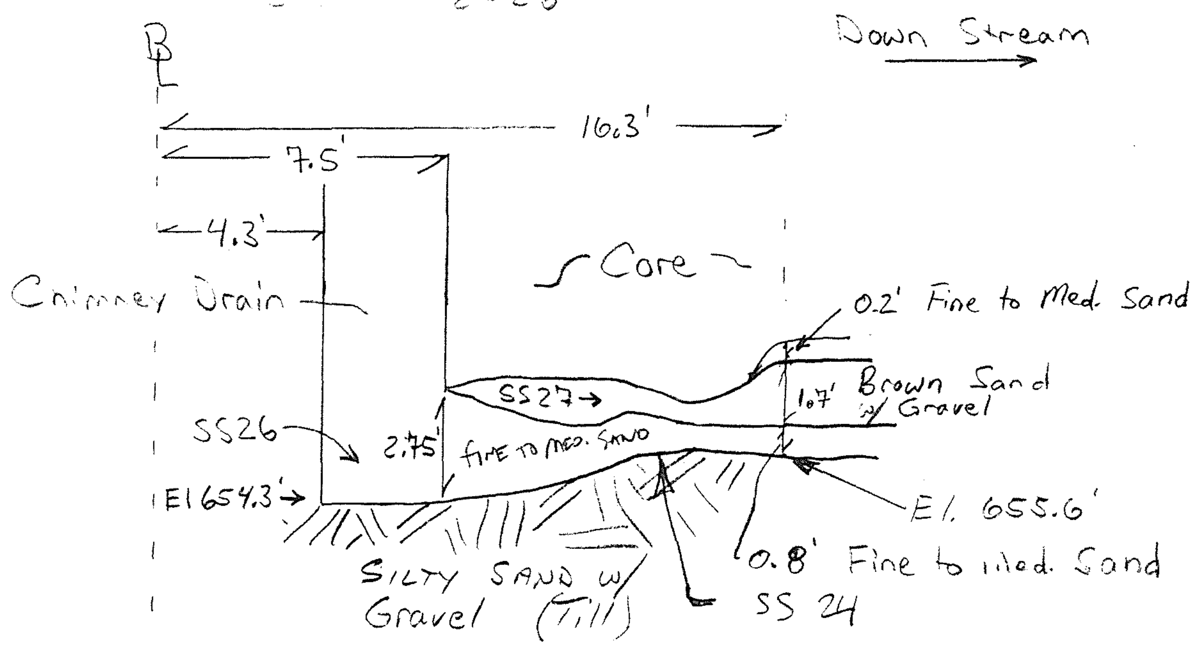
FIGURE 4

Client	NHDES - WRD	Project	96069
		Page	
		Date	4/15/96
		By	WJH
Subject	Meadow Pond Dam 4/4/96	Checked	
		By	
		Approved	
		By	

Soil Profile
Sta 2+26



NOTES:

1) Soil above Brown Sand w/ Gravel is very wet
2) Water is pooling at bottom of excavation ~ approximately elevation 655.6'.

NOT TO SCALE

SIGN IN SHEET

Bergeron Dam

Alton, New Hampshire

Date: April 4, 1996

The undersigned agree that they are responsible for their own safety while on the Bergeron property, and agree to idemnify and hold harmless the property owners for any and all claims arising out of their activities or the activities of their employees whilc on the property.

Signature	*Printed Name*	*Company*
[illegible]	Richard Doherty	Hydro Environmental
Louis H. Foisy	LOUIS FOISY	FOISY PHOTO
Chris Cooley	CHRIS COOLEY	HTE
Ed McSweeney	ED McSWEENEY	HALEY & ALDRICH
Jimmy [illegible]	JIMMY LEUNG	NHDES
Craig F. Ward	CRAIG WARD	GEI
William J. Haswell	WILLIAM HASWELL	GEI
Joseph Tomei	JOSEPH TOMEI	GEOTESTING EXPRESS
Lizetta M Brown	LizettaM Brown	Haley & Aldrich
[illegible]	Steve R'sLoos	Jon Olson Excavating
W. Allen Marr	W. Allen Marr	Geotesting Express
Nathan Whetten	Nathan Whetten	Haley & Aldrich
Tom Vanney	THOMAS W. VANNEY	VANNEY ENG.
[illegible]	Gary Jaworski	JGI
Paul B. Aldinger	PAUL B. ALDINGER	DG PEROSSINI ASSOC.
Jonathan C. Brackett	JONATHAN C. BRACKETT	GEOINSIGHT INC.
W P Konicki	William Konicki	GEI
Eugene L. Boudette	EUGENE L. BOUDETTE	N.H. DES, CONCORD

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FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No.: 96069	Date: April 5, 1996
Client: NHDES, Water Resources Division	Report No. 8
Contractor: J.R. Olson Excavating Contractor	Page 1 of 3

Time of Arrival: 0800 hours	Departure: 1635 hours
Weather: Cloudy, light wind, temperatures in the 40's° F, showers expected.	
Persons Contacted/Company See attached attendance sheet distributed by Richard Doherty of Hydro Environmental Technologies, Inc.	**GEI Representatives** William Haswell Craig Ward

Elevations on the left side of the breached section of the dam were obtained. The elevations and soil profile are shown in Figure 1.

Excavation near the dam foundation at station 2+26 continued. The following observations were made:

- A 2' to 3' diameter boulder was removed from the foundation of the dam at the location of the irregular profile shown in Figure 6 of Field Observation Report No. 7 (April 5, 1996).

- The low level outlet pipe was observed at about station 2+48, 14' downstream of the baseline (see Figure 2). The low level outlet pipe is a 12-inch-diameter plastic corrugated pipe and was observed within a layer of filter sand. Two 4-inch-diameter corrugated, slotted plastic pipes (wrapped in geotextive filter fabric) were observed to run alongside the low level outlet pipe. The elevation of the top of low level outlet pipe was about 654' to 655'. Water was observed to seep out of the sand below the pipes.

  The blanket drain was observed to the right (upstation) of the low level outlet pipe, at about the same elevation. At an excavation face at 2+55, the blanket drain was observed to consist of an approximately 0.8'-thick layer of filter sand over an approximate 2'-thick layer of brown sand and gravel. The excavation was not deepened to observe the lower filter sand layer. The elevation of the top of the sand and gravel layer at 2+51, 14' downstream of the baseline, was approximately 656.7'.

- The excavation was advanced upstream to locate the antiseep collar. The antiseep collar was observed at about station 2+51, just U.S. of the chimney drain. At this location, the bottom of the chimney drain was about 5.9' above the top of the low level outlet pipe.

- The excavation was advanced further to the right to see if the chimney drain connected to the blanket drain on the right side of the low level outlet. The excavation was advanced to about elevation 652' at station 2+63. While the connection of the chimney drain to the blanket drain was not observed, it was noted that the elevation of the bottom of the chimney drain decreased as the excavation proceeded up station (to the right). Among the engineers on-site, it was speculated that the contractor may have intentionally excavated a shallow trench for the chimney drain in this area to avoid disturbance to the low level outlet.

FIELD OBSERVATION REPORT

Project: Meadow Pond Dam Project No.: 96069	Date: April 5, 1996
Client: NHDES, Water Resources Division	Report No. 8
Contractor: J.R. Olson Excavating Contractor	

A test pit (TP1) was excavated at station 2+29, 29' downstream to observe the blanket drain. A portion of the dam had already been excavated where the test pit was logged (top of logged test pit not at original ground surface). The soil profile in the test pit is shown in Figure 3. At this location, the top of the drainage blanket was encountered at about elevation 656'. The upper filter sand layer was about 0.6-feet-thick. The brown sand and gravel beneath the upper filter sand layer was observed to be at least 1.5-feet-thick. Due to collapsing, the excavation could not be advanced deep enough to observe the full thickness of the brown sand and gravel.

Test pit TP2 was excavated at station 2+26, 70' downstream, perpendicular to the low level outlet. As shown in the soil profile in Figure 4, the top of the low level outlet pipe was about 4.8 feet below the grouted riprap at the test pit location. The soils in the test pit consisted of varying thicknesses of sand, brown sand and gravel and gray fine to medium sand. The soil profile on Figure 4 shows logging at one location on the test pit wall. More thorough logging was not possible due to test pit instability. A 4-inch-diameter corrugated slotted drainage pipe was observed in the west side of the test pit, approximately 1' below the grouted rip rap at about station 2+26, 80' downstream. This pipe was probably part of the toe drain.

The left end section of the cutoff wall and the left end section of the spillway was identified in the downstream debris pile. It was determined on the basis of similar reinforcement bar spacing and comparison of distinct fractured aggregate patterns, that these two sections were once attached. Based on the alignment of these end sections, it was concluded that the cutoff wall was terminated about 12" short of the left end of the concrete slab on the left (east) side of the spillway. Staining and rusted reinforcing steel was observed on the underside of the left end of the spillway slab.

A third test pit (TP3) was excavated on the east side of the stream which flowed through the center of the breached section of the dam to investigate the potential presence of a more permeable stratum of soil within the foundation soils. The upper 1.2' of soil was a silty gravel with sand which was underlain by more than 5' of sand and gravel with cobbles. The soil profile is shown in the top of Figure 5.

A shallow trench was excavated on the downstream side of the dam embankment to the right (west) of the spillway where a bulge in the slope was observed which may have indicted shallow sloughing. No displacement was observed at the top of the bulge. The topsoil in the bulge was 6" thick (at the top) and increased to 18" thick (at the bottom). The topsoil thickness indicates that the bulge is due to irregular grading of the topsoil.

During the breach, most of the baffle wall was displaced, leaving only about 7' or 8' of the wall intact. A test pit (TP4) was excavated at the end of the intact portion of the wall, beneath the former location of the footing of the displaced portion of the wall. A 3.5' thick layer of gray silty sand with gravel was encountered and the upper approximately 2' of this layer contained 10" to 12" diameter boulders. Bedrock was encountered in the test pit at a depth of about 3.5' below the base of the footing. The soil profile for TP4 is shown in Figure 5.

The pH and conductivity of the water was measured to be 7.8 and 20 μS respectively.

FIELD OBSERVATION REPORT

Project: Project No.:	Meadow Pond Dam 96069	Date: April 5, 1996
Client:	NHDES, Water Resources Division	Report No. 8
Contractor:	J.R. Olson Excavating Contractor	Page 3 of 3

A summary of the soil samples collected today is provided below:

Sample No.	Station	Off-set	El. (ft)	Sample description	Notes
SS28	2+48	14' DS	NM	Sand	backfill around low level outlet pipe
SS29	2+51	14' DS	NM	Brown sand and gravel	Blanket drain
SS30	1+75	8' DS	652.8	Sand and gravel, natural soil	From TP3, foundation
SS31	1+75	8' DS	653.8	Silty sand and gavel, natural soil	From TP3, foundation

Notes:

NM = indicates not measured.

US and DS indicate upstream and downstream respectively, of baseline stationing. Elevations referenced to "Rivers Datum". Baseline stationing with elevation control established in the field by Civil Consultants on March 19, 1996.

April 5, 1996 concluded the field investigations program conducted at the site.

GEI Consultants Inc.
by William Hasnell
App'd by

GEI Consultants, Inc.

FIGURE 1

Project 96069 Page

Client NHDES - WRD

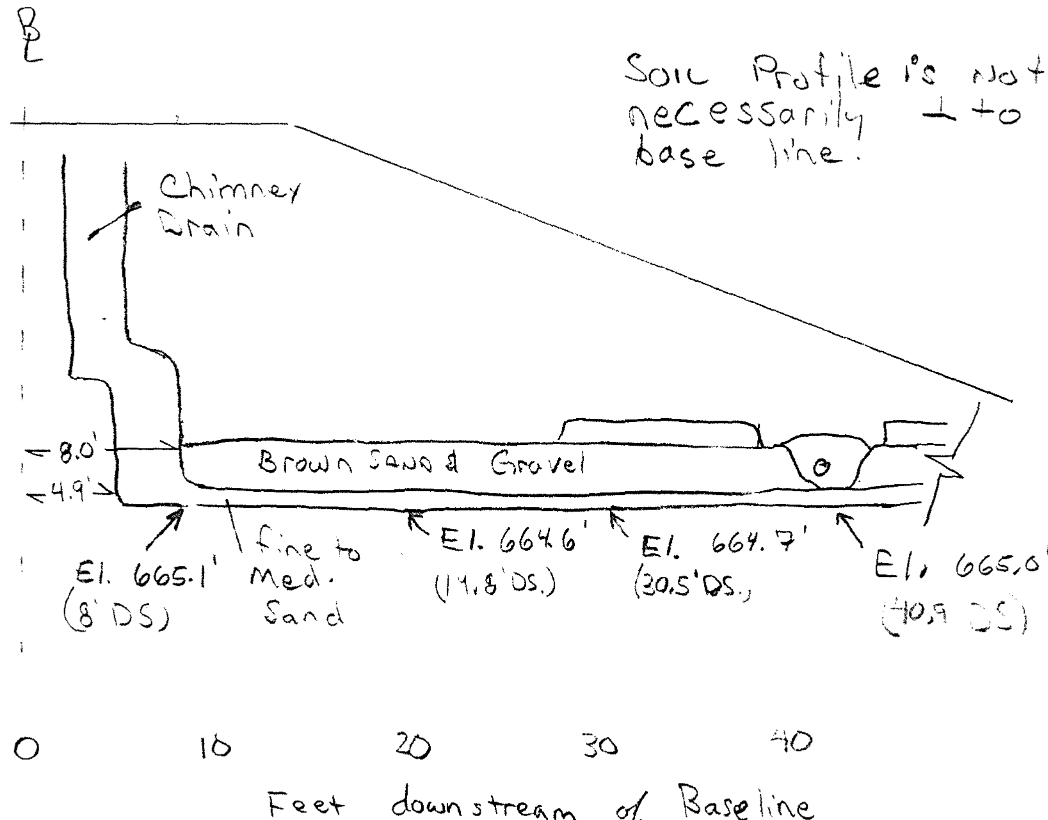
Date 4/15/96 By WJH

Subject Meadow Pond Dam FOR 4/5/96

Checked By

Approved By

SOIL PROFILE
LEFT EMBANKMENT OF BREACH

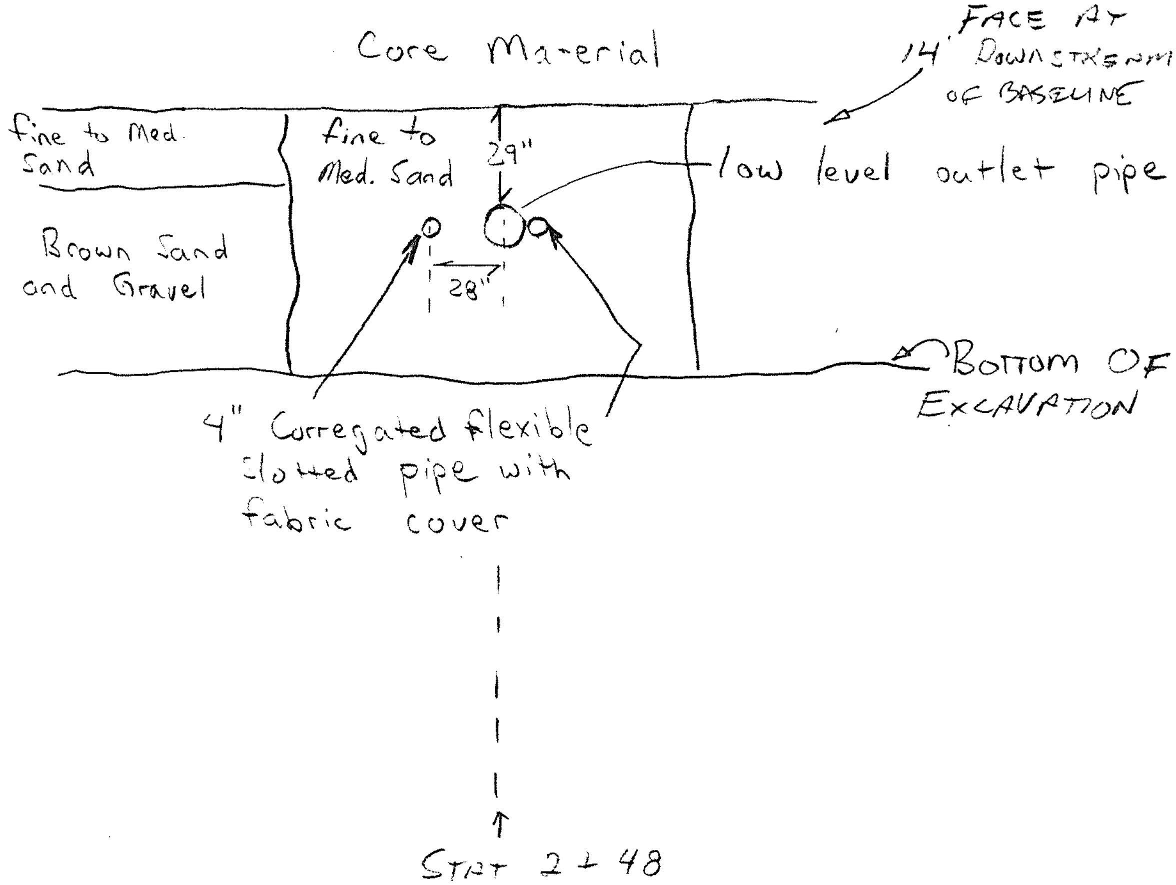


GEI Consultants, Inc.

FIGURE 2

Project	96069	Page	
Client	NHDES-WRD		
Date	4/15/96	By	WJH
Subject	Meadow Pond Dam FOR 4/5/96		
Checked		By	
Approved		By	

SOIL PROFILE AT
LOW LEVEL OUTLET PIPE
(LOOKING UPSTREAM)
14' DOWNSTREAM OF BASELINE



NOTE:
Ground water seepage observed below low level outlet

GEI Consultants, Inc.

FIGURE 3

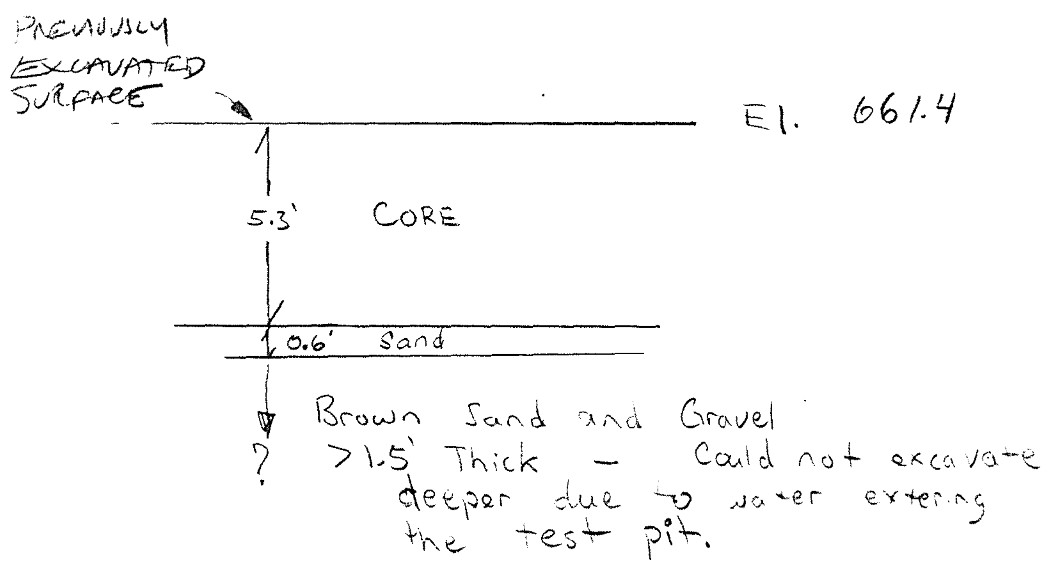
Project	76069	Page	
Date	4/15/96	By	JJL
Checked		By	
Approved		By	

Client NHDES - WRD

Subject Meadow Pond Dam FOR 4/15/96

SOIL PROFILE

"TP1" 2+29, 39' Down Stream



NOTE: Ground water seepage observed at about elevation 654.5'

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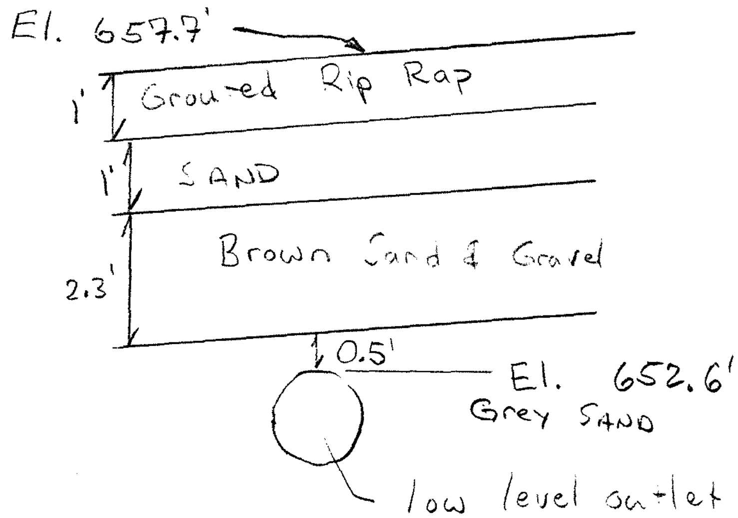
FIGURE 4

Client: NHDES - WRD	Project: 96069	Page:	
Subject: Meadow Pond Dam FOR 4/5/96	Date: 4/5/96	By: WJH	
	Checked:	By:	
	Approved:	By:	

SOIL PROFILE

TP2 2+26, 70' Down Stream



NOTE:
This figure provides the soil profile at one location. The types and thicknesses of materials encountered varied widely. More accurate logging of the soil profile was not possible due to the instability of the excavation and water seepage

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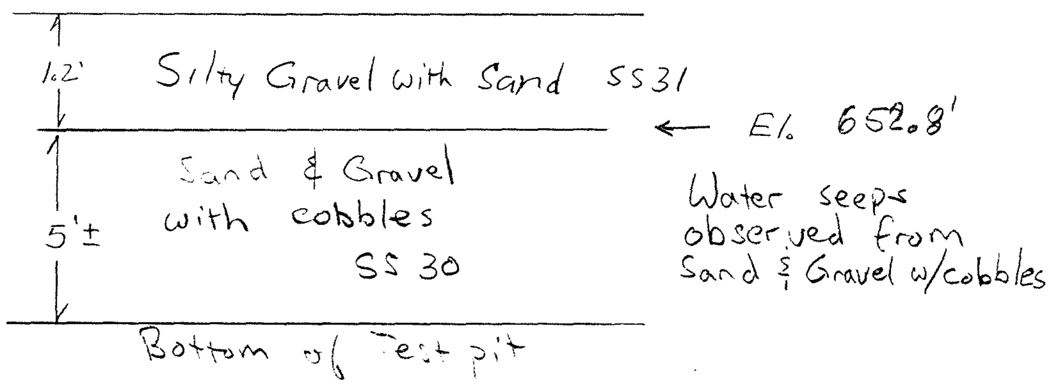
FIGURE 5

Client	NHDES - WRD	Project	7[illegible]069
		Page	
Subject	Meadow Pond Dam FOR 4/5/96	Date	4/5/96
		By	[illegible]
		Checked	
		By	
		Approved	
		By	

SOIL PROFILES

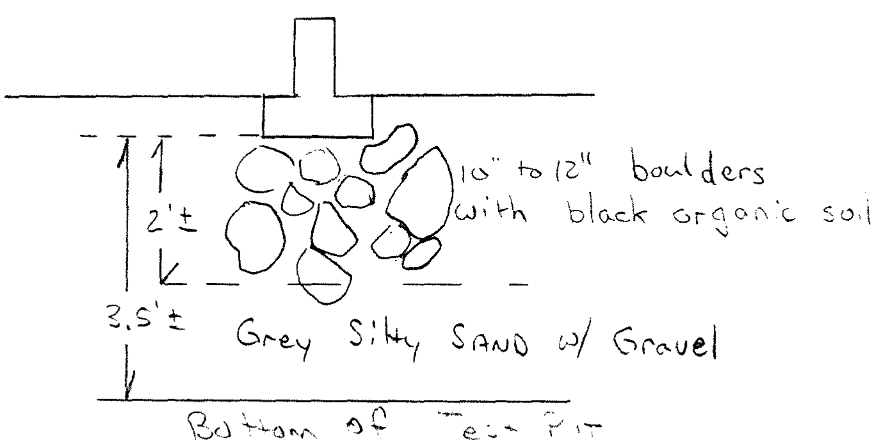
TP 3

Station 1+75', 8' DS (estimated location)



TP 4

At east end of intact portion of baffle wall



Test pit sidewalls collapsing due to groundwater.

SIGN-IN SHEET
Bergeron Dam
Alton, New Hampshire

Date: April 5, 1996

The undersigned agree that they are responsible for their own safety while on the Bergeron property, and agree to idemnify and hold harmless the property owners for any and all claims arising out of their activities or the activities of their employees while on the property.

Signature	Printed Name	Company
[signature]	Richard Doherty	Hydro-Environmental
[signature]	Gary Jaworski	JGI
[signature]	CA PRETZER	DOUGLAS G PETERSON
[signature]	Lizetta M Brown	Haley & Aldrich
[signature]	CRAIG WARD	GEI
[signature]	CHRIS COOLEY	HTE
[signature]	JIMMY LEUNG	NHDES
[signature]	Todd A. Moore	GeoInsight
[signature]	JOSEPH TOMEI	GEOTESTING EXPRESS
[signature]	NATHAN L. WHETTEN	Haley + Aldrich, Inc.
[signature]	WILLIAM J. HASWELL	GEI
[signature]	W. Allen Marr	GTX
[signature]	Tony Vannoy	VANNOY ENG.
[signature]	ED MCSWEENEY	HALEY & ALDRICH
[signature]	DAVE THOMPSON	H & A
[signature]	TIM FREESE PM	ACADIA
[signature]	CHIP ROBERTS	FAILURE ANALYSIS

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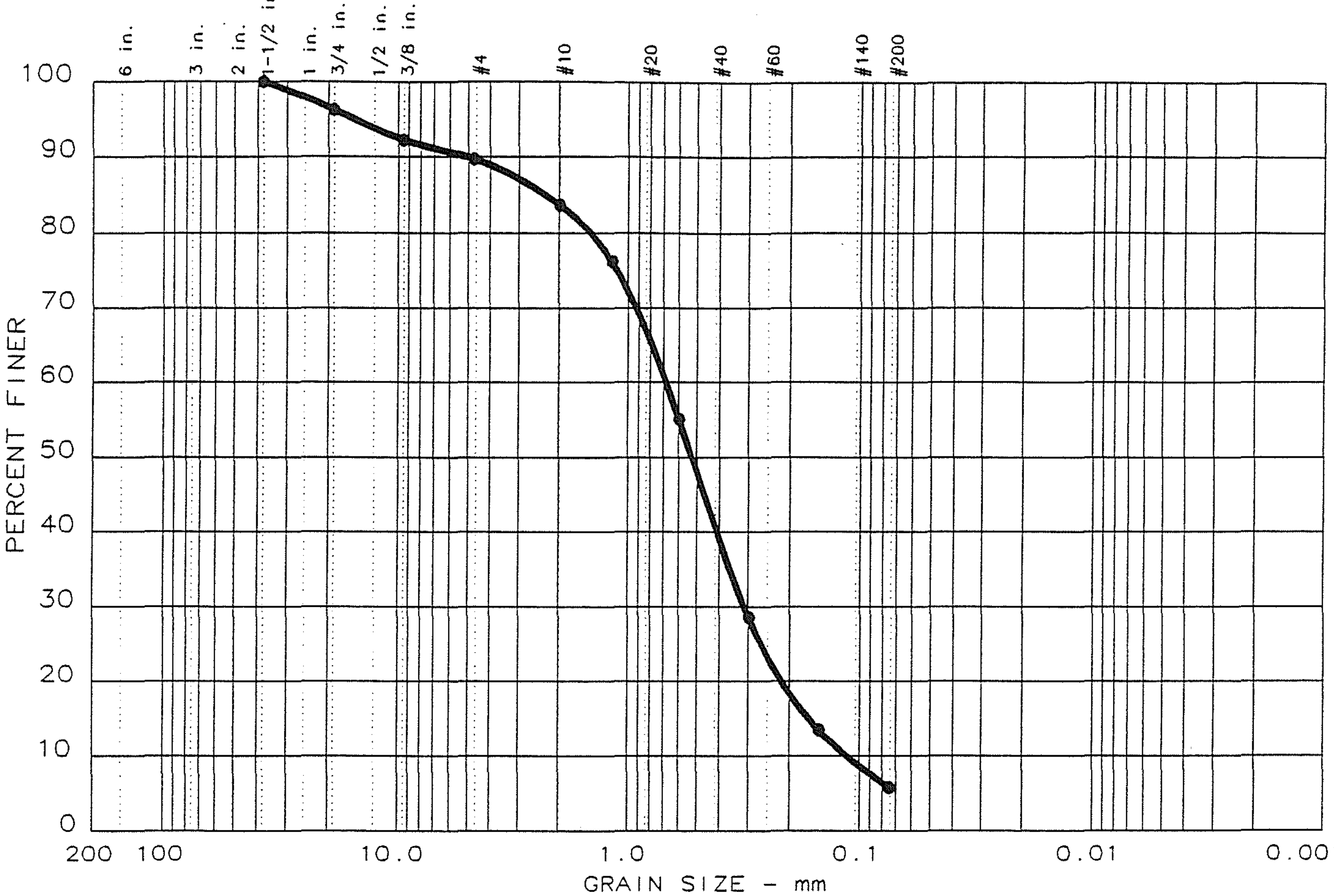
APPENDIX E

Laboratory Results

Appendix E.1

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	1	0.0	10.3	83.9	5.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.29	0.683	0.527	0.313	0.164	0.114	1.26	6.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Widely graded SAND with silt	SW-SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S1

Date: April 1, 1996

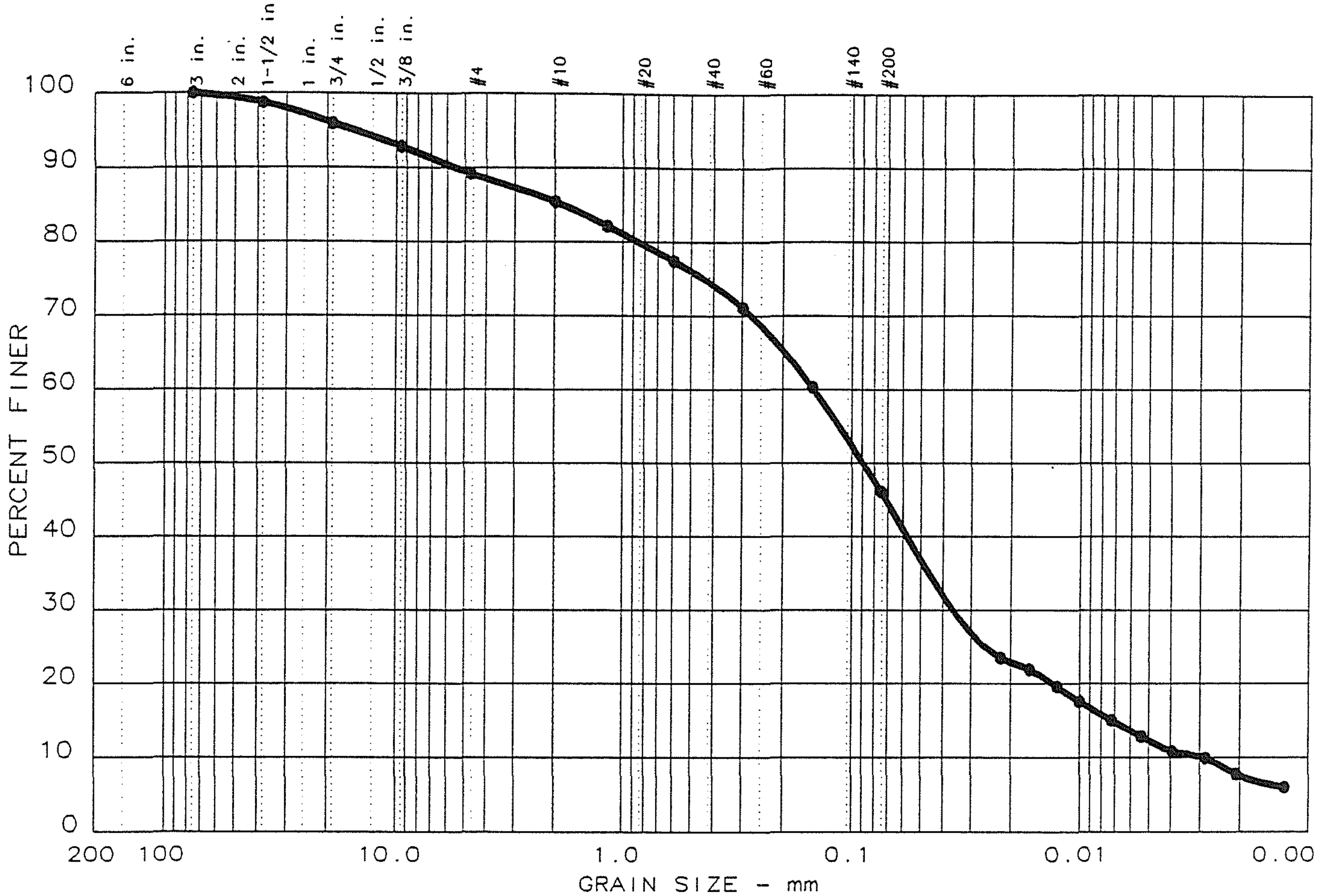
Remarks:
Station 1+48, 8 ft DS
Chimney Drain

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	9	0.0	10.8	43.1	46.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.86	0.146	0.0891	0.0359	0.0072	0.0029	3.05	50.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND	SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S2

Date: April 2, 1996

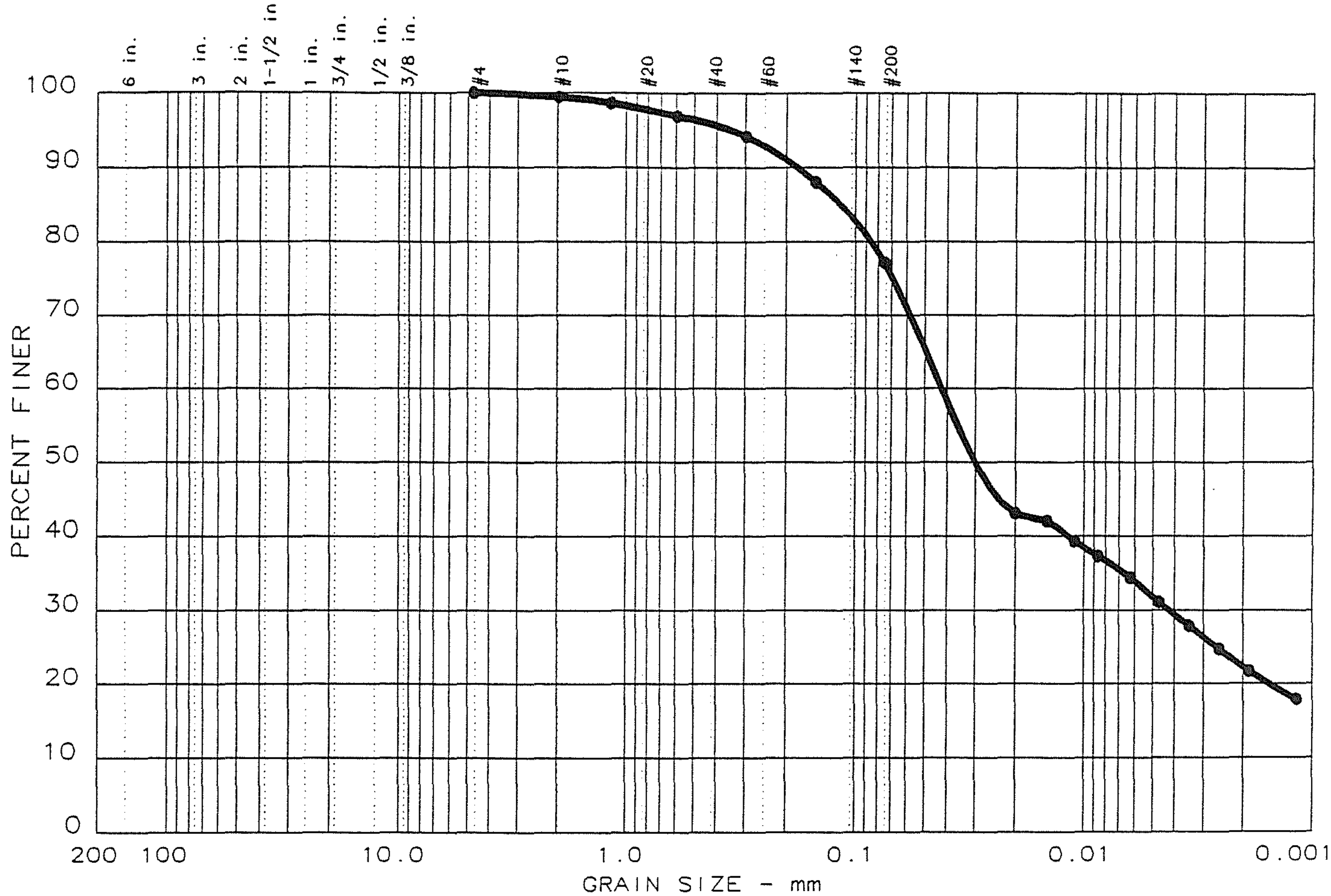
GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:
Station 1+47, 1 ft DS
Fill upstream of
Chimney Drain
Water Content = 13.5%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	10	0.0	0.0	22.9	77.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.116	0.0422	0.0301	0.0042				

MATERIAL DESCRIPTION	USCS	AASHTO
● SILT with sand	ML	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S3

Date: April 2, 1996

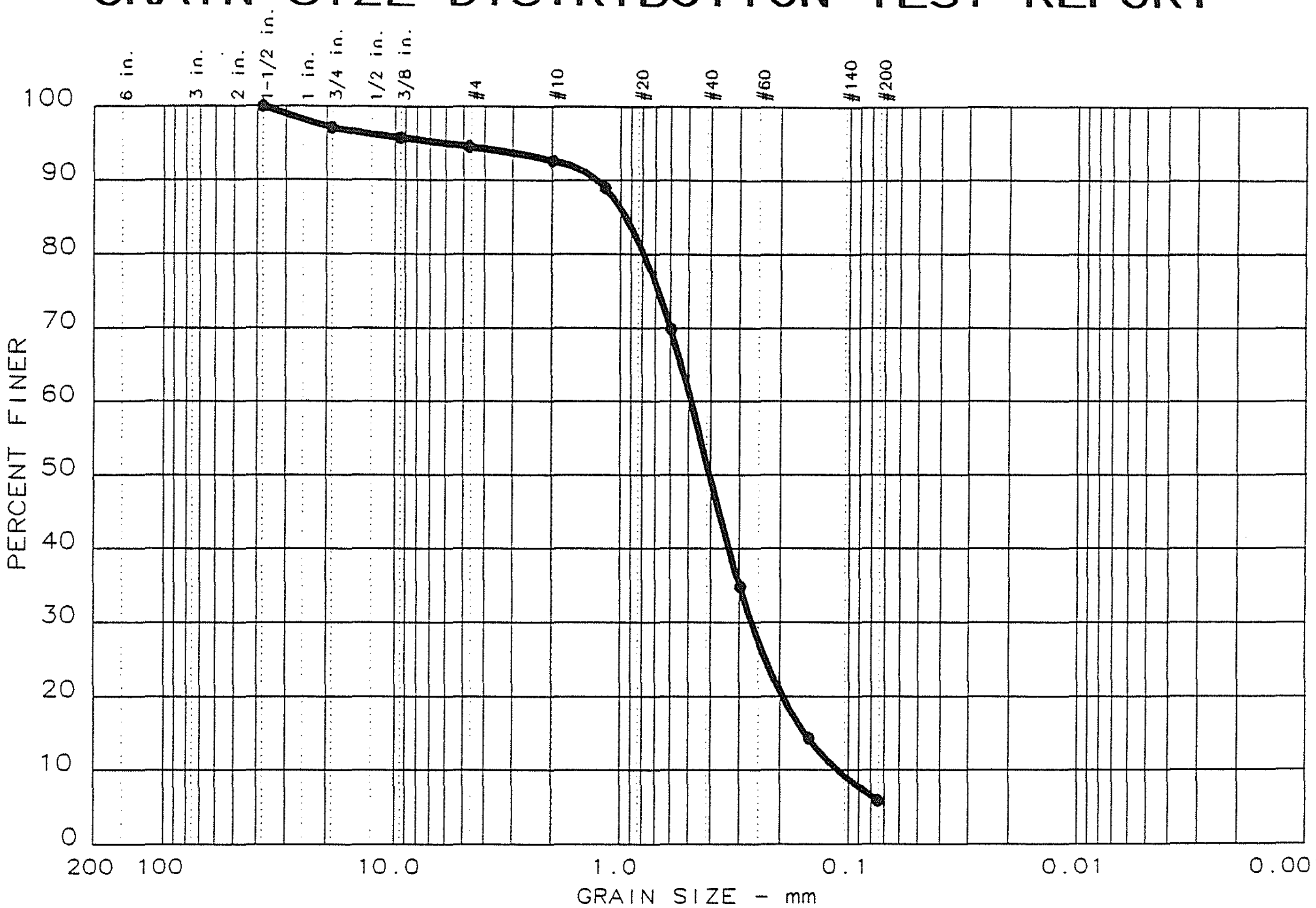
Remarks:
Station 1+47, 1 ft DS

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	2	0.0	5.4	88.7	5.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.944	0.489	0.406	0.267	0.155	0.111	1.31	4.4

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with silt	SP-SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S4

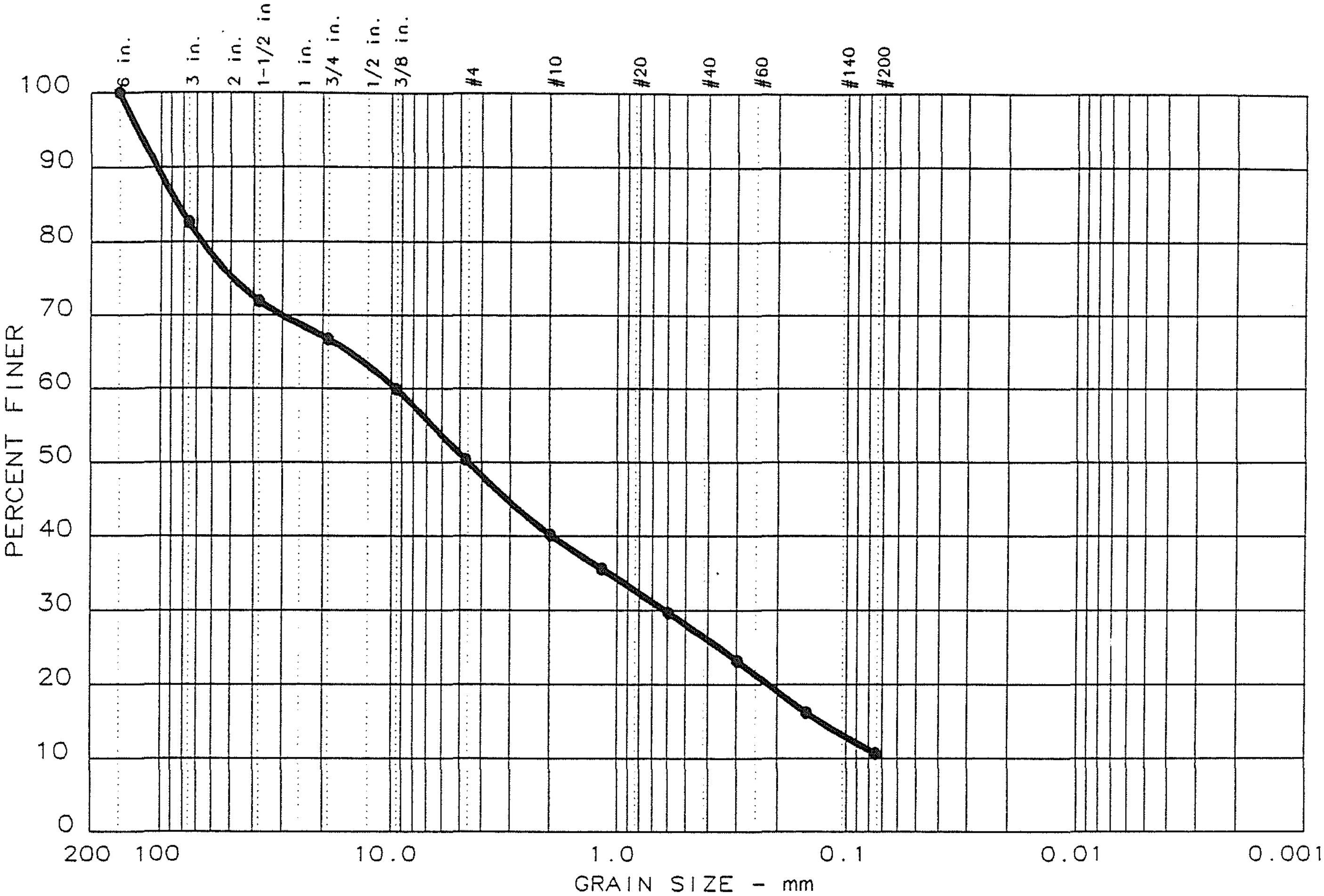
Date: April 1, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT
GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:
Station 1+47, 5 ft DS
Chimney Drain
on right side

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	3	17.3	32.3	39.6	10.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			84.1	9.55	4.62	0.617	0.130			

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with silt and gravel	SP-SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S5

Date: April 1, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

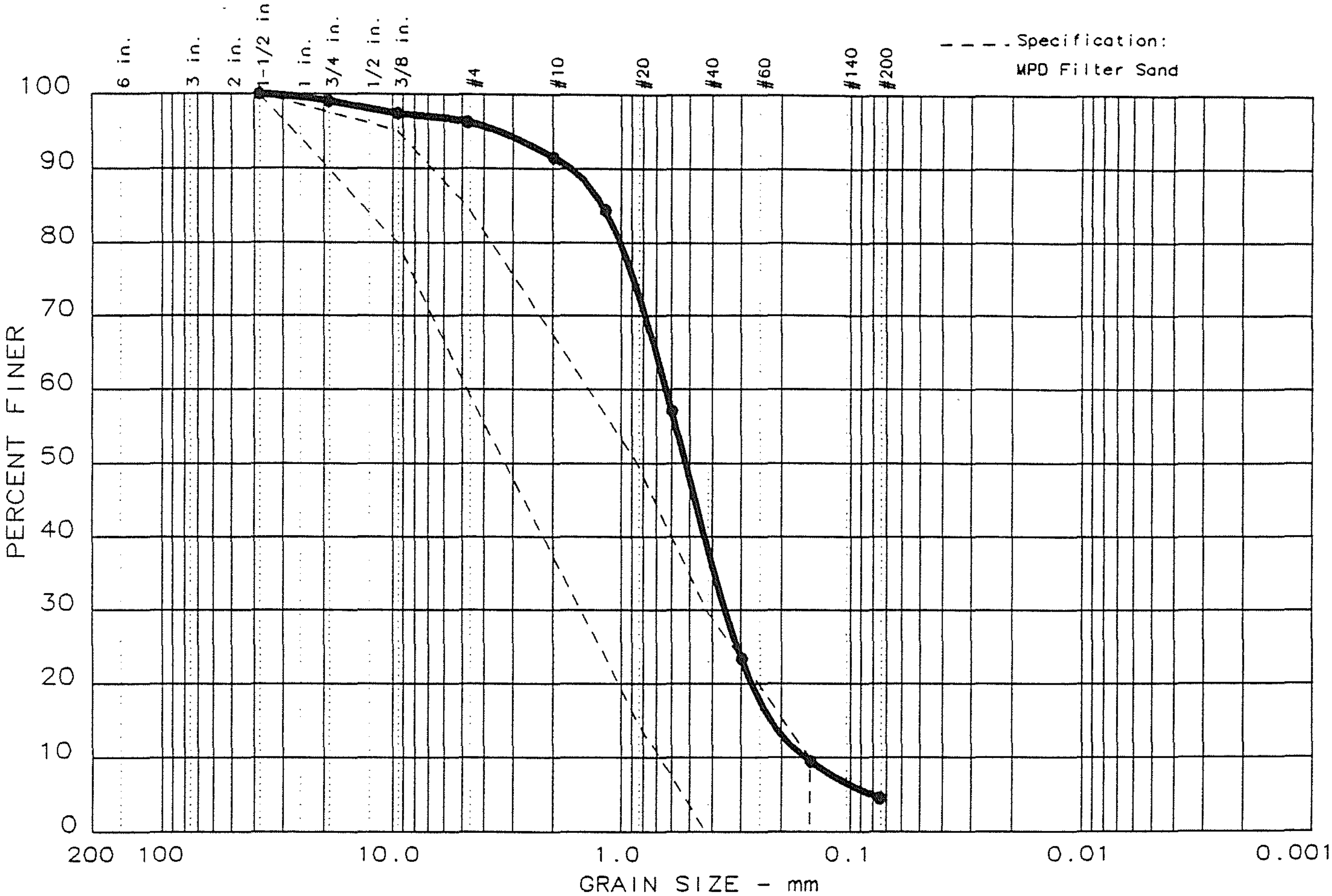
Station 1+28, 4 ft US

Embankment Fill

Water Content = 9.0%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	8	0.0	3.8	91.7	4.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.20	0.635	0.522	0.353	0.220	0.156	1.26	4.1

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND	SP	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S6, "Filter Sand"

Date: April 2, 1996

Remarks:

Station 1+28

Depth 4 ft

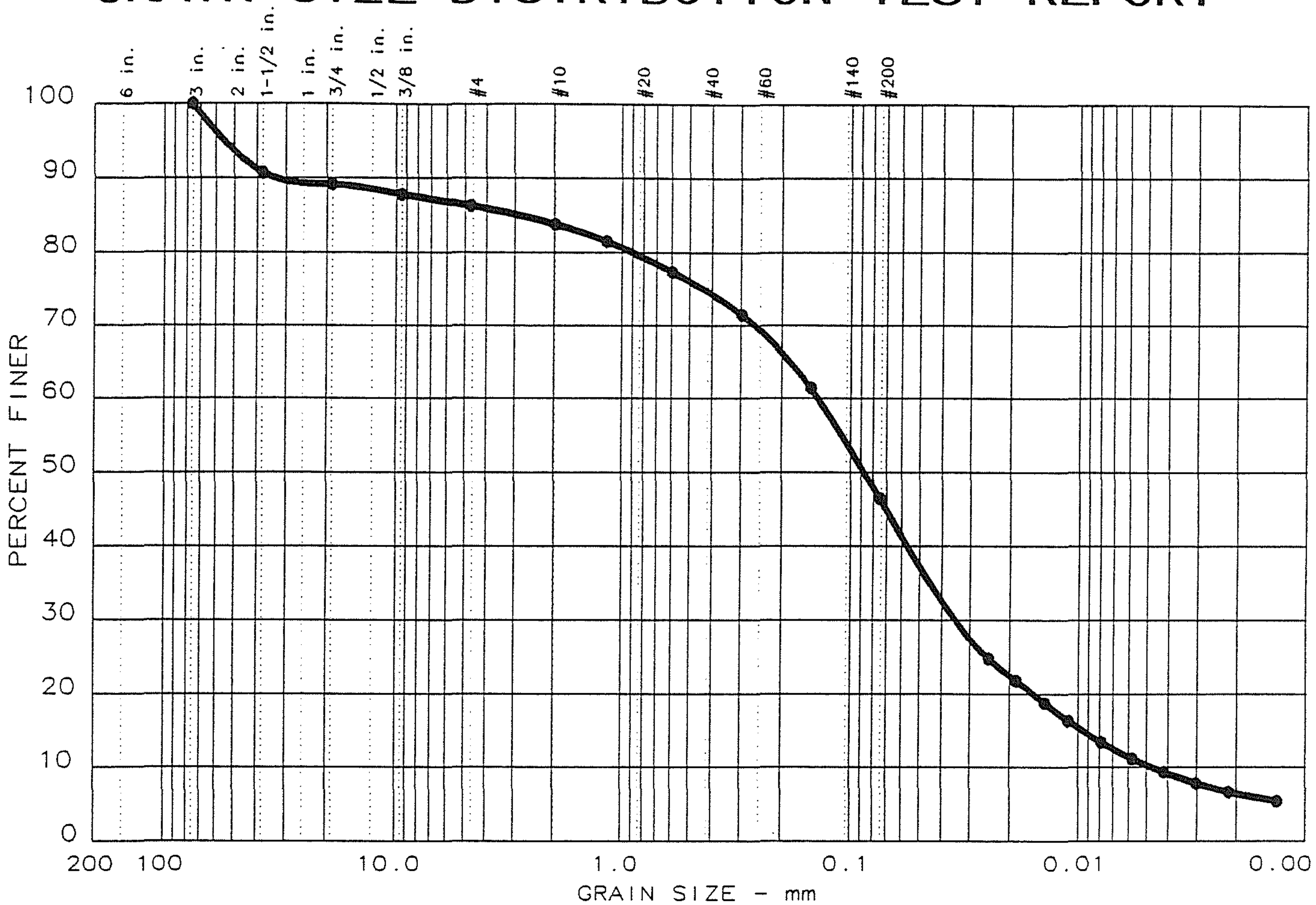
Chimney Drain

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	11	0.0	13.7	39.9	46.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.88	0.138	0.0871	0.0347	0.0095	0.0047	1.84	29.2

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND	SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S7, Depth 7.3 ft

Date: April 2, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

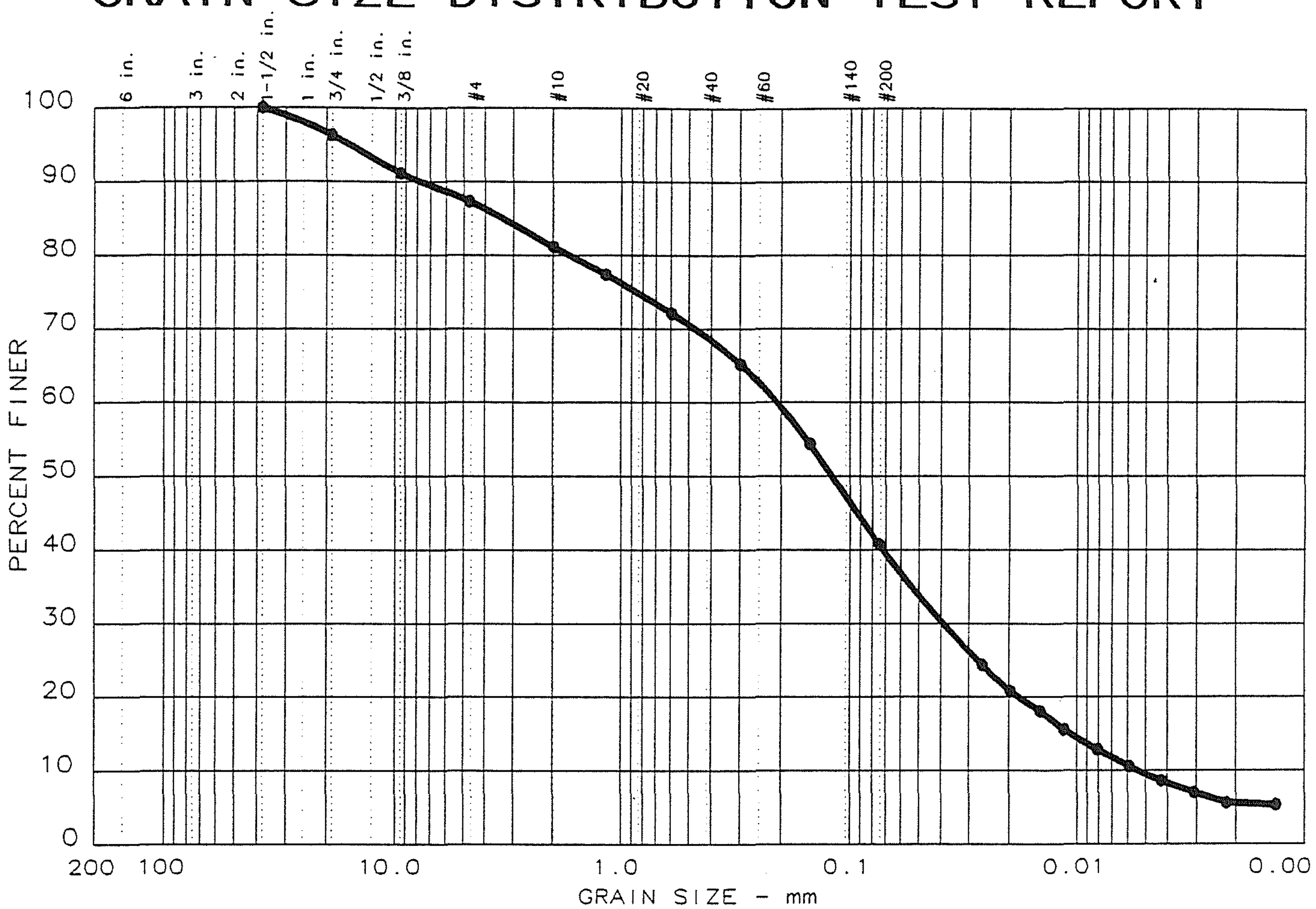
Station 1+28

Soft Embankment Fill

Water Content = 14.4%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	12	0.0	12.7	46.6	40.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			3.35	0.207	0.119	0.0389	0.0107	0.0054	1.35	38.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND	SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S8, Depth 11.7 ft

Date: April 2, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

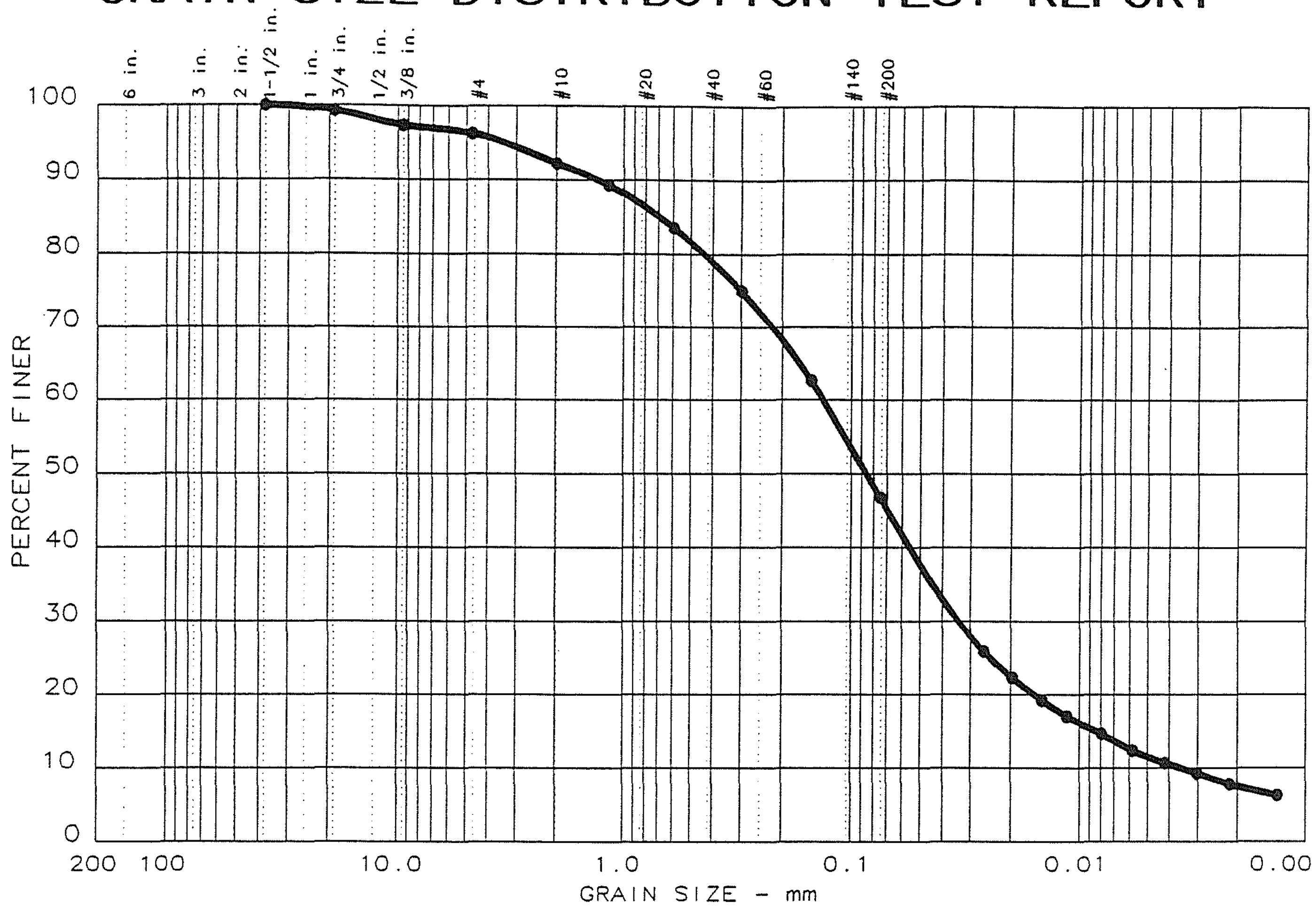
Station 1+28

Embankment Fill

Water Content = 11.7%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	13	0.0	3.7	49.5	46.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.692	0.132	0.0861	0.0339	0.0084	0.0035	2.45	37.2

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND	SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S9, Depth 0.7 ft

Date: April 2, 1996

Remarks:

Station 1+28

Embankment Fill

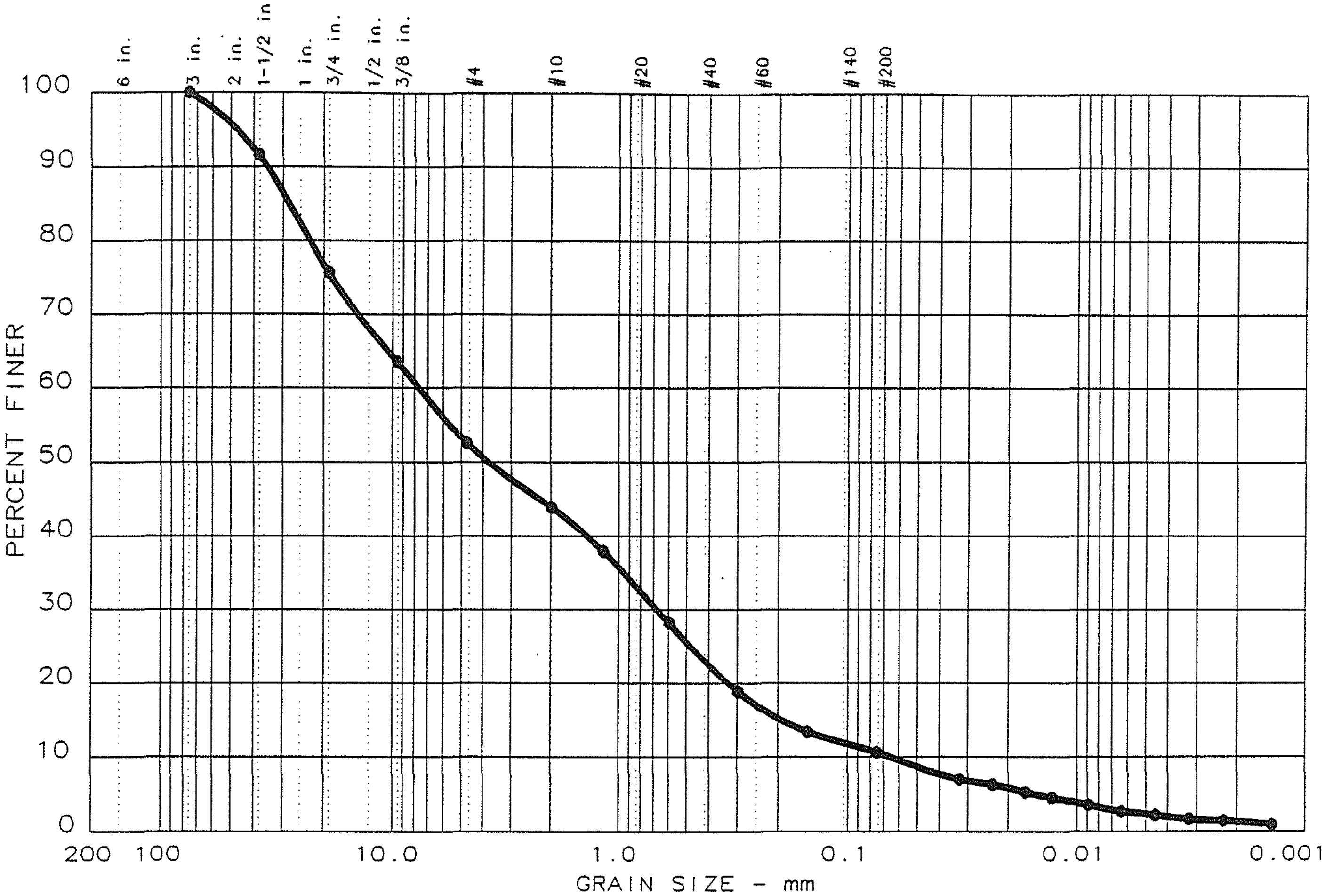
Water Content = 14.6%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	14	0.0	47.4	42.0	10.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			28.2	7.59	3.76	0.676	0.195	0.0653	0.92	116.1

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with silt and sand	GP-GM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S10, Depth 20 ft

Date: April 2, 1996

Remarks:

Station 1+33, 9 ft DS

Blanket Drain

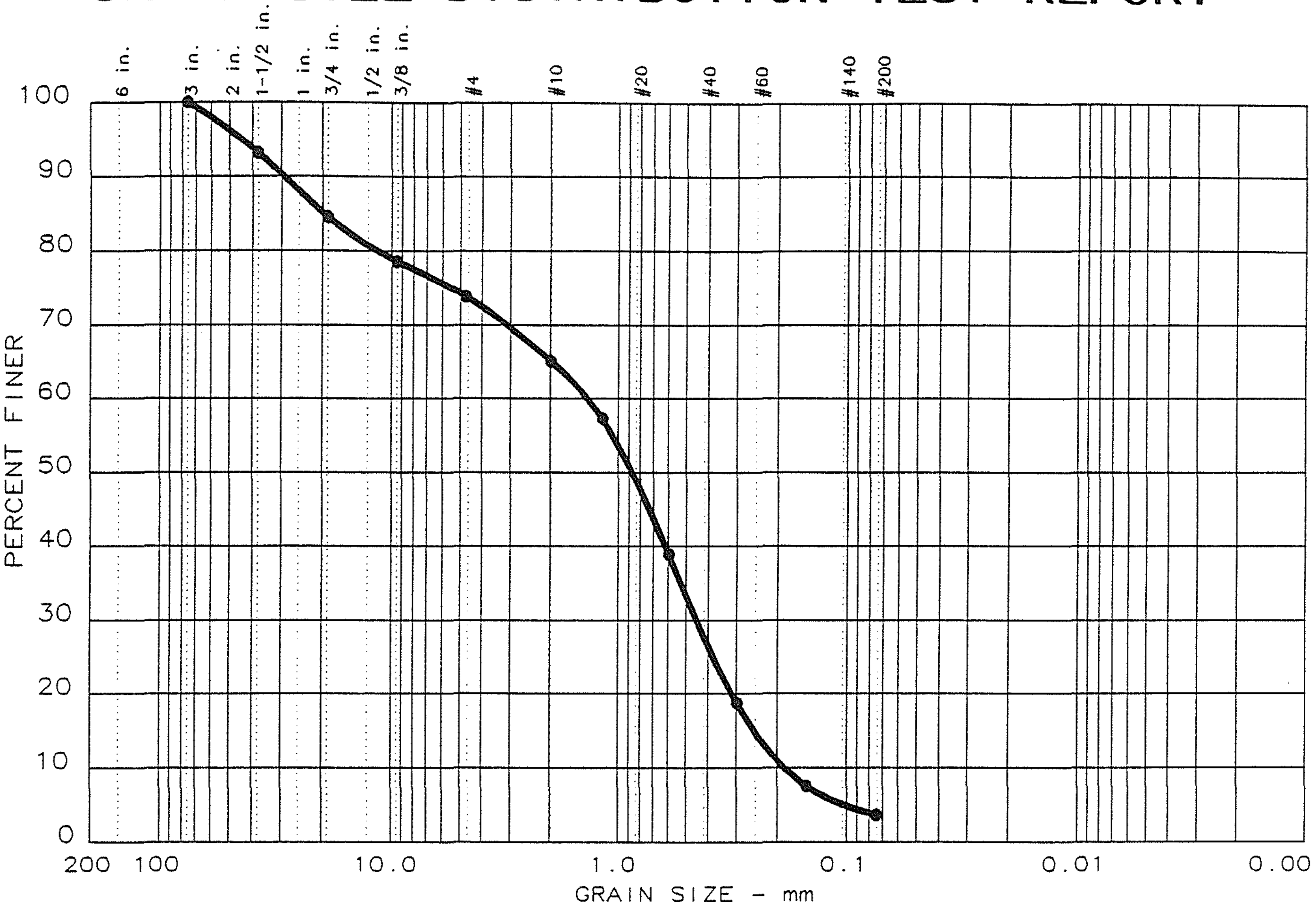
Water Content = 13.1%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	4	0.0	26.1	70.3	3.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			19.7	1.36	0.870	0.451	0.251	0.186	0.80	7.3

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with gravel	SP	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S11, Depth 21 ft

Date: April 1, 1996

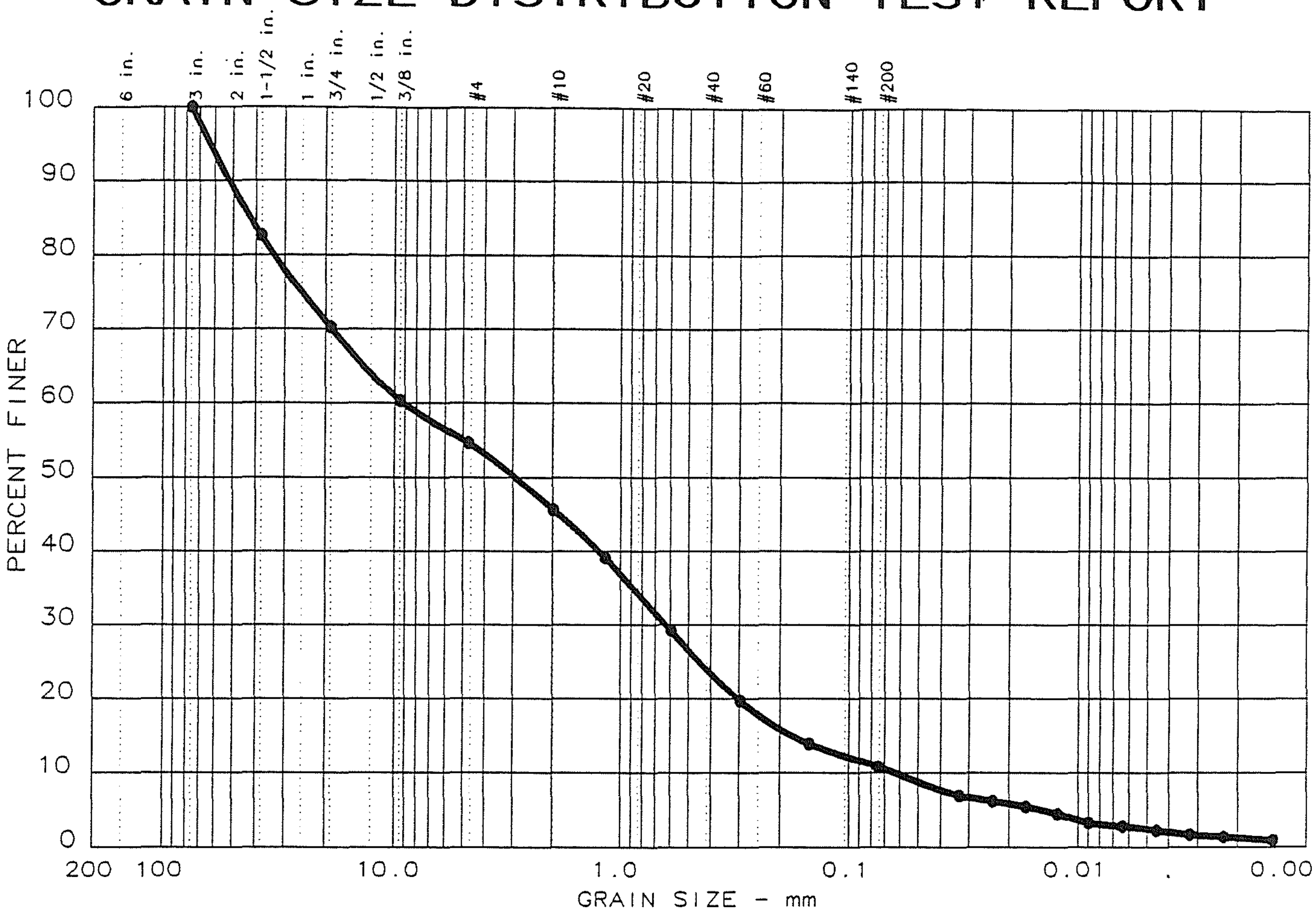
Remarks:
Station 1+33, 20 ft DS
Blanket Drain Filter
Water Content = 11.2%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	15	0.0	45.4	43.8	10.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			42.2	9.12	2.92	0.631	0.178	0.0631	0.69	144.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with silt and sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S12, Depth 21.5 ft

Date: April 2, 1996

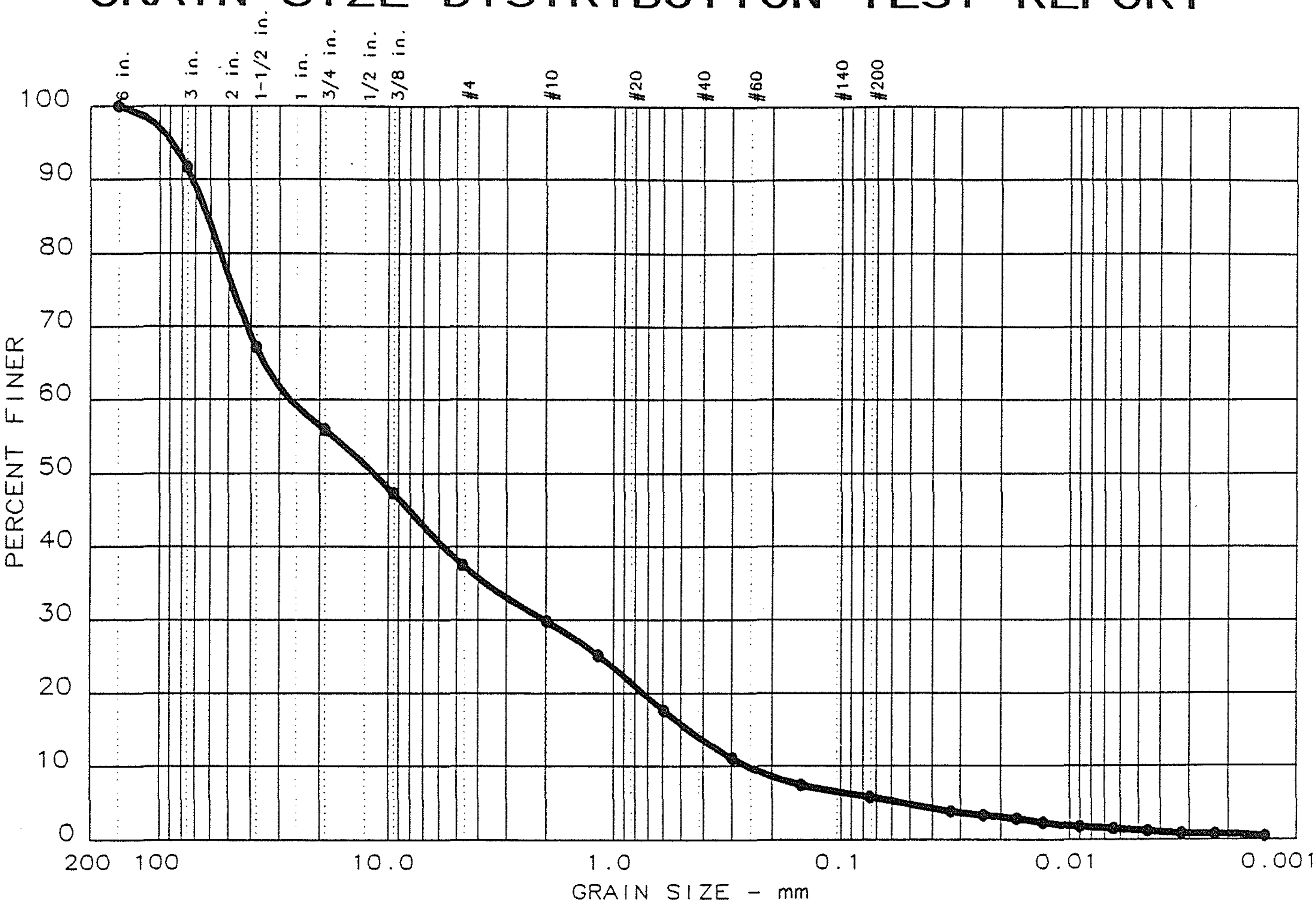
GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:
Station 1+33, 20 ft DS
Blanket Drain
Water Content = 9.7%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	16	8.3	54.2	31.7	5.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			62.0	26.8	11.5	2.03	0.465	0.256	0.60	104.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with silt and sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S13, Depth 20.5 ft

Date: April 2, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

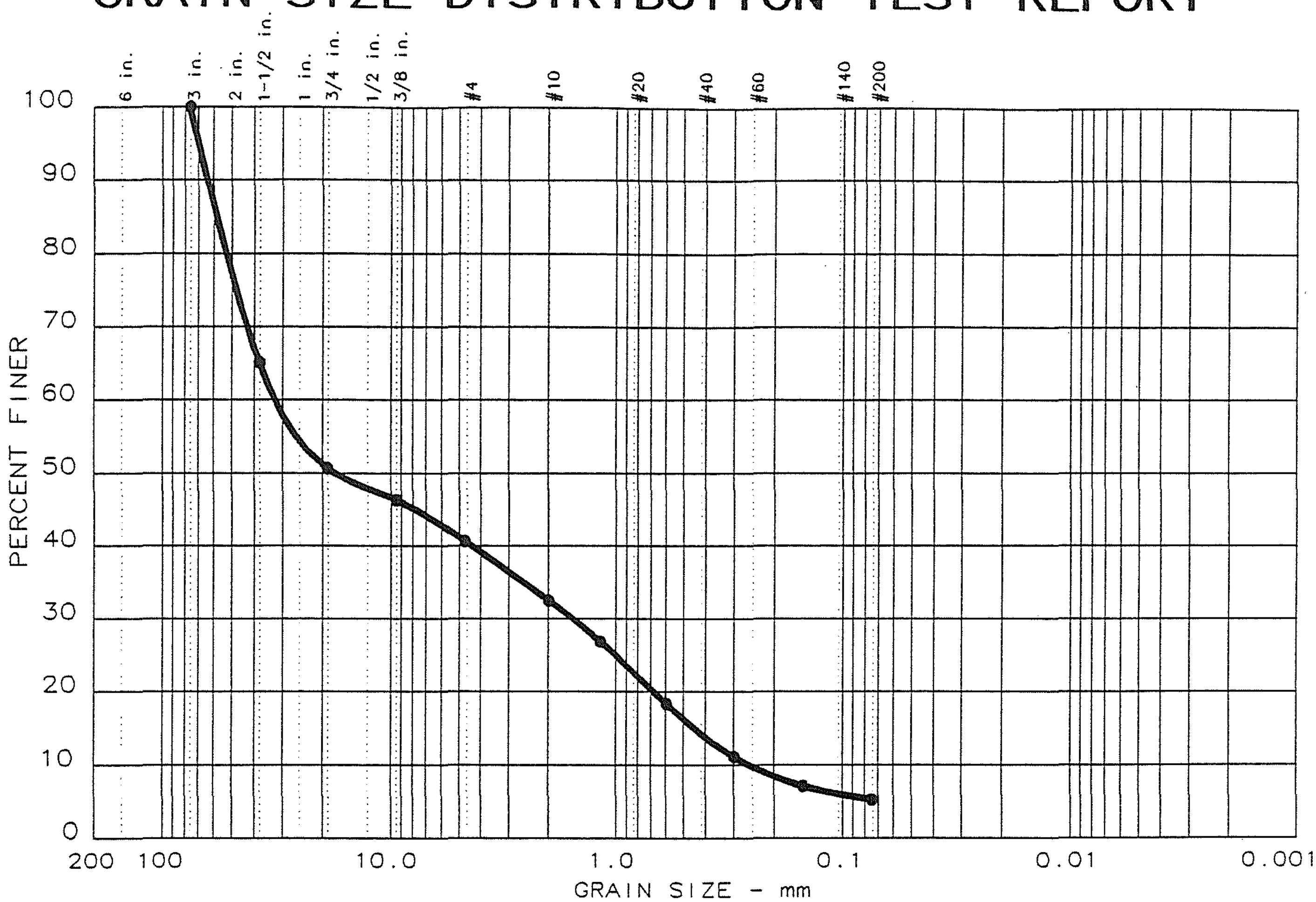
Station 1+33, 32 ft DS

Blanket Drain

Water Content = 12.2%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	5	0.0	59.4	35.4	5.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			58.2	32.4	17.6	1.57	0.447	0.257	0.30	125.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with silt and sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S14

Date: April 1, 1996

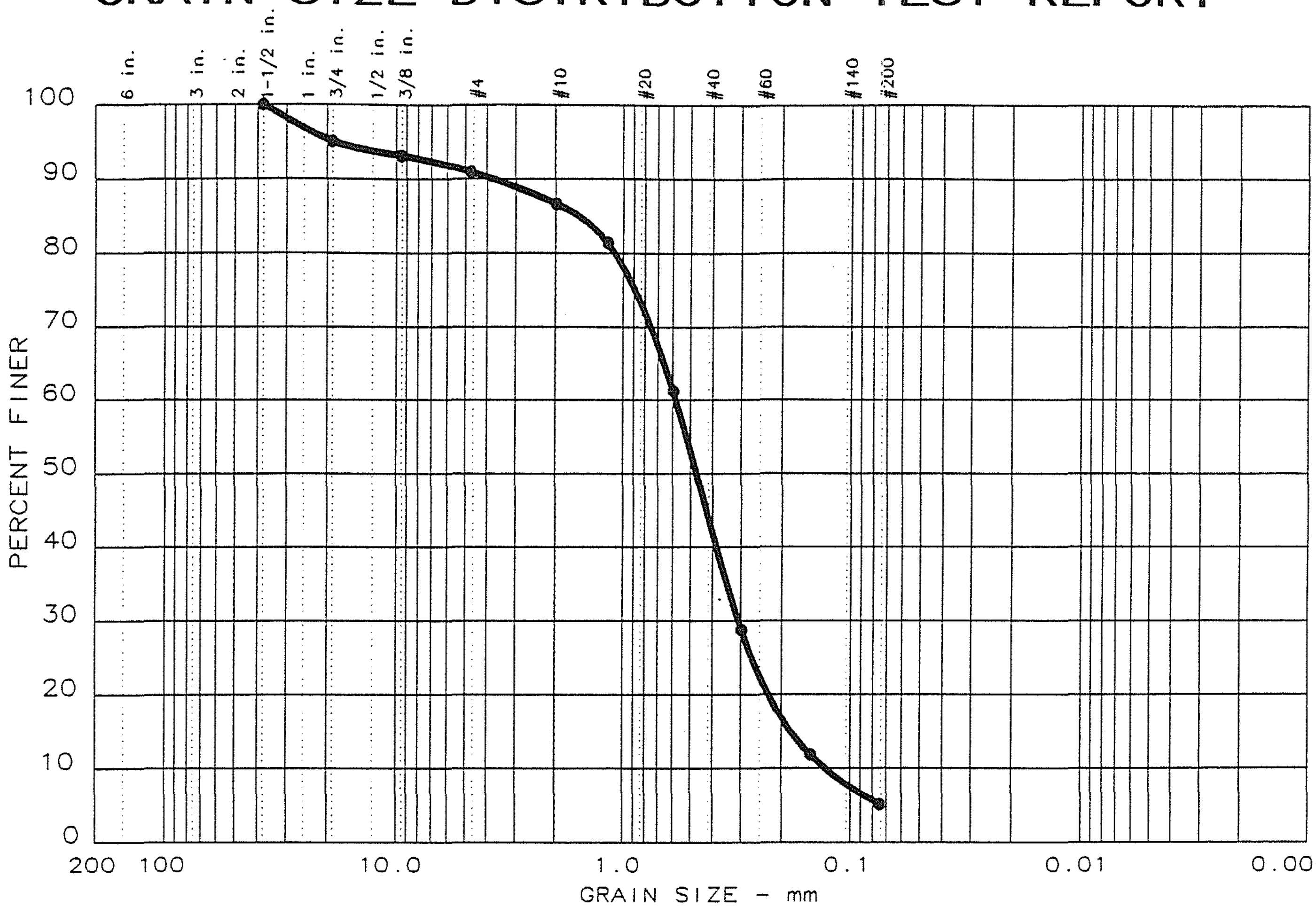
GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:
Station 1+33, 41 ft DS
Above 4-inch HDPE
Perforated Drain Pipe
Water Content = 12.2%

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	6	0.0	9.1	85.8	5.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.58	0.582	0.472	0.308	0.182	0.129	1.27	4.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with silt	SP-SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S15, 18 ft from Spillway

Date: April 1, 1996

Remarks:

Station 2+30, 8 ft DS

Chimney Drain

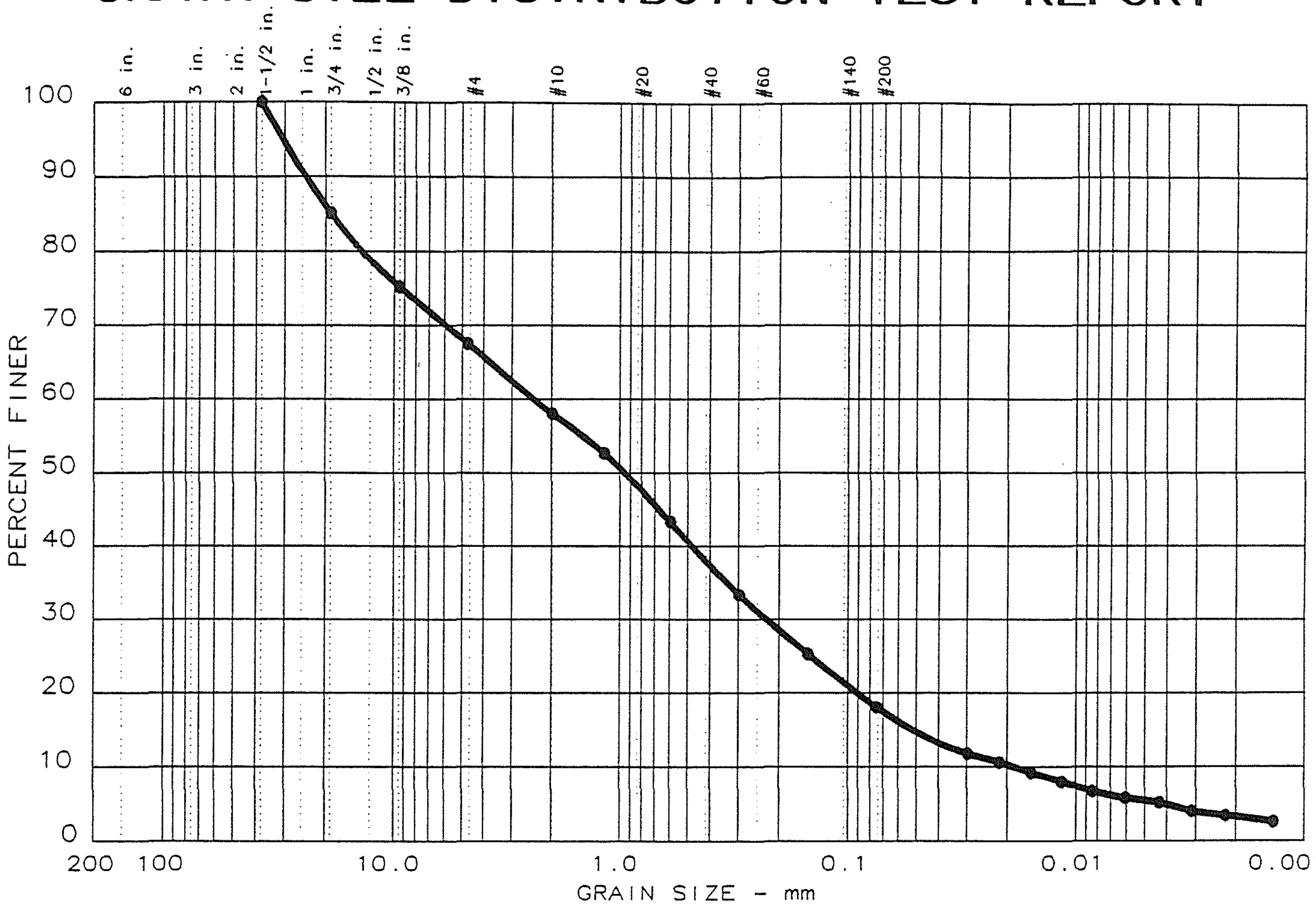
Water Content = 7.5%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	17	0.0	32.4	49.5	18.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			18.8	2.37	0.955	0.226	0.0519	0.0188	1.15	125.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND with gravel	SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S16

Date: April 2, 1996

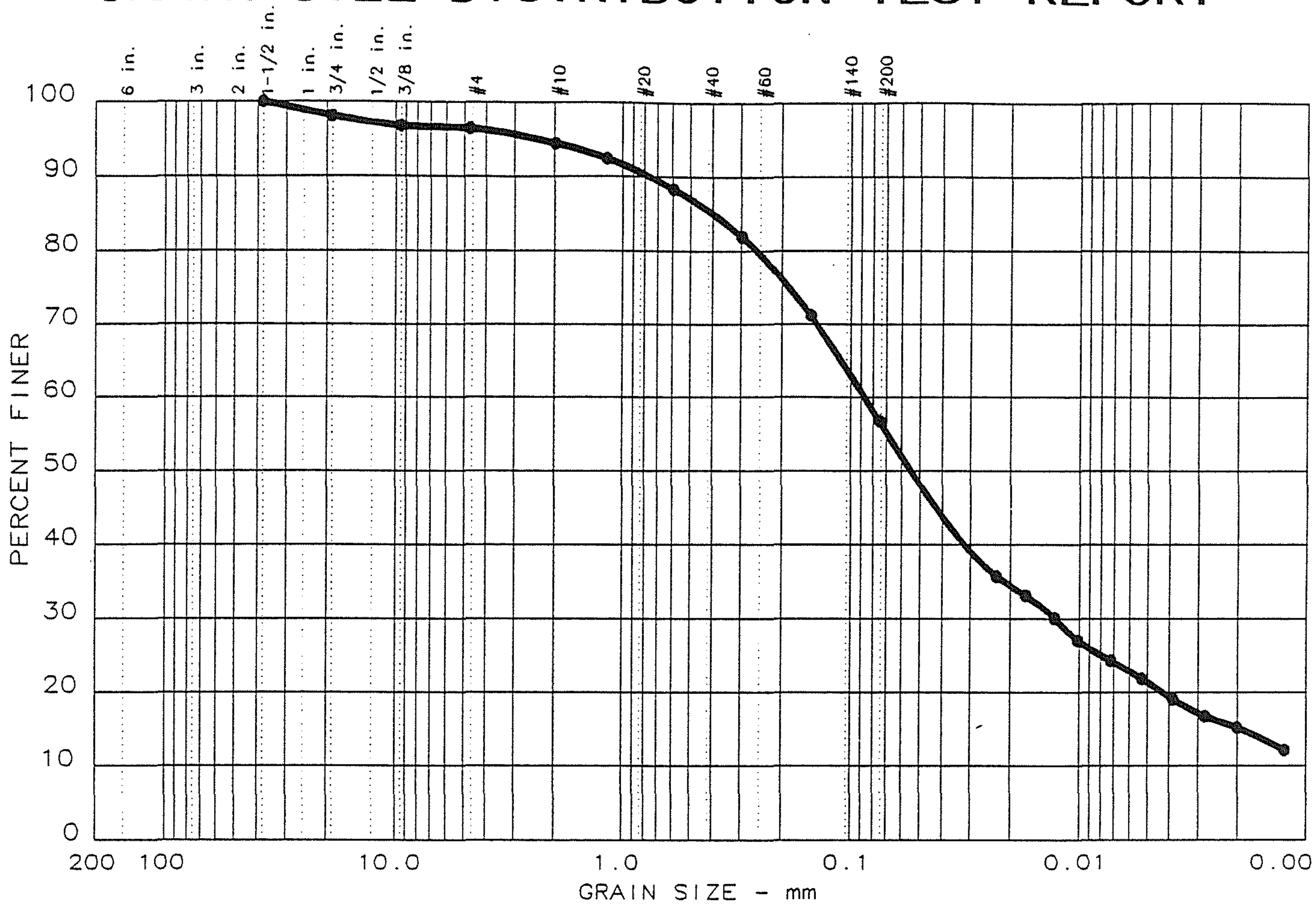
Remarks:
Station 2+50, 15 ft DS
Soil beneath DS riprap
Water Content = 11.6%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	18	0.0	3.5	39.7	56.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.398	0.0870	0.0543	0.0127	0.0019			

MATERIAL DESCRIPTION	USCS	AASHTO
● Sandy SILT	ML	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample S17, Depth 22.5 ft

Date: April 2, 1996

Remarks:

Station 2+30

Glacial Till below

Dam Crest

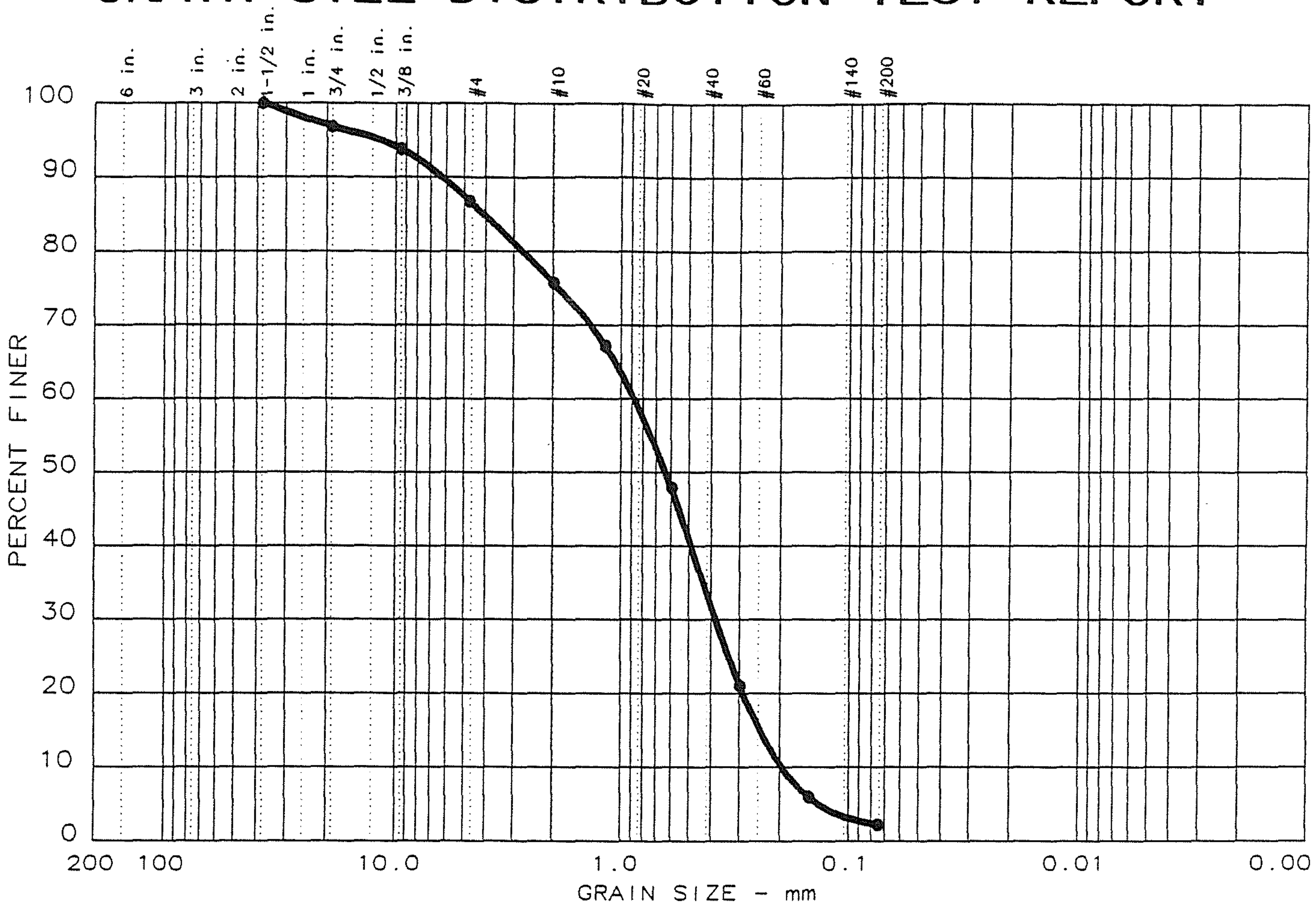
Water Content = 12.4%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	7	0.0	13.2	84.5	2.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			4.07	0.871	0.638	0.383	0.245	0.194	0.87	4.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND	SP	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample S18, Station 2+30, 12 ft DS

Date: April 1, 1996

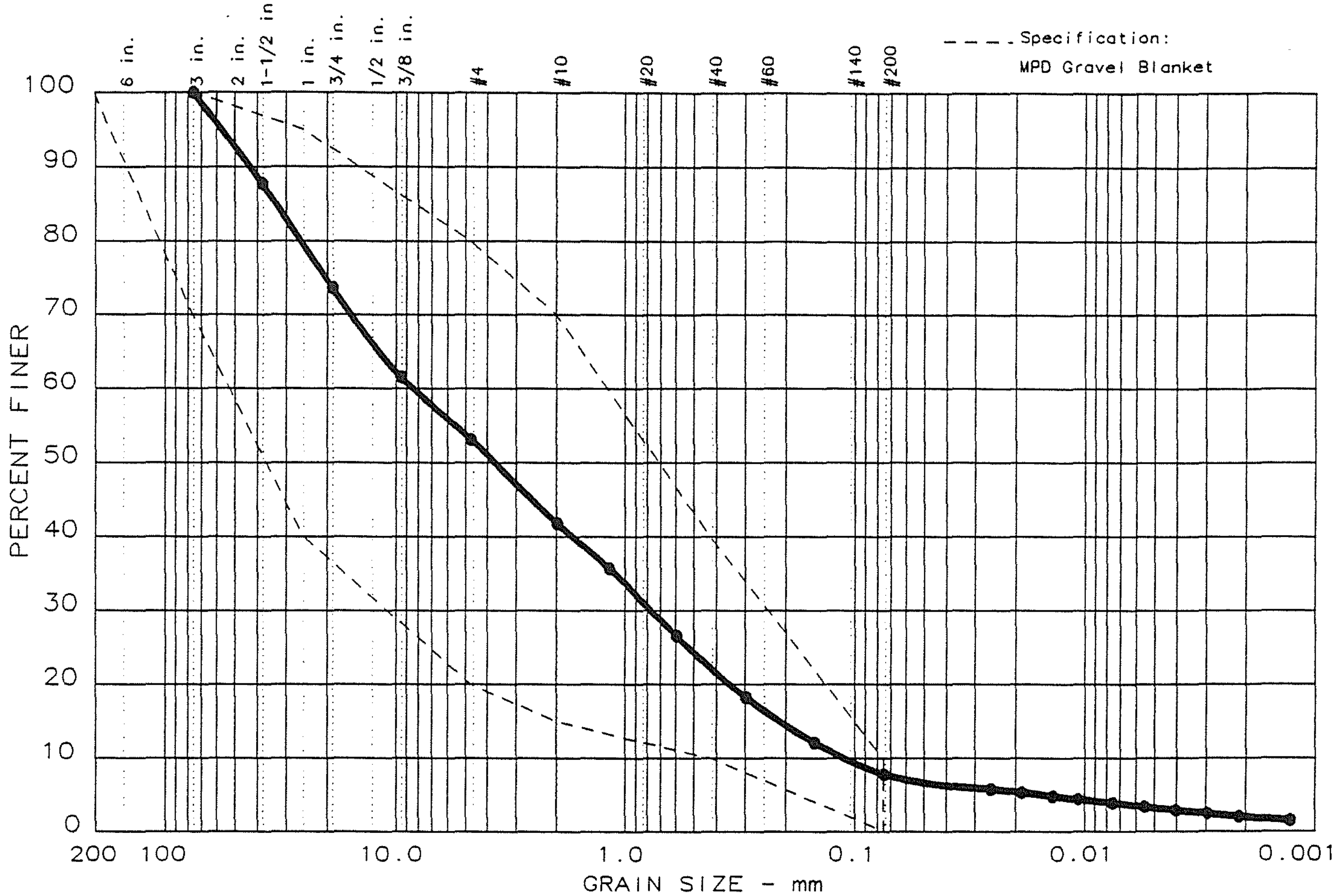
Remarks:
Filter Sand below
Drainage Blanket
right side of Breach
Water Content = 17.5%

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	3	0.0	46.9	45.3	7.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			33.1	8.41	3.72	0.767	0.211	0.111	0.63	75.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with Silt and Sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample SS22, "Gravel Blanket"

Date: April 30, 1996

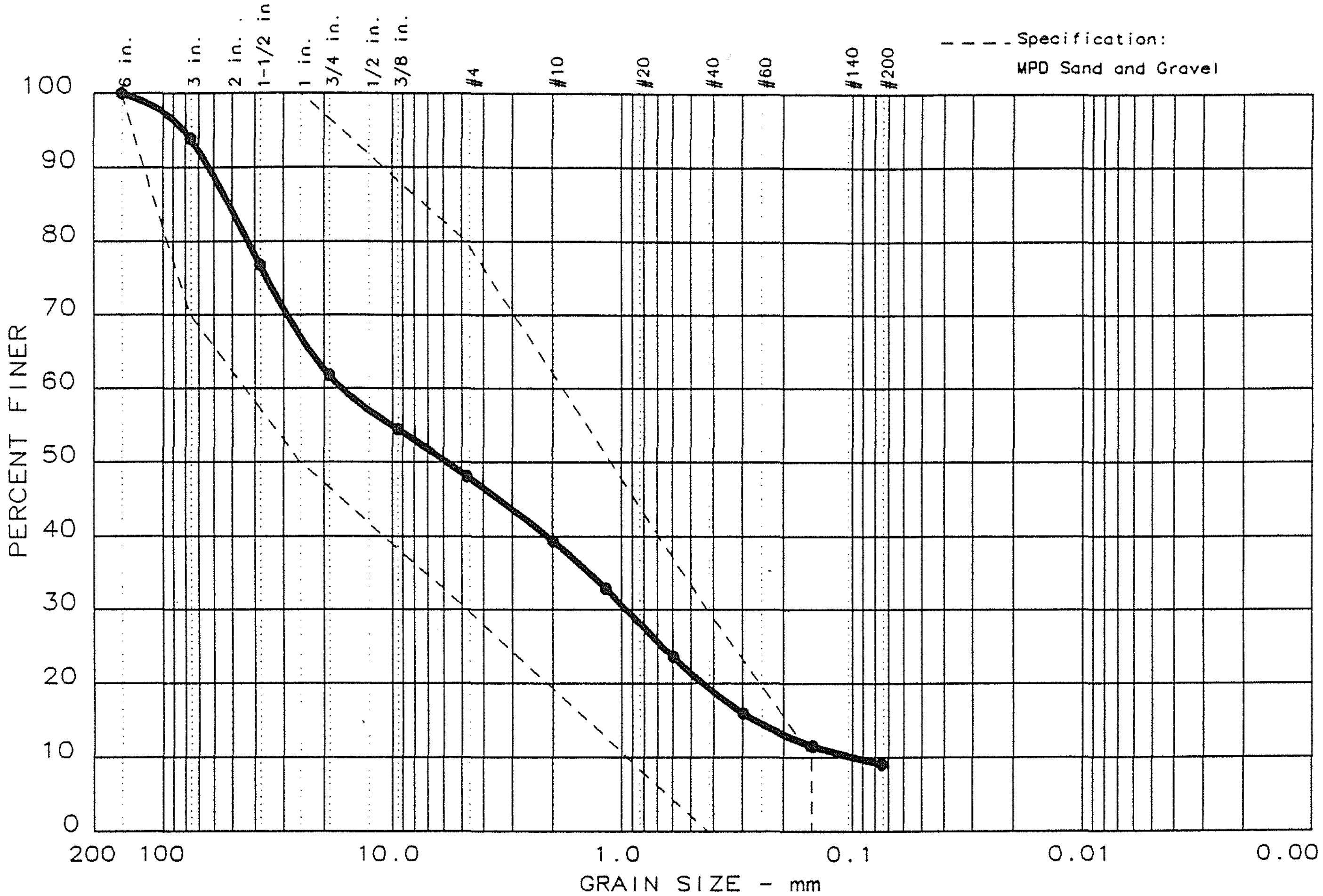
Remarks:
Station 2+30, 29 ft DS
Below grouted rip-rap

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	4	6.2	45.8	38.9	9.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			51.3	16.6	5.82	0.955	0.266	0.0944	0.58	175.8

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with Silt and Sand	GP-GM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample SS27, "Sand and Gravel"

Date: April 23, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

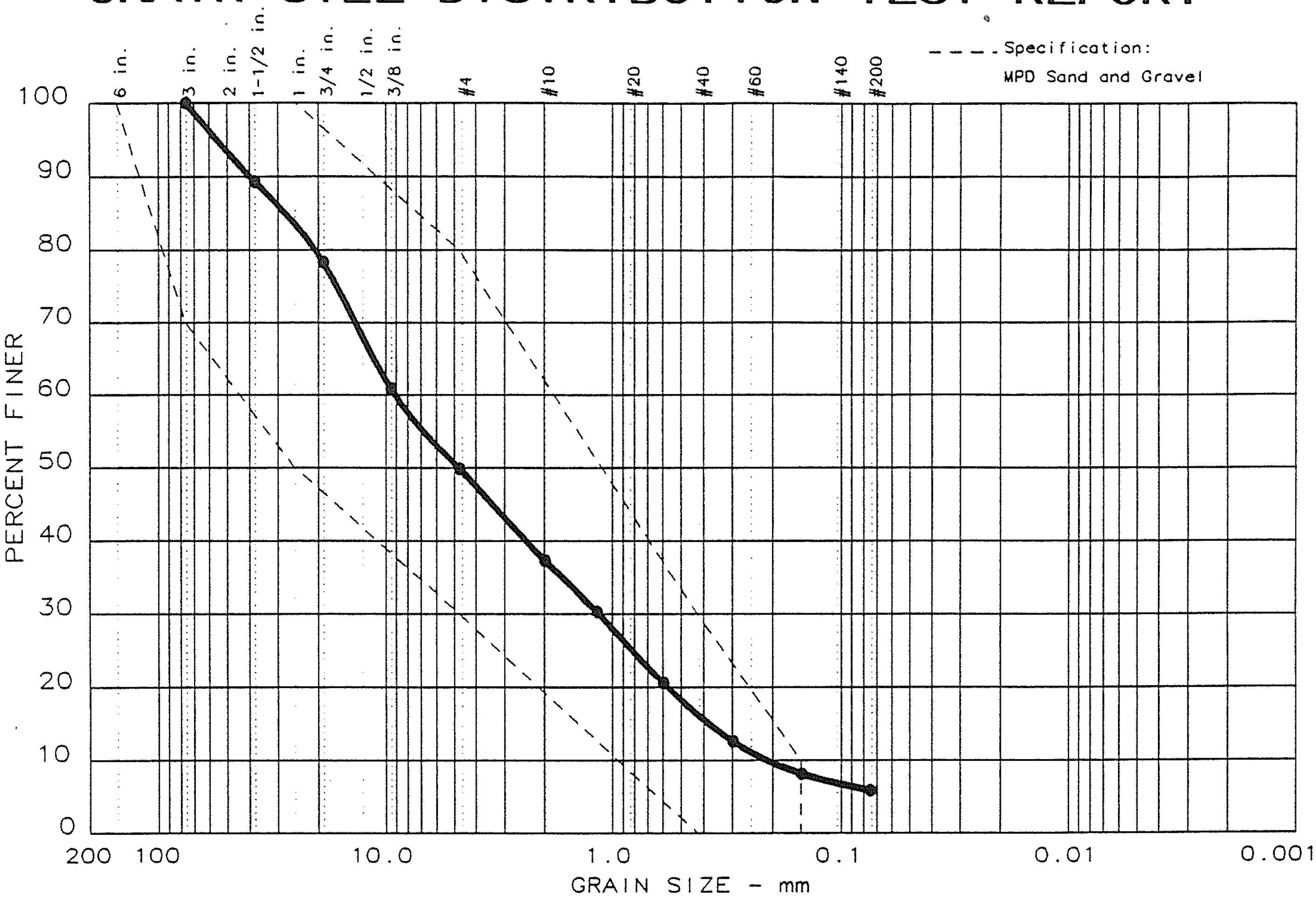
Remarks:

Station 2+26, 12 ft DS

Blanket Drain

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	4	0.0	50.1	44.0	5.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			27.9	9.02	4.79	1.15	0.376	0.211	0.69	42.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with Silt and Sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample SS29, "Sand & Gravel"

Date: April 30, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

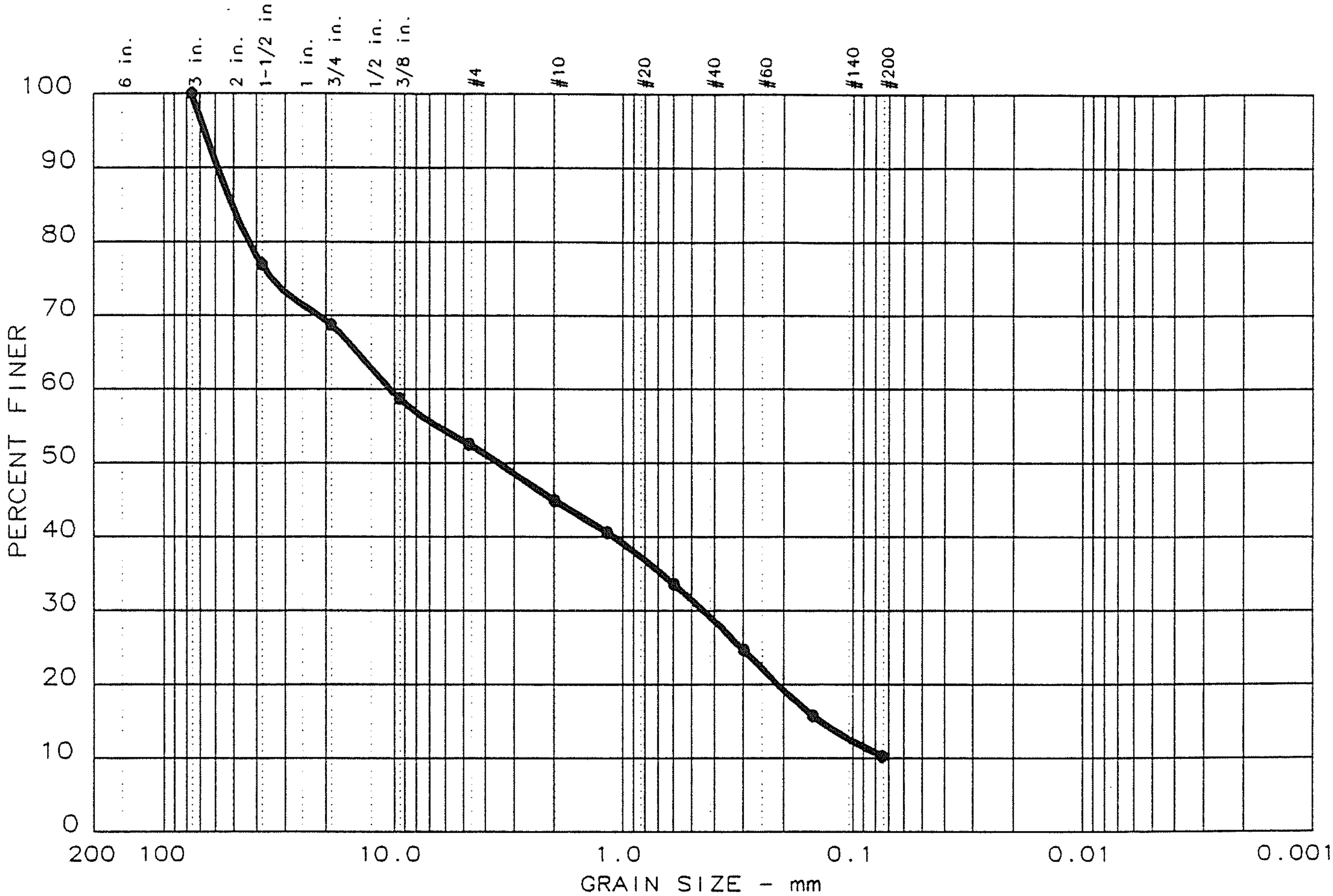
Remarks:

Station 2+51, 14 ft DS

Blanket drain

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	5	0.0	47.5	42.3	10.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			50.7	10.4	3.51	0.447	0.138			

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded GRAVEL with Silt and Sand	GP-GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample SS30, "Foundation"

Date: April 30, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

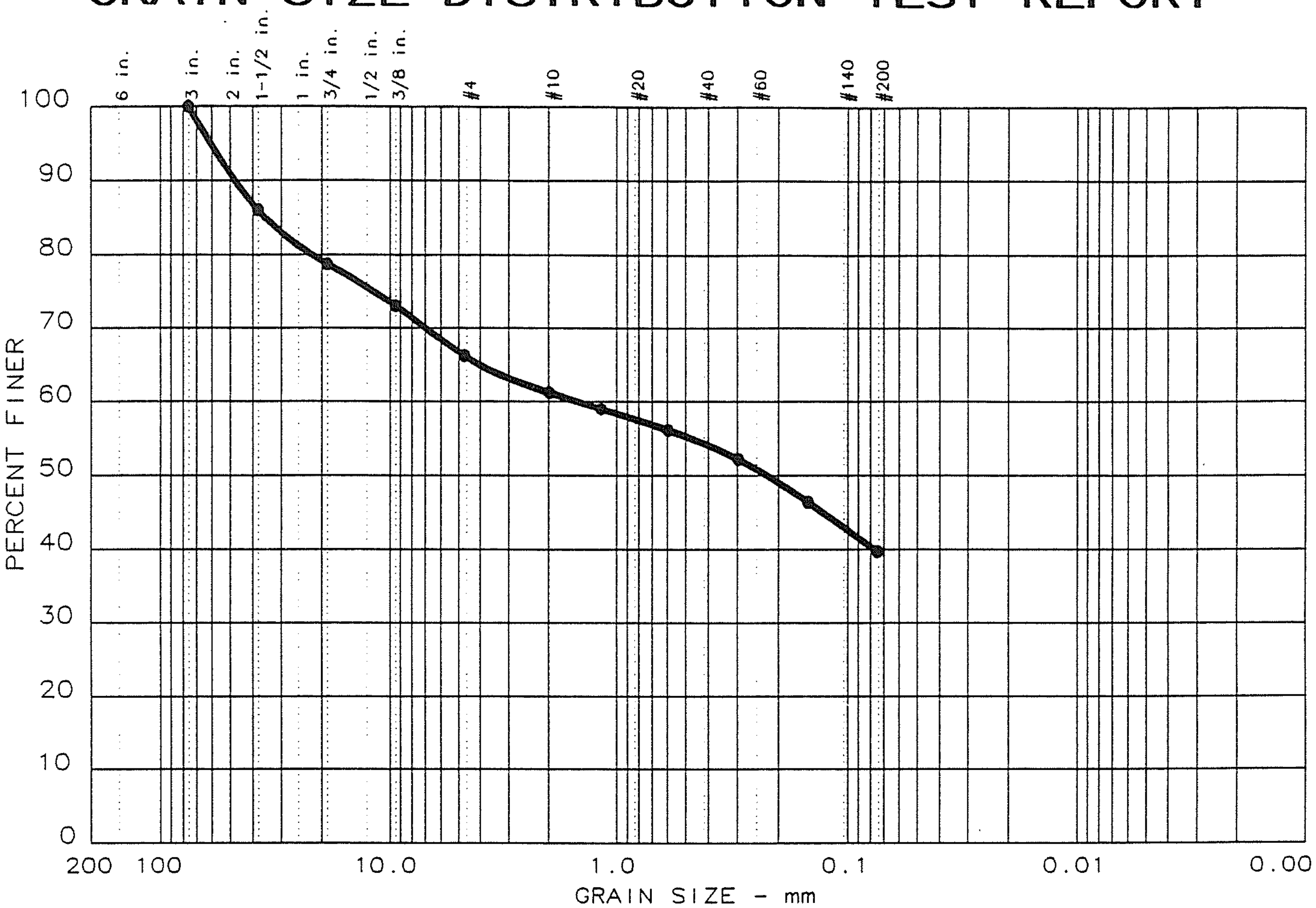
GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

From TP adjacent to stream foundation

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	6	0.0	33.8	26.6	39.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			35.5	1.50	0.226					

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty GRAVEL with Sand	GM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample SS31, "Existing Glacial Till"

Date: April 30, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

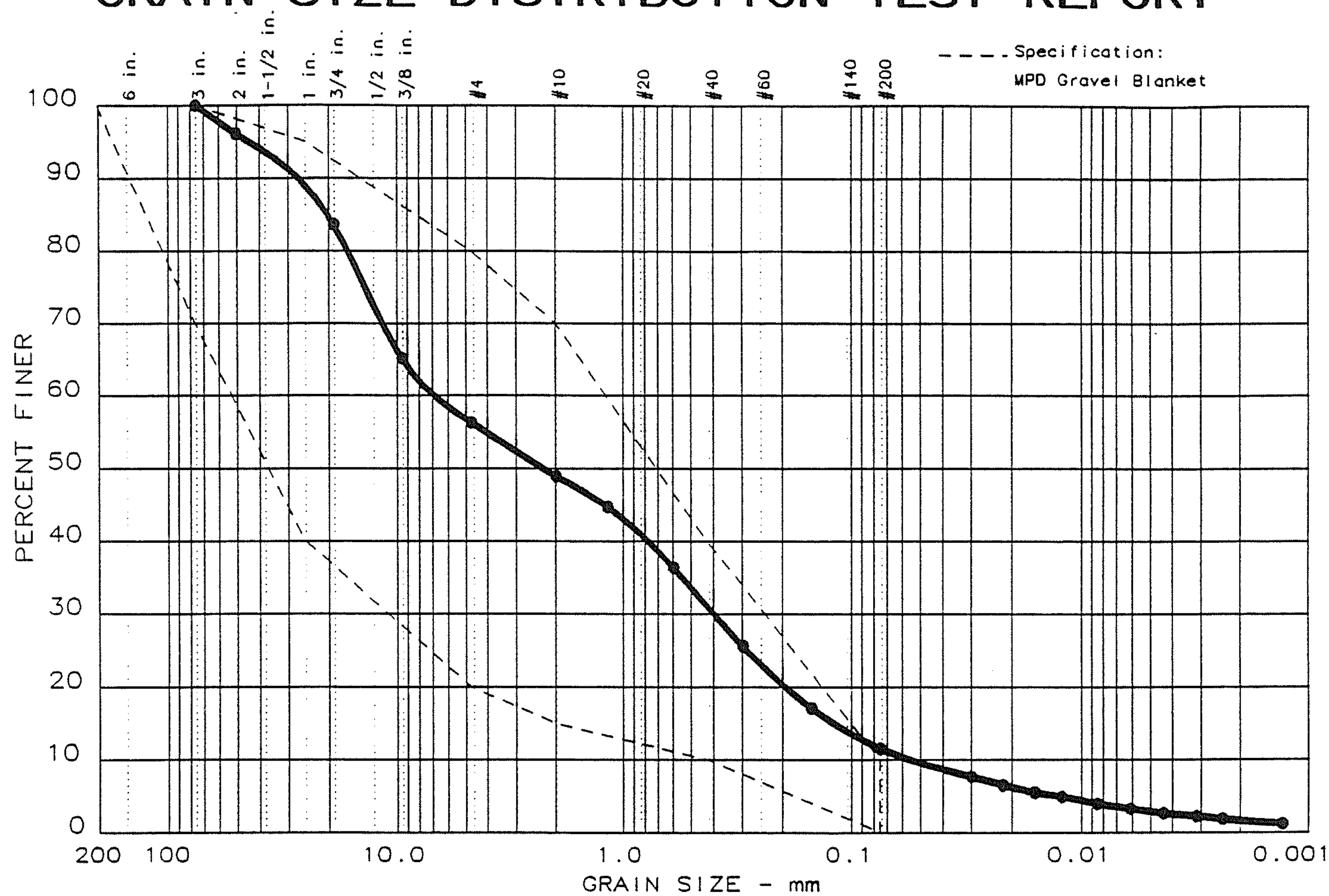
GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

Above SS30, foundation

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	1	0.0	43.7	44.8	11.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			20.2	6.92	2.29	0.398	0.119	0.0556	0.41	124.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with Silt and Gravel	SP-SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample FD1, "Gravel Blanket"

Date: April 22, 1996

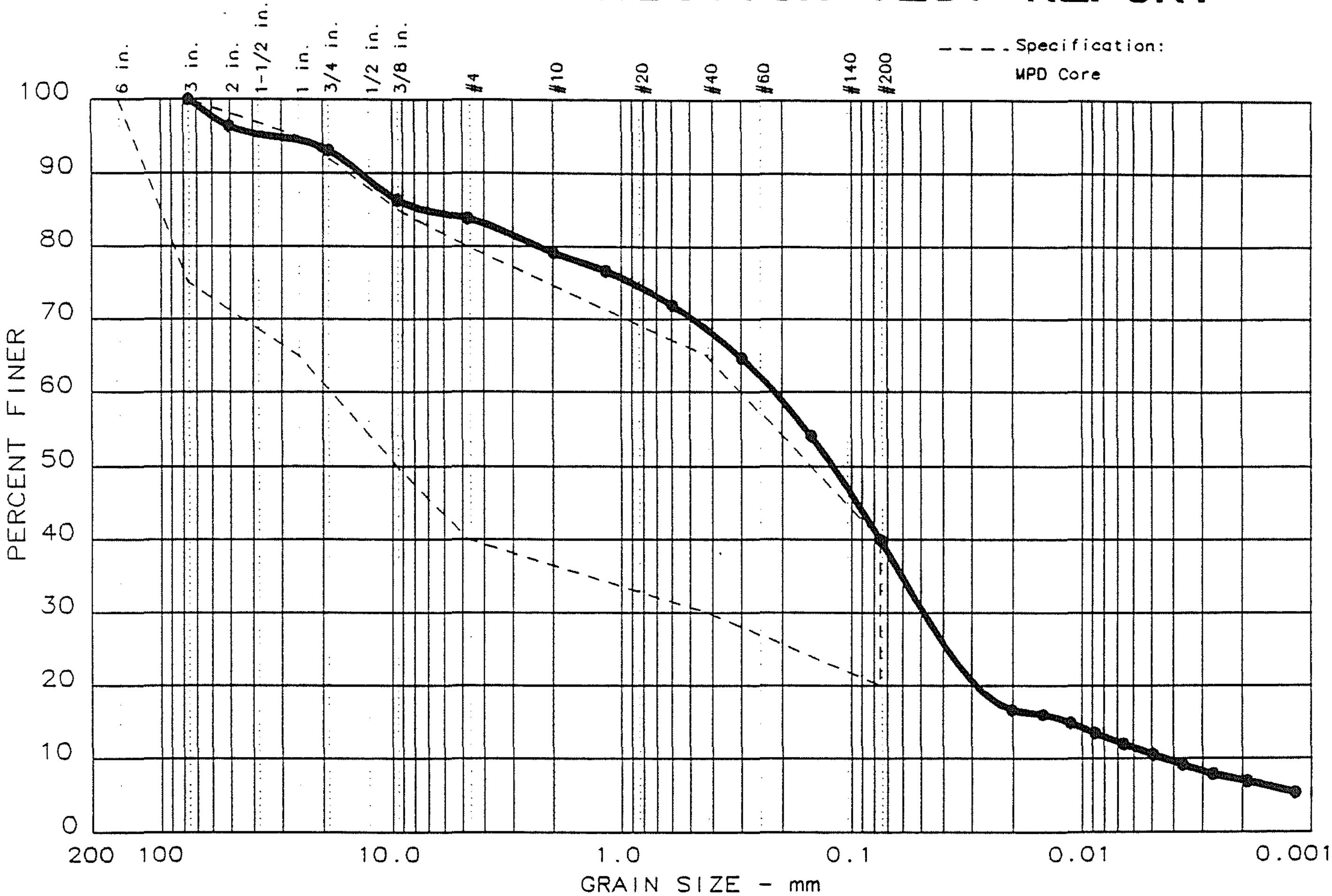
Remarks:
Station 2+48, 5 ft US
Beneath Spillway Slab

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	2	0.0	16.2	43.9	39.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			7.50	0.214	0.120	0.0484	0.0115	0.0044	2.48	48.4

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND with Gravel	SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample FD2, "Core"

Date: April 22, 1996

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

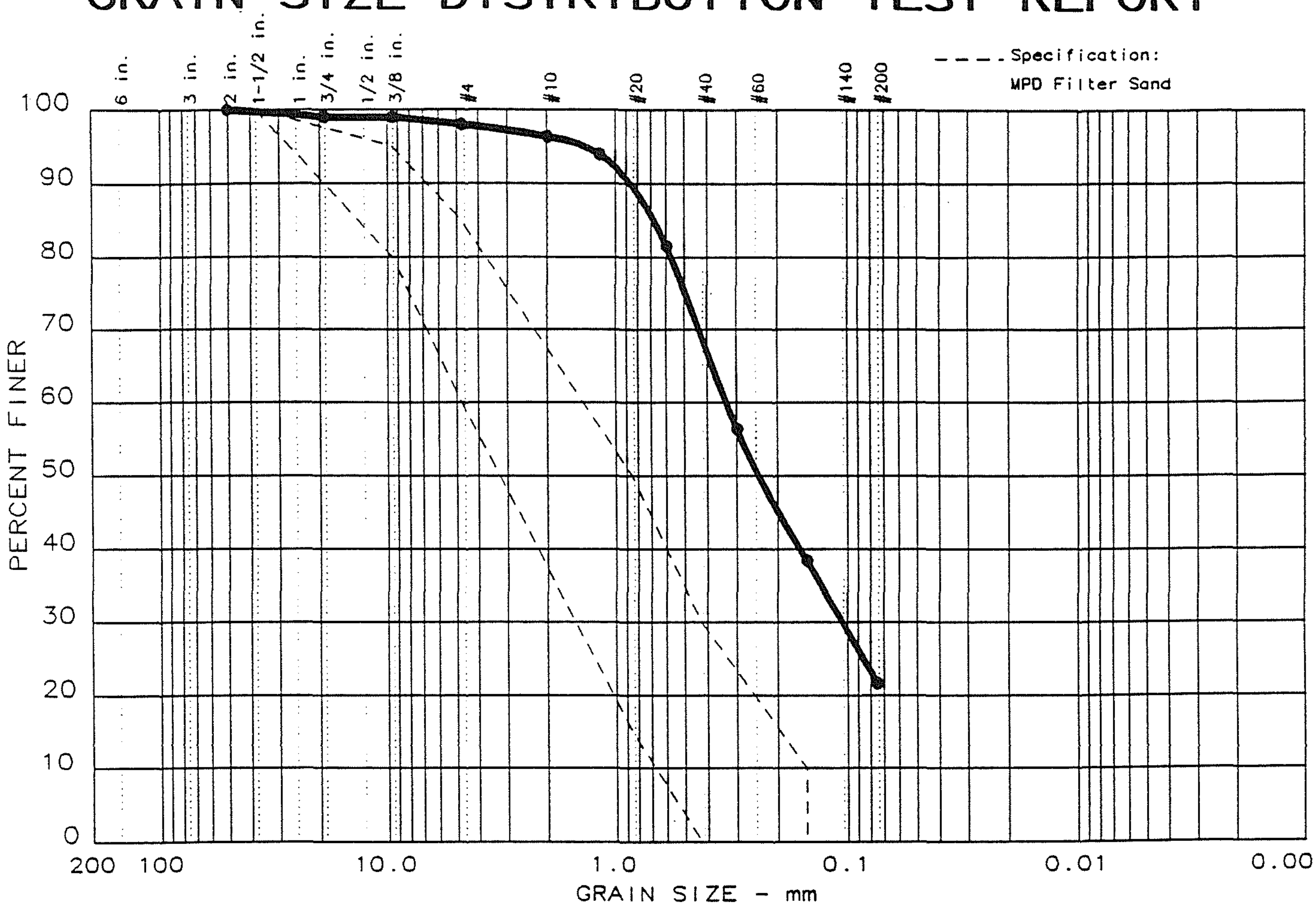
Remarks:

Station 2+48, 4 ft US

Embankment Fill

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	3	0.0	2.1	76.3	21.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.676	0.333	0.241	0.105				

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty SAND	SM	

Project No.: 96069
Project: Meadow Pond Dam
● Location: Sample FD3, "Filter Sand"

Date: April 22, 1996

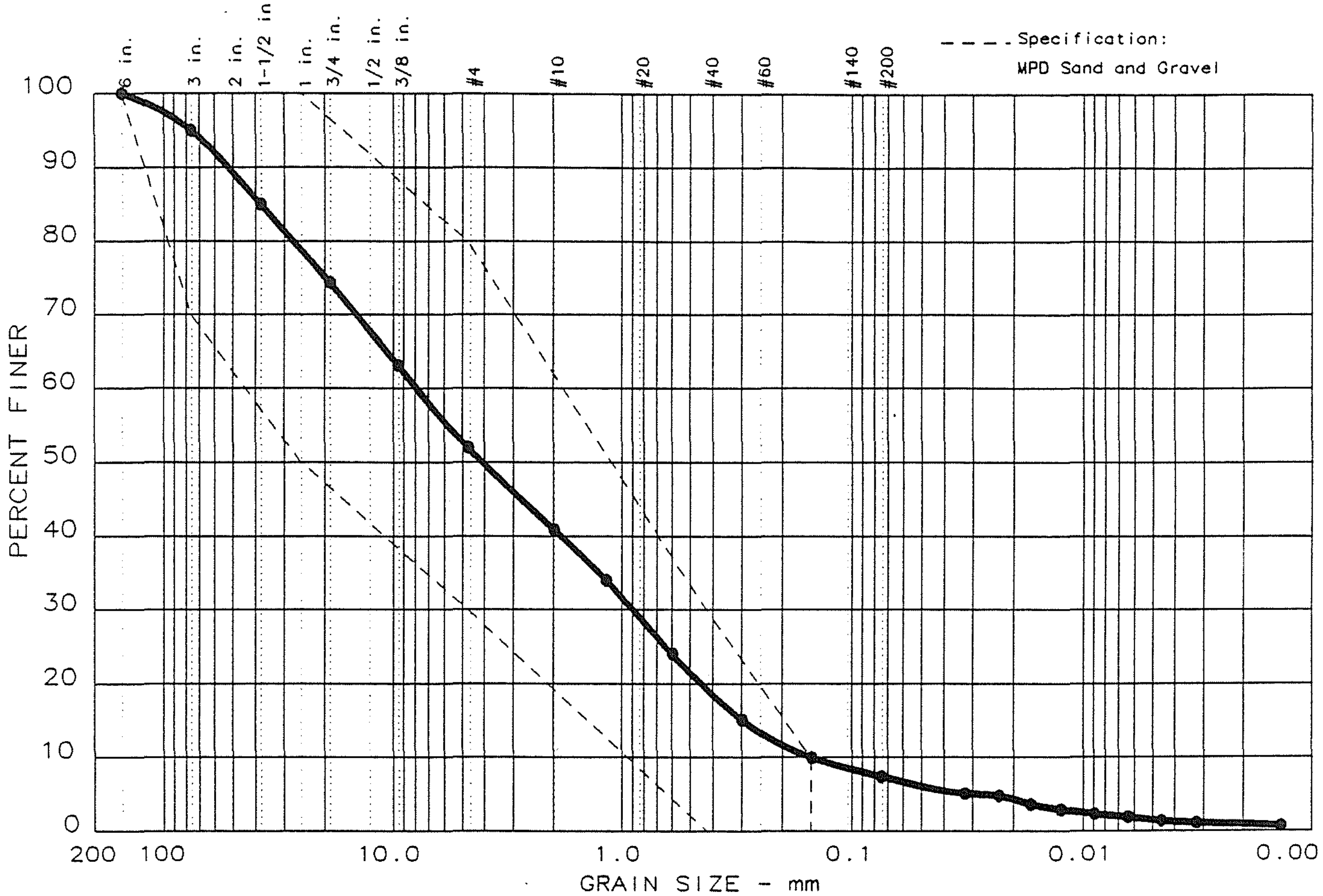
Remarks:
Station 2+47, 5 ft DS
Chimney Drain

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% FINES
●	2	5.0	43.0	44.6	7.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			37.6	7.85	4.12	0.891	0.295	0.151	0.67	51.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Narrowly graded SAND with Silt and Gravel	SP-SM	

Project No.: 96069

Project: Meadow Pond Dam

● Location: Sample FD19, "Sand and Gravel"

Date: April 30, 1996

Remarks:

Station 2+32, 12 ft DS

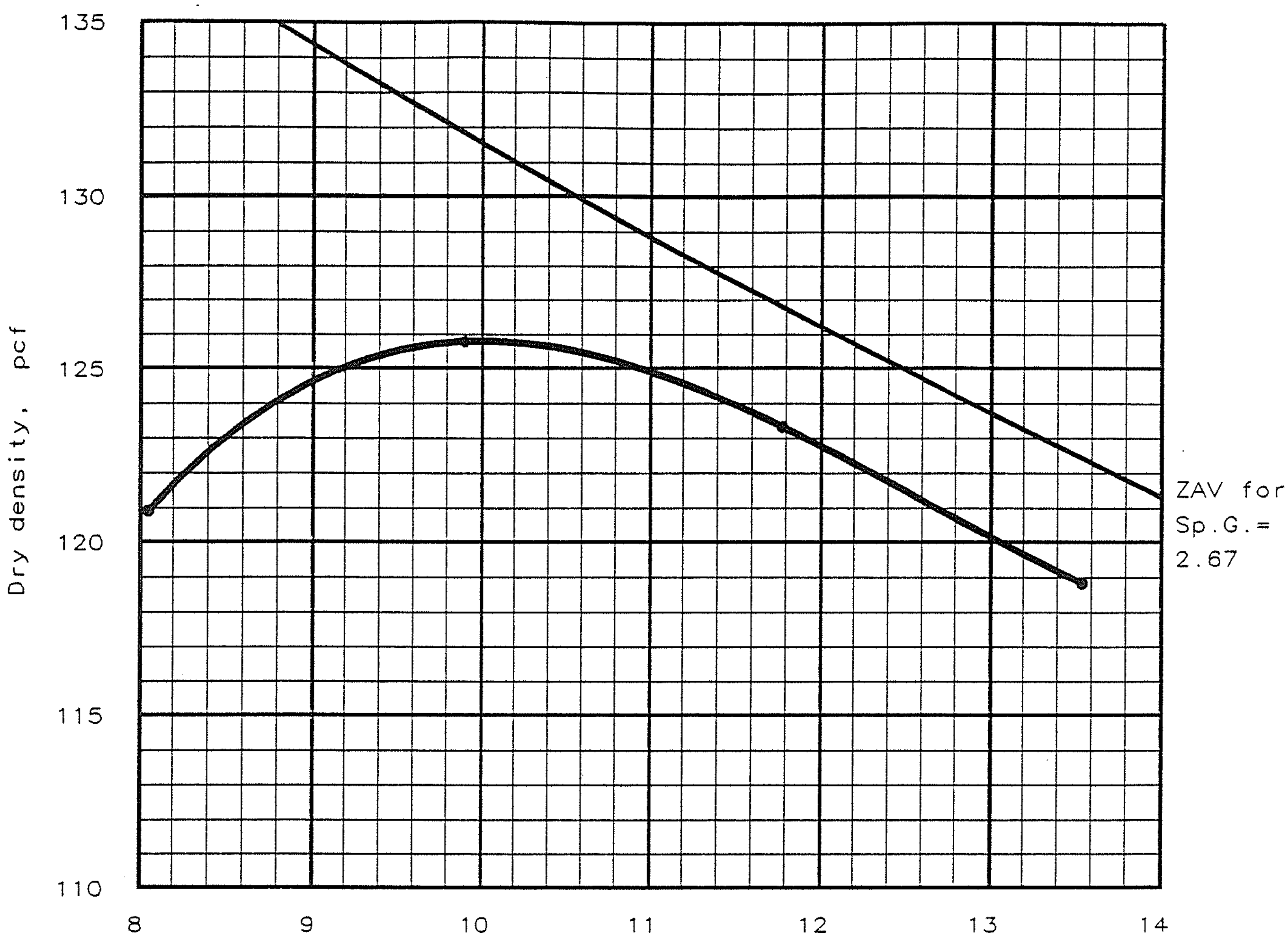
Blanket drain, DS of CD

GRAIN SIZE DISTRIBUTION TEST REPORT

GEI CONSULTANTS, INC., WINCHESTER, MA

Figure No. ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Method C, Modified

Oversize correction applied to final results

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM						4.1 %	46.0 %

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 127.1 pcf Optimum moisture = 9.6 %	125.8 pcf 10.0 %	Silty SAND

Project No.: 96069

Project: Meadow Pond Dam

Location: Sample S2

Station 1+47, 1 ft downstream

Date: April 9, 1996

MOISTURE-DENSITY RELATIONSHIP TEST

GEI CONSULTANTS, INC., WINCHESTER, MA

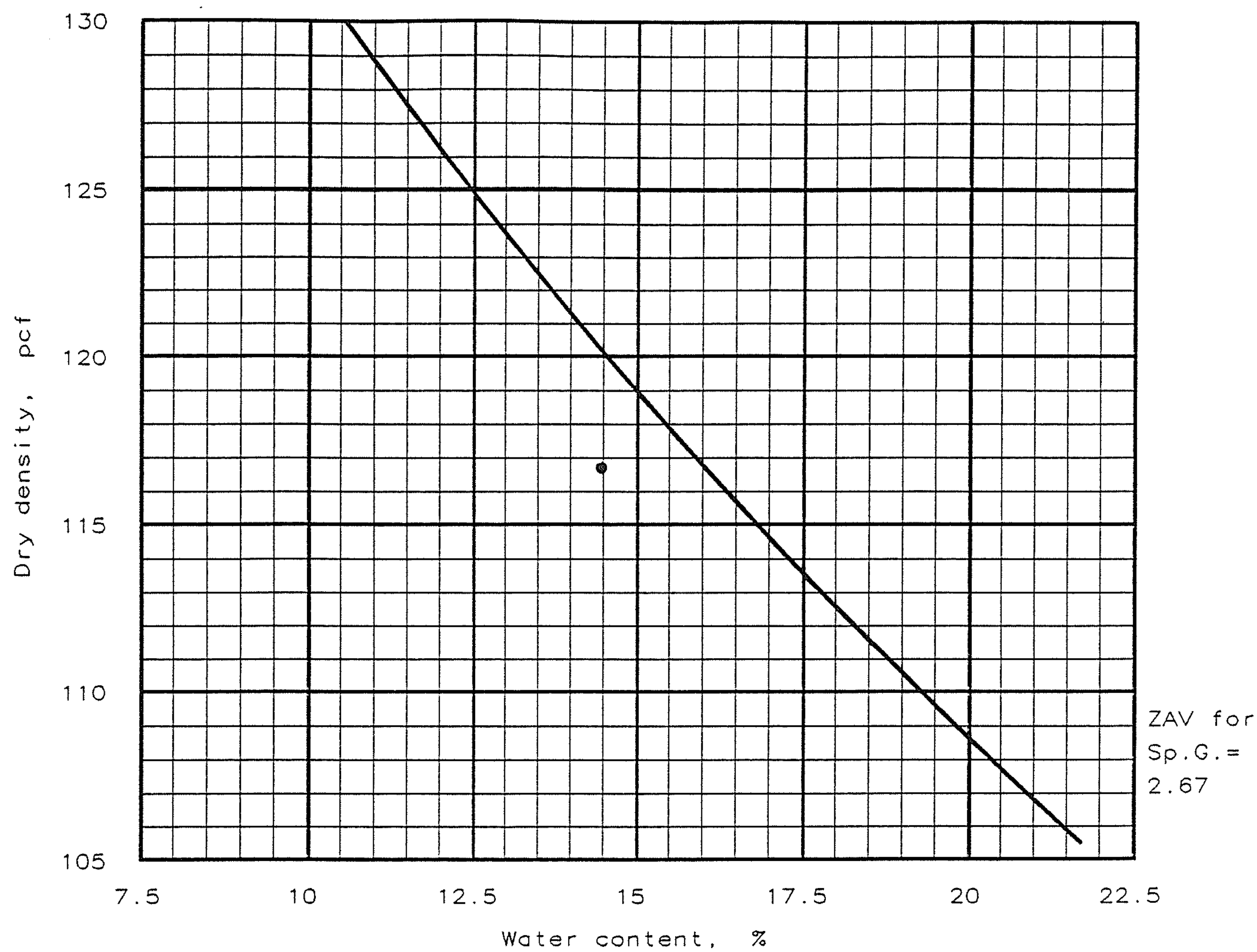
Remarks:

Fill upstream of

Chimney Drain

Fig. No. ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Method C, Modified

Oversize correction applied to final results

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
4 ft	SP			2.67			1 %	4.5 %

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Dry density = 116.7 pcf Moisture = 14.5 %	116.7 pcf 14.5 %	Narrowly graded SAND

Project No.: 96069

Project: Meadow Pond Dam

Location: Sample S6

Chimney Drain

Date: April 8, 1996

MOISTURE-DENSITY RELATIONSHIP TEST

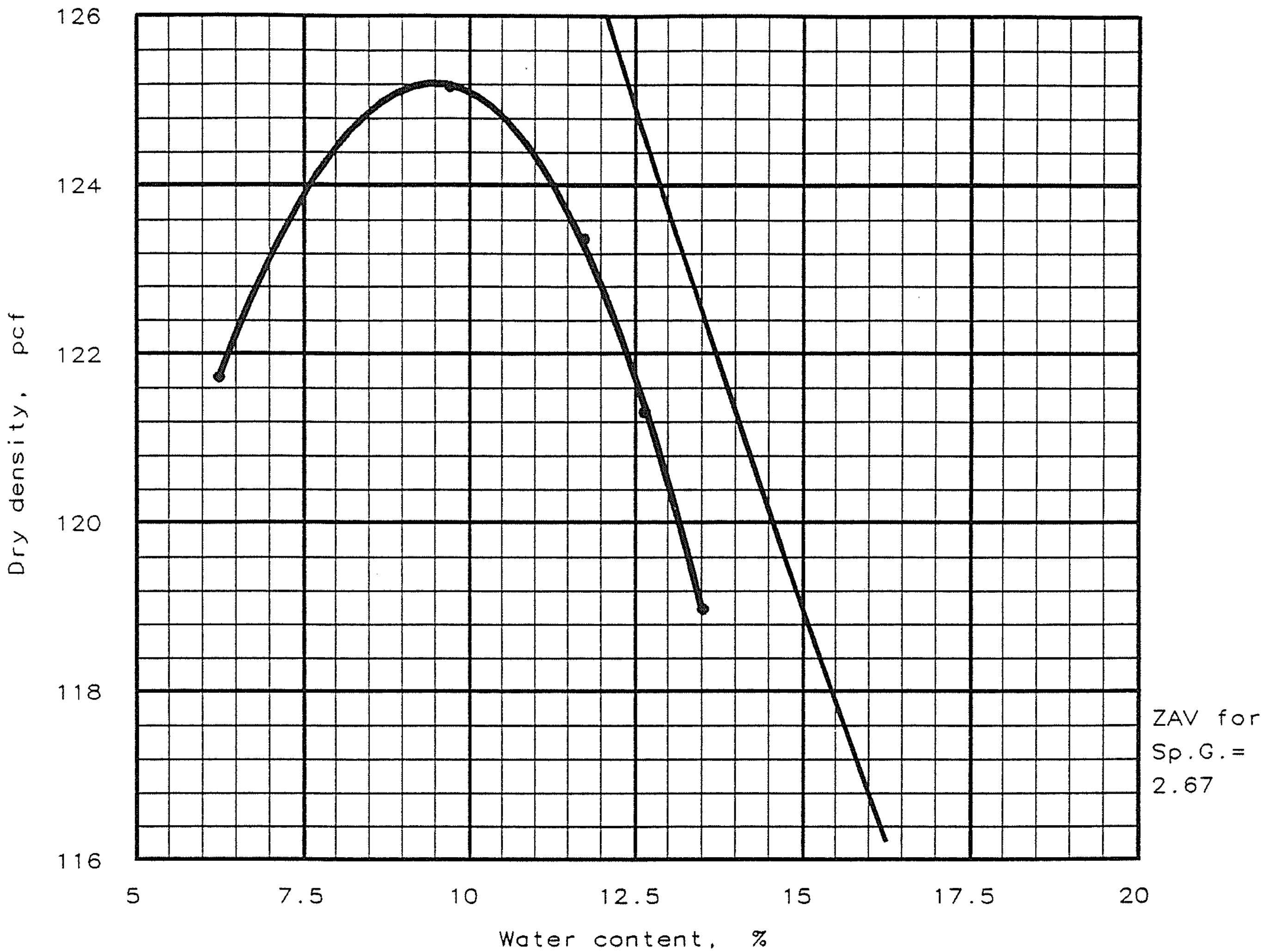
GEI CONSULTANTS, INC., WINCHESTER, MA

Remarks:

Station 1+28

Fig. No. ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Method C, Modified
Oversize correction applied to final results

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	GP						53.9 %	9.1 %

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 144.6 pcf Optimum moisture = 4.4 %	125.2 pcf 9.5 %	Narrowly graded GRAVEL with Sand

Project No.: 96069

Project: Meadow Pond Dam

Location: Sample SS27, "Sand and Gravel"

Date: April 26, 1996

MOISTURE-DENSITY RELATIONSHIP TEST

GEI CONSULTANTS, INC., WINCHESTER, MA

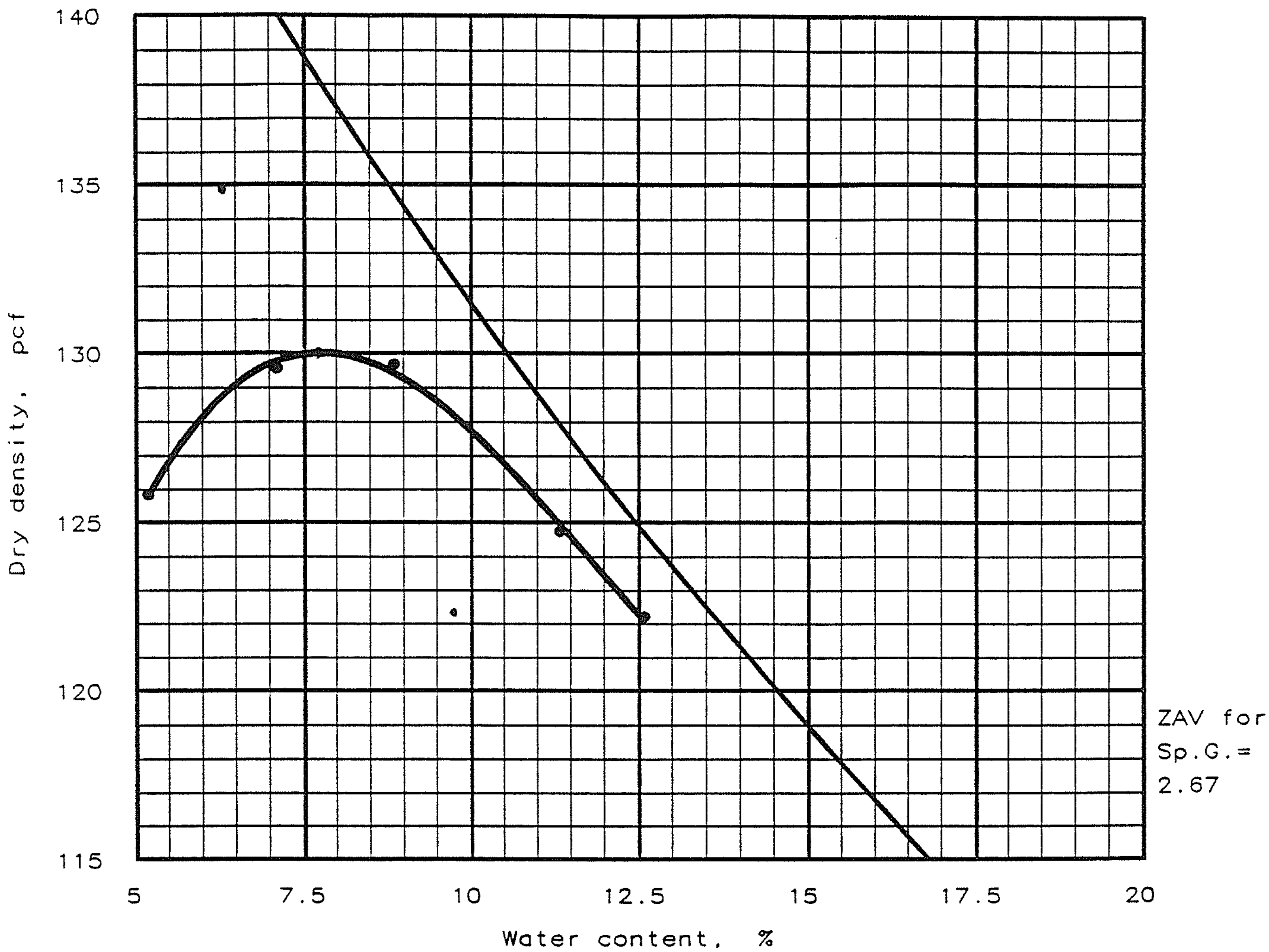
Remarks:

Station 2+26, 12 ft DS

Blanket Drain

Fig. No. ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Method C, Modified
Oversize correction applied to final results

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SP-SM						16.4 %	11.5 %

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 134.9 pcf Optimum moisture = 6.5 %	130.1 pcf 7.7 %	Narrowly Graded SAND with Silt and Gravel

Project No.: 96069

Project: Meadow Pond Dam

Location: Sample FD1, "Gravel Blanket"

Date: April 17, 1996

Remarks:

Station 2+48, 5 ft US

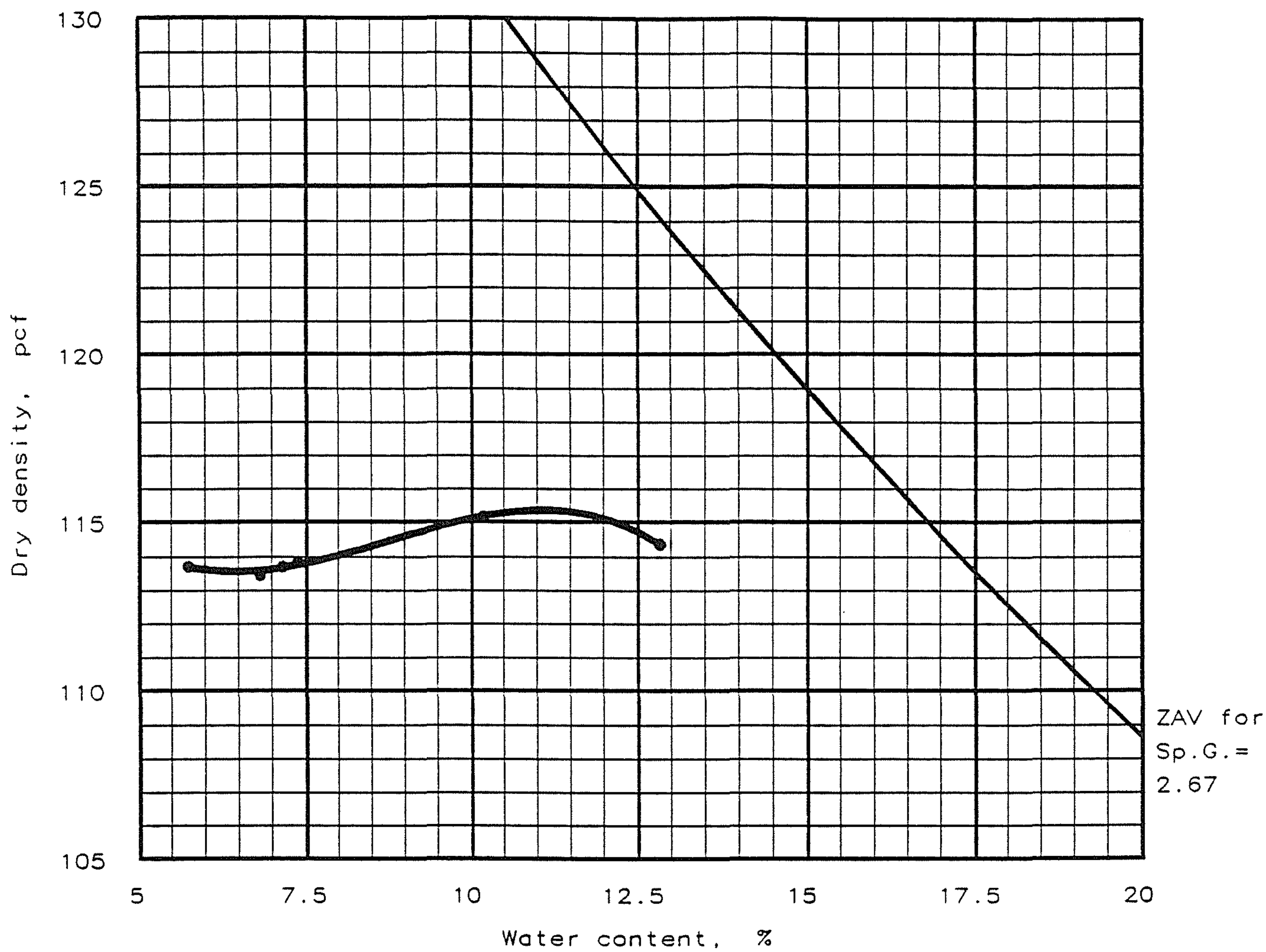
Beneath spillway slab

MOISTURE-DENSITY RELATIONSHIP TEST

GEI CONSULTANTS, INC., WINCHESTER, MA

Fig. No. ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Method C, Modified
Oversize correction applied to final results

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	SM						1 %	21.6 %

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 115.7 pcf	115.4 pcf	Silty SAND
Optimum moisture = 10.9 %	11.1 %	

Project No.: 96069

Project: Meadow Pond Dam

Location: Sample FD3, "Filter Sand"

Date: April 18, 1996

Remarks:

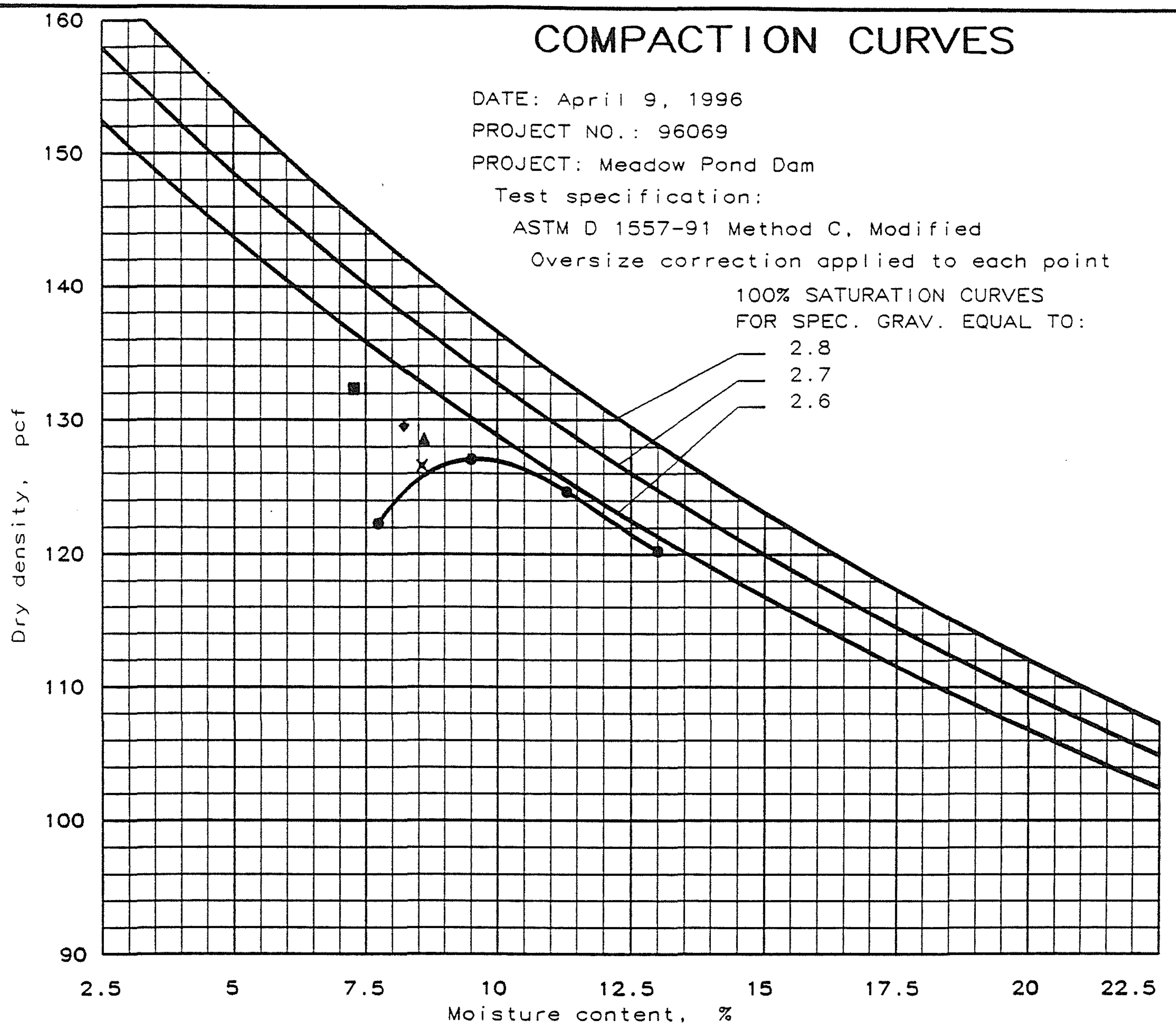
Station 2+47, 5 ft DS

Chimney Drain

MOISTURE-DENSITY RELATIONSHIP TEST

GEI CONSULTANTS, INC., WINCHESTER, MA

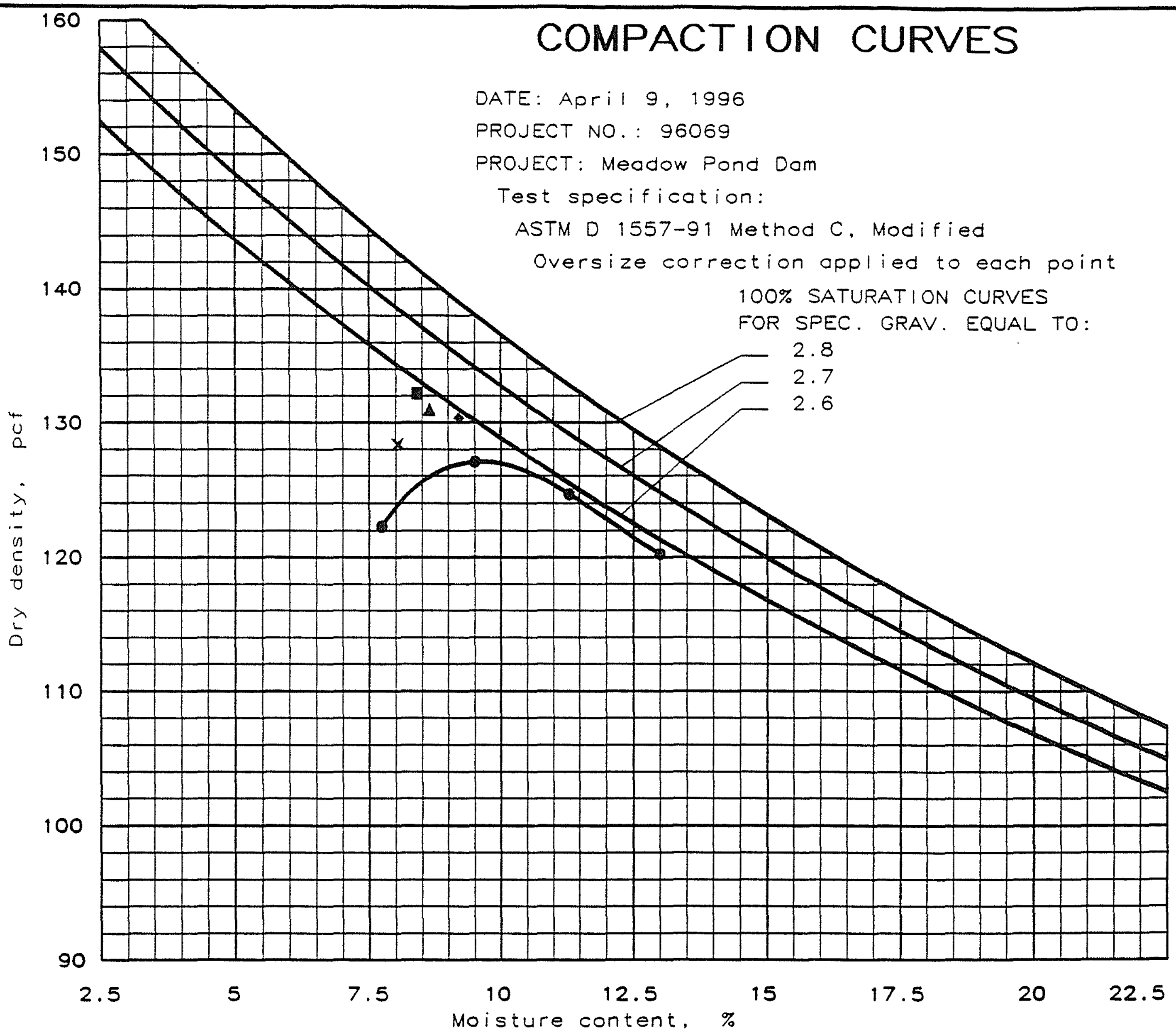
Fig. No. ______



	NO.	LOCATION AND DESCRIPTION	REMARKS
●		Sample S2, "Core" Silty SAND	Station 1+47, 1 ft DS Fill upstream of
▲		Sample FD10, "Core" Silty SAND	Station 2+56, 1 ft DS Embankment Fill,
■		Sample FD12, "Core" Silty SAND	10 ft DS Embankment Fill,
◆		Sample FD14, "Core" Silty SAND	Station 2+50, 11 ft DS Embankment Fill,
✕		Sample FD15, "Core" Silty SAND	Station 2+41, 0 ft DS Embankment Fill,

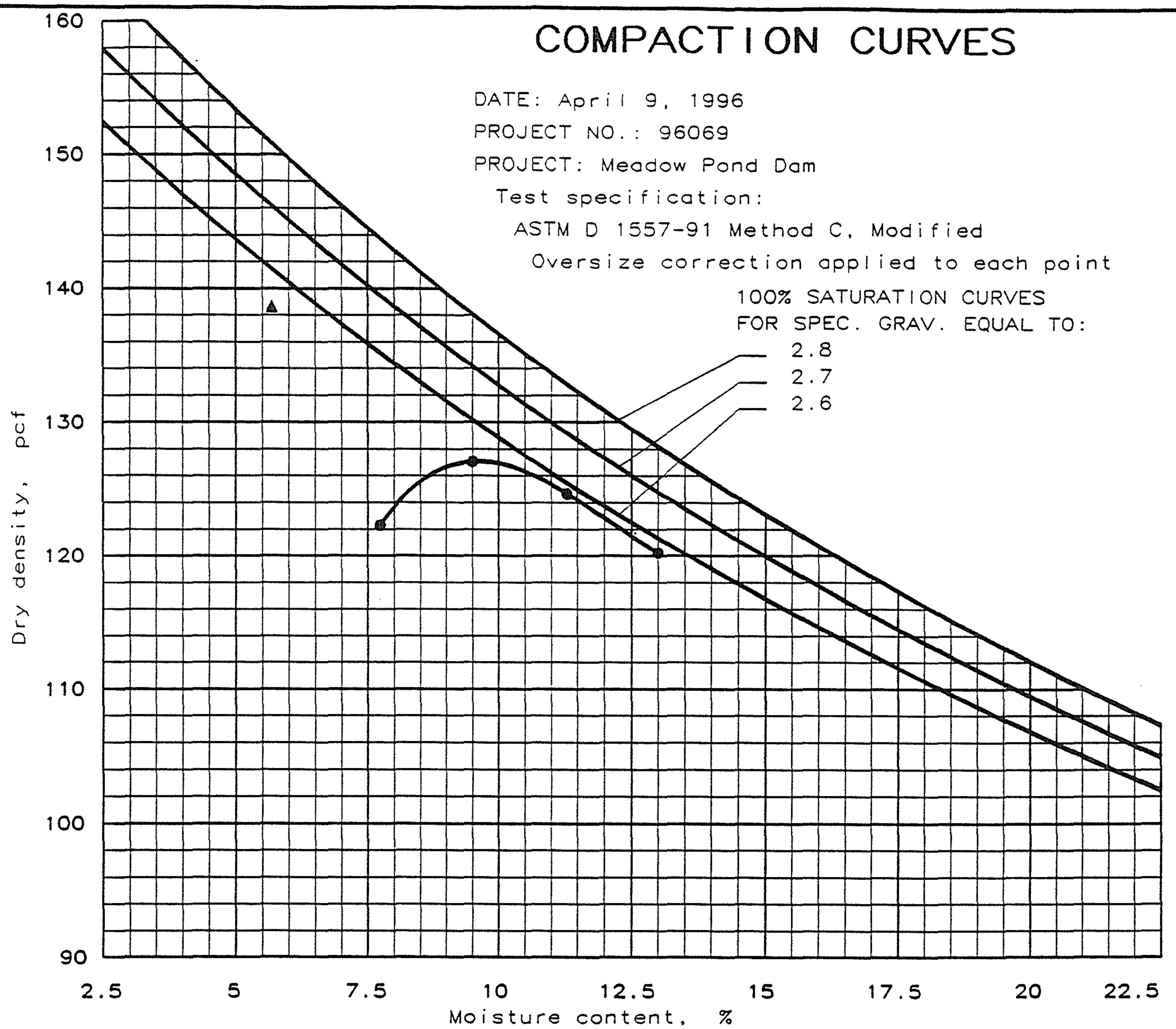
	NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●		SM		4.1%	46.0%	127.1 pcf	9.6%
▲		SM		1.0%		128.6 pcf	8.6%
■		SM		12.8%		132.4 pcf	7.3%
◆		SM		2.3%		129.6 pcf	8.2%
✕		SM		1.7%		126.6 pcf	8.6%

GEI CONSULTANTS, INC., WINCHESTER, MA Figure No.



	NO.	LOCATION AND DESCRIPTION	REMARKS
●		Sample S2, "Core" Silty SAND	Station 1+47, 1 ft DS Fill upstream of
▲		Sample FD2, "Core" Silty SAND	Station 2+48, 4 ft US Embankment Fill
■		Sample FD4, "Core" Silty SAND	Station 2+57, 0 ft DS Embankment Fill
◆		Sample FD7, "Core" Silty SAND	Station 2+63, 10 ft DS Embankment Fill,
×		Sample FD9, "Core" Silty SAND	Station 2+63, 2.5 ft US Embankment Fill,

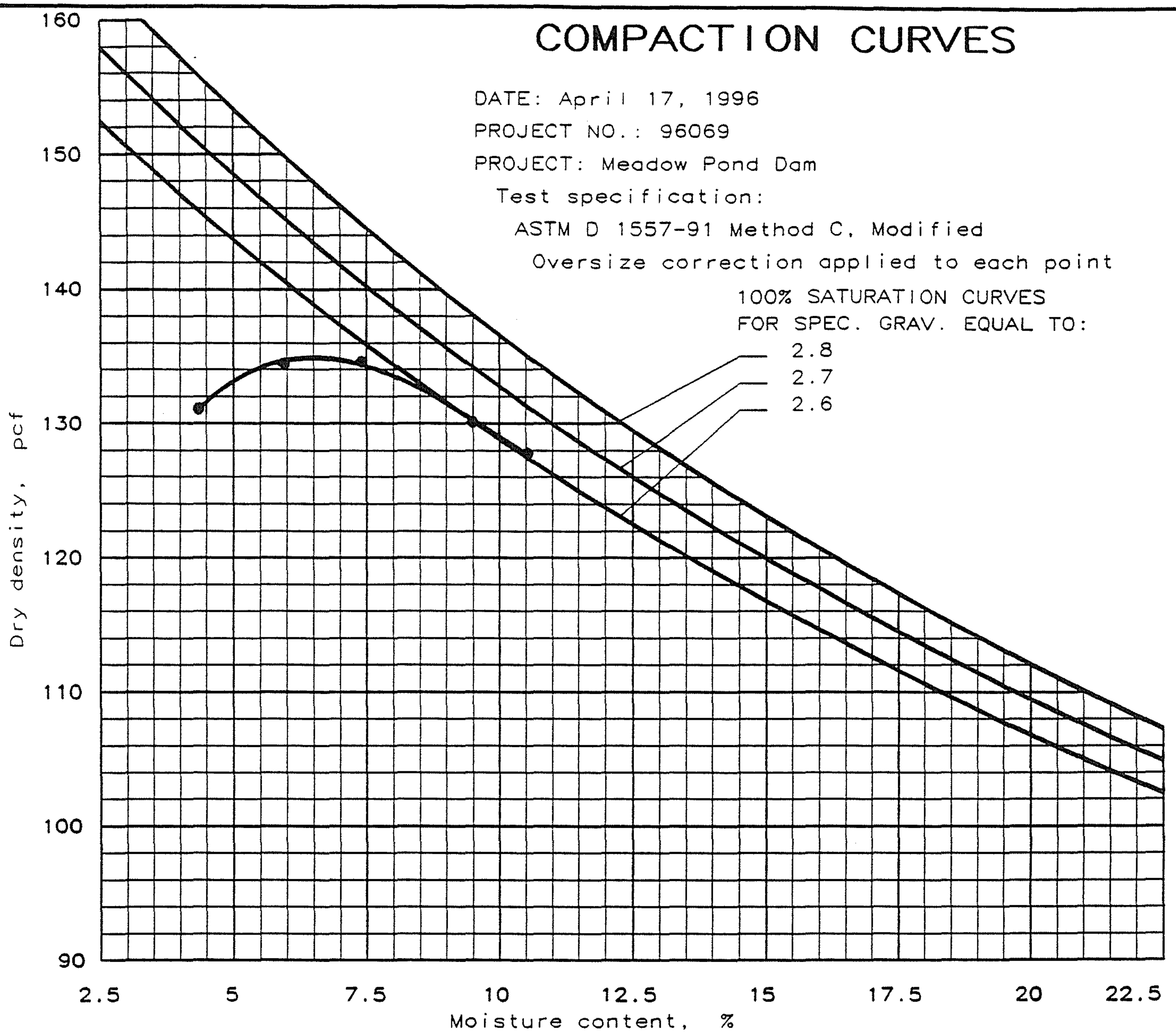
	NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●		SM		4.1%	46.0%	127.1 pcf	9.6%
▲		SM		7.5%		131.0 pcf	8.6%
■		SM		9.8%		132.2 pcf	8.4%
◆		SM		4.5%		130.4 pcf	9.2%
×		SM		0.2%		128.4 pcf	8.0%



	NO.	LOCATION AND DESCRIPTION	REMARKS
●		Sample S2, "Core" Silty SAND	Station 1+47, 1 ft DS Fill upstream of
▲		Sample FD17, "Core" Silty SAND with Gravel	Station 2+41, 13.5 ft DS Embankment Fill,

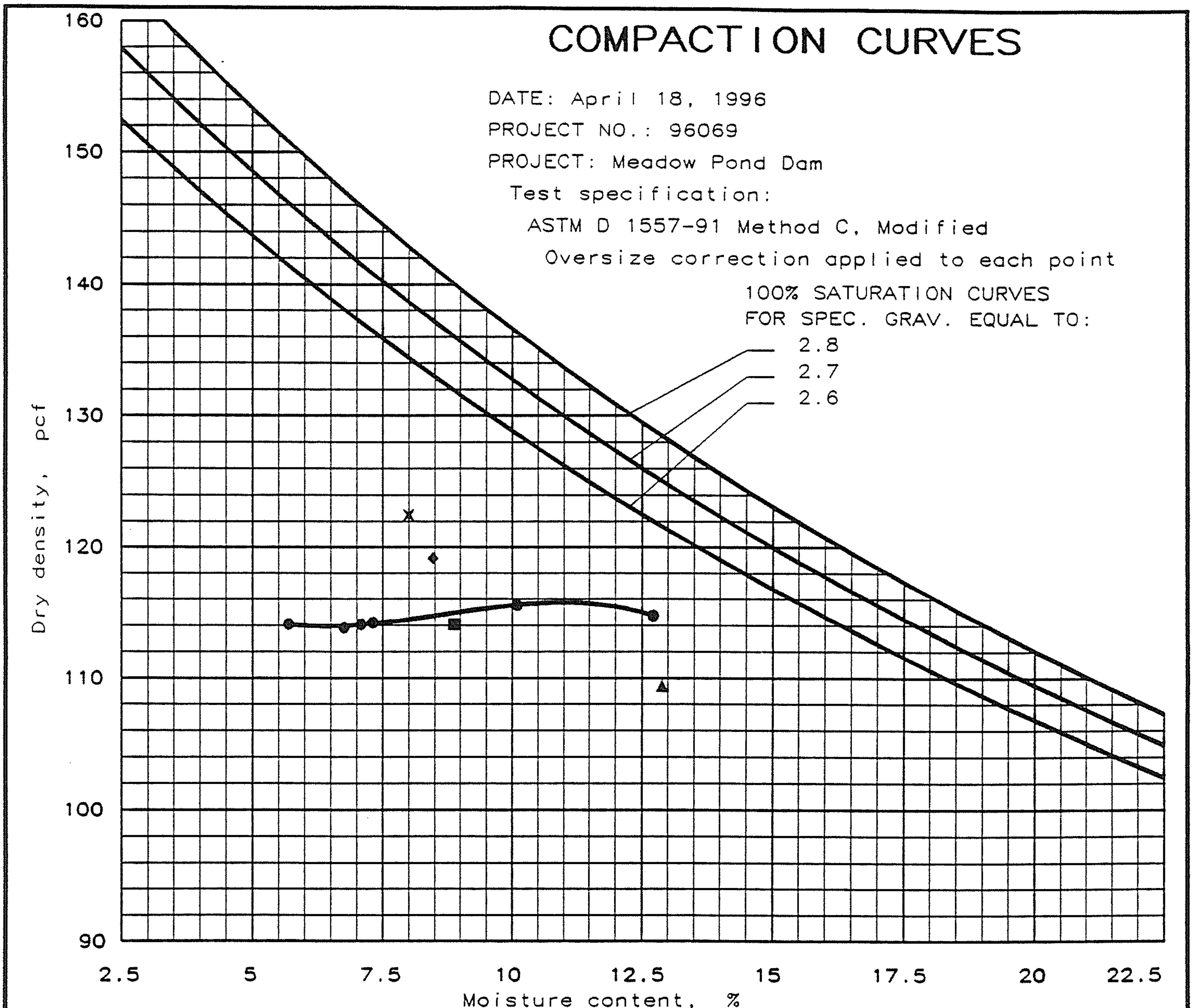
	NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●		SM		4.1%	46.0%	127.1 pcf	9.6%
▲		SM		33.0%		138.7 pcf	5.7%

GEI CONSULTANTS, INC., WINCHESTER, MA Figure No. ____



NO.	LOCATION AND DESCRIPTION	REMARKS
●	Sample FD1, "Gravel Blanket" Narrowly Graded SAND with Silt and Gravel	Station 2+48, 5 ft US Beneath spillway slab

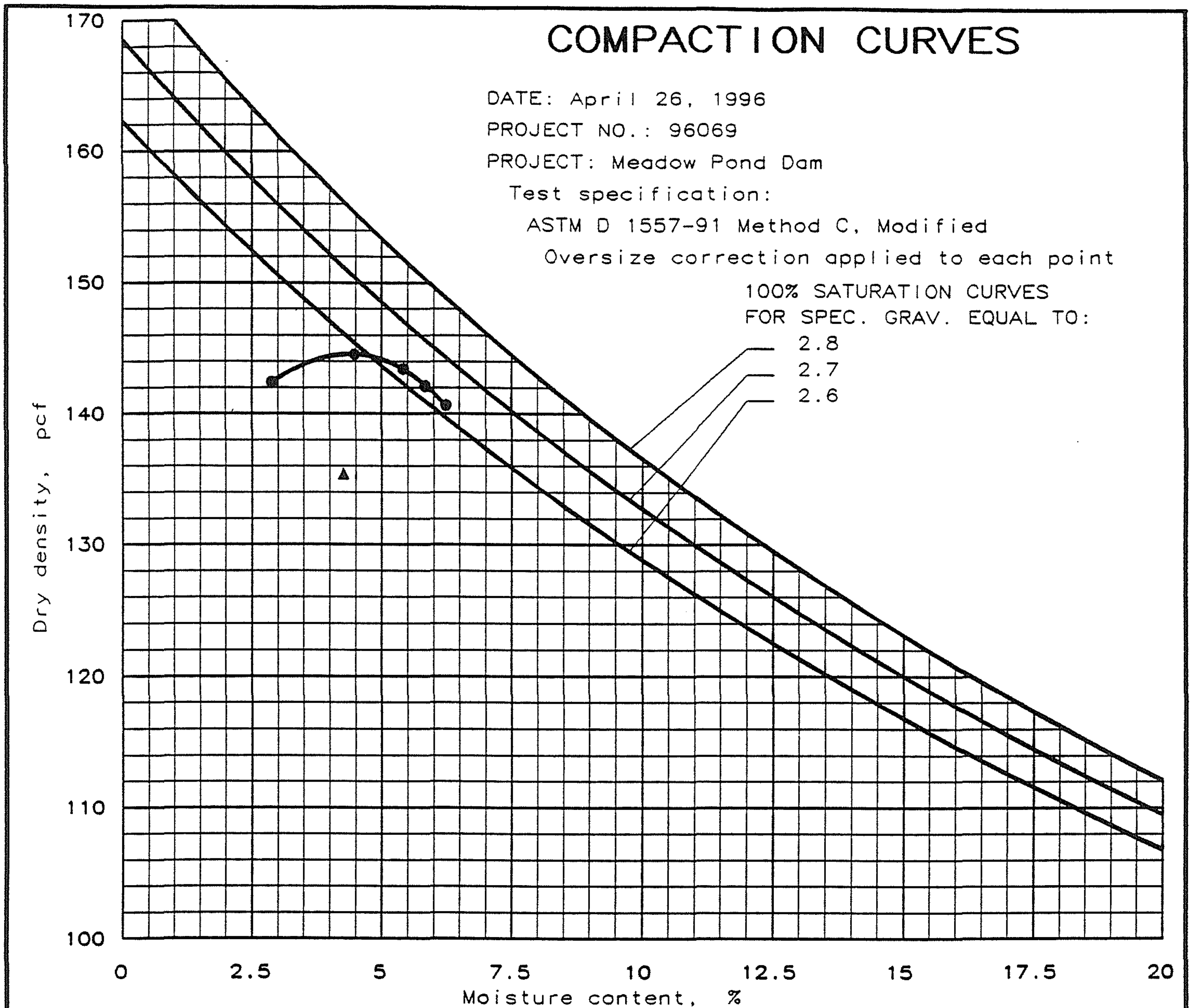
NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●	SP-SM		16.4%	11.5%	134.9 pcf	6.5%



	NO.	LOCATION AND DESCRIPTION	REMARKS
●		Sample FD3, "Filter Sand" Silty SAND	Station 2+47, 5 ft DS Chimney Drain
▲		Sample FD8, "Filter Sand" Silty SAND with Gravel	Station 2+63, 5 ft DS Chimney Drain
■		Sample FD11, "Filter Sand" Silty SAND with Gravel	Station 2+63, 6 ft DS Chimney Drain
◆		Sample FD13, "Filter Sand" Silty SAND with Gravel	Station 2+50, 5 ft DS Chimney Drain
X		Sample FD16, "Filter Sand" Silty SAND with Gravel	Station 2+41, 6.5 ft DS Chimney Drain

	NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●		SM		1%	21.6%	115.7 pcf	10.9%
▲		SM		0.6%		109.4 pcf	12.9%
■		SM		8.0%		114.1 pcf	8.9%
◆		SM		10.8%		119.2 pcf	8.5%
X		SM		21.4%		122.5 pcf	8.0%

GEI CONSULTANTS, INC., WINCHESTER, MA Figure No. ____



	NO.	LOCATION AND DESCRIPTION	REMARKS
●		Sample SS27, "Sand and Gravel" Narrowly graded GRAVEL with Sand	Station 2+26, 12 ft DS Blanket Drain
▲		Sample FD19, "Sand and Gravel" Narrowly graded SAND with Silt and Gravel	Station 2+32, 12 ft DS Blanket Drain DS of CD

	NO.	USCS	AASHTO	%> 3/4 in	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●		GP		53.9%	0.2%	144.6 pcf	4.4%
▲		SP-SM		26.4%		135.4 pcf	4.3%

GEI CONSULTANTS, INC., WINCHESTER, MA Figure No. ___

MEMO

To: Bill Haswell, GEI Concord, N.H.
From: Todd D. Moline
Subject: Meadow Pond Dam, Project 96069
Date: June 6, 1996

Enclosed are the laboratory files which contain all the data sheets for Meadow Pond Dam. Please include these in the project file. No tests were ordered for sample SS24.

The permeability test results are as follow:

Sample No.	Test No.	Perm. Test Type.	Corrected Results
S6	K1	Rigid Wall	1×10^{-3} cm/s
FD1	K3	Triaxial	1×10^{-4} cm/s
FD19	K2	Triaxial	1×10^{-3} cm/s

A permeability correction for the triaxial cell porous stone was applied to the results of FD1 and FD19. The correction applied to FD1 was negligible. The correction to FD19 was significant.

Please call me if you have any questions.

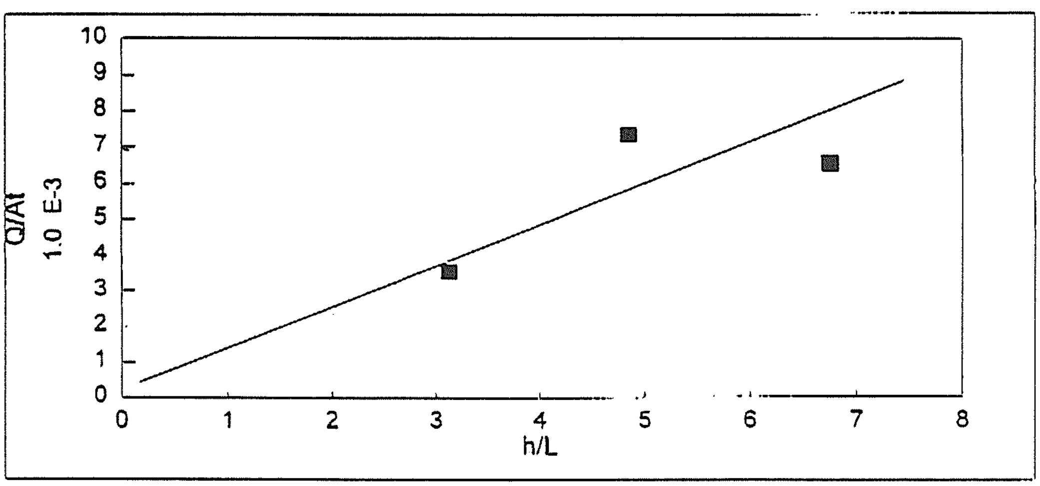
CONSTANT HEAD PERMEABILITY TEST

Project:	Meadow Pond Dam
Project No.:	96069
Sample:	S6, "Filter Sand"
Soil Description:	Narrowly graded SAND
Test No.:	K1
Performed by:	T. Moline
Date:	04/18/96
Checked by:	
Date:	

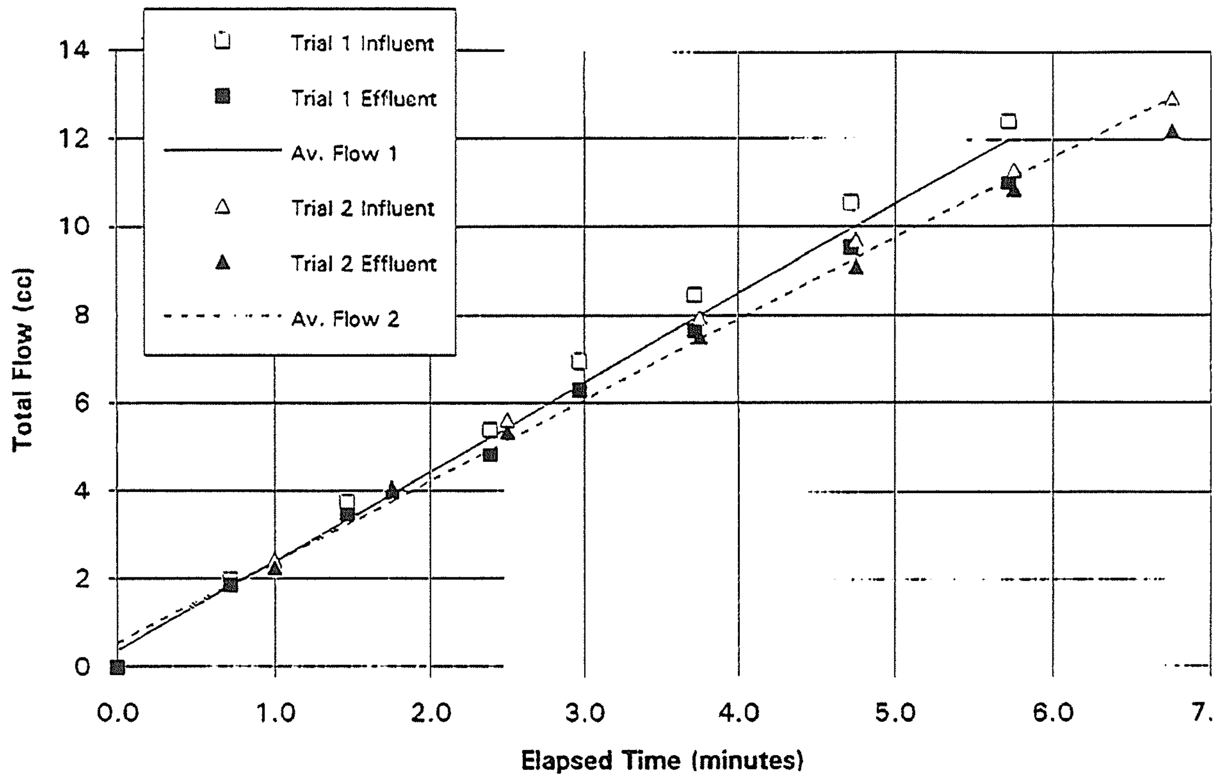
Sample Information

			G =	2.67	(assumed)
Area (A):	42	cm^2	e=	0.55	
Length (L):	16	cm	w =	4.4%	(initial)
Dry Unit Wt	1.72	g/cm^3	S =	21.3%	(initial)

Trial No.	h (cm)	Q (cm^3)	t (s)	Q/At	h/L	k (cm/s)
1	77.5	191.1	600	7.6E-03	4.84	1.6E-03
	77.5	166.2	540	7.3E-03	4.84	1.5E-03
	77.5	180.6	600	7.2E-03	4.84	1.5E-03
2	50	200.6	1320	3.6E-03	3.13	1.2E-03
	50	205.7	1440	3.4E-03	3.13	1.1E-03
	50	193.8	1290	3.6E-03	3.13	1.1E-03
3	108	200.7	690	6.9E-03	6.75	1.0E-03
	108	193.4	720	6.4E-03	6.75	9.5E-04
	108	191.7	720	6.3E-03	6.75	9.4E-04



k= 1.2E-03 cm/s



TEST SUMMARY

PERMEABILITY : 1.1×10^{-4} cm/sec

SAMPLE INFORMATION

Sample: FD1, "Gravel Blanket" Type: Compacted to 95% modified proctor density at 9.6 % water content

Description: Narrowly graded SAND with Silt and Gravel

SPECIMEN INFORMATION

Height:	6.27 inch	Water Content:	14.8 %
Diameter:	2.88 inch	Total Unit Weight:	133.5 pcf
Area:	6.53 in^2	Dry Unit Weight:	116.3 pcf

TEST DATA

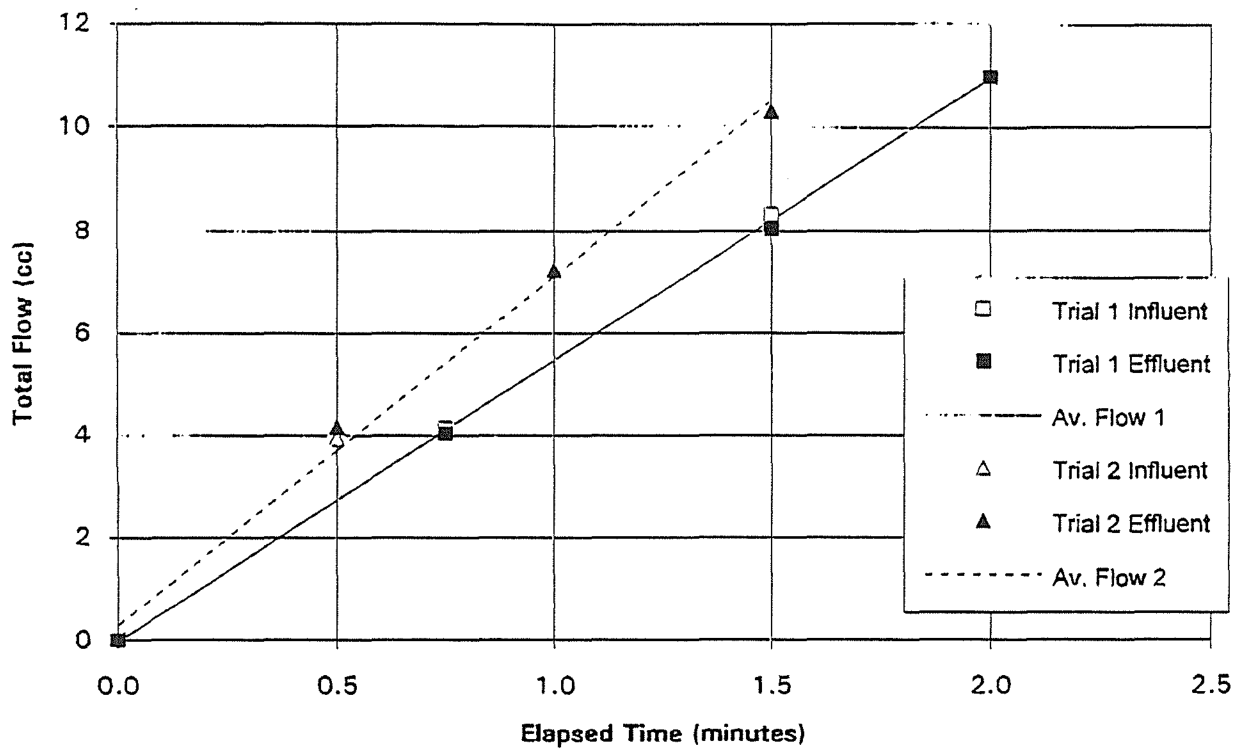
			Gradient	Flow Rate cm^3/min	Permeability cm/sec
Consolidation Stress	1.2 ksf				
Permeant	Tap Water				
B - Value	0.96	Trial 1	7.128501	2.02975093	1.3×10^{-4}
		Trial 2	7.756563	1.83826035	9.3×10^{-5}

Remarks: Tested using 1 teflon porous stone and 1 bronze porous stone.

Test by: T. Moline Test Date: 5/7/96 Checked By:

State of New Hampshire Dept. of Environmental Services	Forensic Evaluation Meadow Pond Dam Alton, NH	TRIAXIAL PERMEABILITY TEST FD1, "Gravel Blanket"
ΦGEI Consultants, Inc.	Project 96069	May-96

6/6/96



TEST SUMMARY

PERMEABILITY : 7.8×10^{-4} cm/sec

SAMPLE INFORMATION

Sample: FD19, "Sand and Gravel" Type: Compacted to 92% modified proctor density at 5.8 % water content

Description: Narrowly graded SAND with Silt and Gravel

SPECIMEN INFORMATION

Height:	6.24 inch	Water Content:	%
Diameter:	2.88 inch	Total Unit Weight:	133.1 pcf
Area:	6.50 in^2	Dry Unit Weight:	114.9 pcf

TEST DATA

			Gradient	Flow Rate cm^3/min	Permeability cm/sec
Consolidation Stress	1.0 ksf				
Permeant	Tap Water				
B - Value	0.94	Trial 1	2.711095	5.49115645	7.8×10^{-4}
		Trial 2	3.436155	6.82360004	7.7×10^{-4}

Remarks: Tested using two teflon porous stones.

Test by: T. Moline Test Date: 5/13/96 Checked By:

State of New Hampshire Dept. of Environmental Services	Forensic Evaluation Meadow Pond Dam Alton, NH	TRIAXIAL PERMEABILITY TEST FD19, "Sand and Gravel"
Φ GEI Consultants, Inc.	Project 96069	May 1996

6/6/96

Appendix E.2

Concrete Compressive Strength Test Results

Simpson Gumpertz & Heger Inc.

Consulting Engineers
Arlington, MA
San Francisco, CA

297 Broadway
Arlington, MA
02174-5310

Telephone.
617 643 2000
Fax:
617 643 2009

4 April 1996

Dr. Mahmoodi
Thomson & Lichtner Co. Inc.
111 First Street
Cambridge Massachusetts 02141

Comm. 96132 - Investigation of Bergeron Dam Failure, Alton NH

Dear Mr. Mahmoodi:

As we discussed by phone today, we are submitting six core samples and requesting you to test the samples for compressive strength in accordance with ASTM C 42-94, Section 6. There are a total of 9 tests. The samples are labeled with the designations, W6, W7, W9, S4, S5, and S2. Each core is 3 3/4 inch diameter and about 12 inches long. Test one sample each from the "S" samples. Test two samples from each of the "W" series of samples, I have marked the ends of the "W" samples "End A" and "End B", the samples should be cut at the center to obtain two samples. End A is the tan colored end and End B is the blue/green colored end. After testing please return all parts of each of the cores with labeling to identify the sample. Your test report should include sample identification, preparation procedures, sample conditioning, all sample measurements, load data, correction factors (if used), and ultimate stress.

The results of this testing are to be shared with other engineers investigating the Bergeron Dam failure. Please release results of testing to Dr. Harri K. Kytomaa of Failure Analysis Associates or Mr. William O. Hood of Wakefield Concrete if they call you.

If you have any questions, please call me or Donald Dusenberry.

Sincerely yours

Arthur G. Davies
AGD1-96.ras

cc: Mr. Richard Doherty

SGH

THE THOMPSON & LICHTNER COMPANY, INC.

Consulting Engineers
Engineering and Testing Laboratories

111 First Street
Cambridge, Massachusetts 02141
Tel (617) 492-2111 Fax (617) 492-5448

April 12, 1996

SIMPSON GUMPERTZ & HEGER, INC.
ARLINGTON, MASSACHUSETTS

TESTS OF CONCRETE CORES

COMM. 96132
BERGERON DAM
ALTON, NEW HAMPSHIRE

Test Number — UU-881

Date Received — 4-4-96 Date Tests Completed — 4-8-96

Source — Submitted by your Mr. Arthur G. Davies via courier mail, reference his letter dated 4 April 1996

Samples — Six nominal 4" diameter cores of hardened concrete, identified by you as:

— S2, S4, S5, W6, W7, and W9

Test Procedure — ASTM Designation: C 42-90 methods where they apply

				W6		W7		W9	
Specimen Mark	S2	S4	S5	A	B	A	B	A	B
Core Dimensions, Inches									
Length as Received	12.3	12.2	12.3	12.3		12.2		12.2	
Diameter	3.75	3.75	3.76	3.74	3.75	3.74	3.76	3.75	3.74
Length as Trimmed	7.57	7.60	7.58	3.72	3.73	5.62	5.56	5.61	5.45
Length after Capping	7.71	7.71	7.70	3.82	3.84	5.75	5.67	5.73	5.58
Concrete Density as Tested, SSD, pcf	138.7	139.1	139.3	133.3	133.9	134.8	132.1	135.4	137.8
Uncorrected Compressive Strength, PSI	5590	5460	5670	4100	4800	3570	4120	4280	4230
Corrected Compressive Strength, PSI	5590	5460	5670	3600	4200	3450	3960	4120	4060

Remarks — 1. As requested, the cores identified as W6, W7, and W9 were cut through the center to obtain two cores, marked by you as End A and End B.

2. All the cores were soaked in a saturated lime solution for 64 hours prior to testing.

3. As requested, the tested samples are being returned.

THE THOMPSON & LICHTNER COMPANY, INC.

A. H. Mahmoodi

APPENDIX F

Interviews

GEI Consultants, Inc.

MEMORANDUM

53 Regional Drive
Concord, NH 03301-8500
Tel: 603 · 224 · 7979
Fax: 603 · 224 · 7990

TO: **FILE**

FROM: **Craig Ward** CW

DATE: **June 4, 1996**

RE: **Interview with CSSI**
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire

This memorandum was prepared to summarize an interview with Mr. John Halvatzes and Mr. Costas Halvatzes of Connie's Septic Service, Inc. (CSSI), the earthwork contractors for the construction of the Meadow Pond Dam. The interview was conducted at the offices of Acadia Insurance on April 26, 1996, and was attended by the following:

John Halvatzes	CSSI
Costas Halvatzes	CSSI
Joyce Tucker	Acadia Insurance
Timothy Freese	Acadia Insurance
Michael Lenehan, Esquire	Ransmeier & Spellman, P.C. (representing CSSI)
Gonzalo Castro, Ph.D., P.E.	GEI Consultants, Inc. (GEI)
Craig Ward, P.E.	GEI

A draft copy of this memorandum was provided to CSSI for review and comment to insure that their responses are accurately represented. This memorandum has been revised to reflect comments provided by CSSI.

At the beginning of the interview, Dr. Castro briefly described GEI's scope of work for the forensic evaluation: to determine the mechanism of failure; to determine if the design was adequate; and to determine if the dam was constructed in accordance with the design.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Lenehan in a letter dated April 11, 1996. Each of GEI's preliminary questions is restated in italics below with a summary of CSSI's responses. Although additional information may have been provided by CSSI, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. The summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with CSSI.

1. *What was the latest revision date in the plans used to build the dam? Were there any other design documents (sketches, letters, reports) given to the contractor containing instructions pertaining to*

the construction of the dam? Any changes to the design made during construction? Any communications with the dam designers?

CSSI indicated that the design drawings provided by Mr. Bergeron for construction of the dam were "Bergeron Lake Dam", sheets C1 through C3, prepared by Rivers Engineering Corporation, Revision 3, dated December 3, 1992. CSSI was not aware of the existence of Revision 4 of the drawings, dated December 17, 1992, until after the failure of the dam. No other documents were provided to CSSI by Mr. Bergeron showing design information.

CSSI brought a copy of the Revision 3 drawings to the interview. Sheet C2 of the drawings was in CSSI's files. Sheets C1 and C3 of the drawings were missing from CSSI's files and copies of these sheets were obtained from Mark Moser. Mr. Moser received a set of the drawings from Mr. Bergeron when he prepared a proposal to provide quality control engineering services during construction of the dam (the role later awarded to Varney Engineering). Unlike the Revision 4 drawings, the Revision 3 drawings were not stamped "Not For Construction".

The only design change made during construction was the use of corrugated polyethylene pipe with a Ripley's Dam antiseep collar for the low level outlet instead of the 14 gauge corrugated metal pipe with a cast-in-place concrete cutoff specified in the design. CSSI was verbally notified of this change by Mr. Bergeron.

CSSI had communications with only Mr. Bergeron and, to a lesser degree, Mr. Thomas Varney of Varney Engineering (the construction quality control engineer). Mr. Bergeron supervised most aspects of the construction and addressed most of CSSI's questions. For example, Mr. Bergeron identified on-site borrow areas and survey control points. Mr. Bergeron also supervised and assisted with the installation of the low level outlet and Ripley's Dam antiseep collar, laid out the location of the spillway structure, and assisted Putnam Concrete (concrete contractor hired by Mr. Bergeron) with the setting of concrete forms.

2. *Were there any subcontractors? If so, what part of the work did they perform and what plans were given to them?*

The only subcontractor hired by CSSI was A.J. Cameron of Farmington, New Hampshire, who was contracted to hydroseed the dam.

CSSI was originally hired to perform earthwork and to build the concrete structures. However, the concrete subcontractor that CSSI had planned to use couldn't meet Mr. Bergeron's schedule so Mr. Bergeron hired Putnam Concrete and removed concrete work from CSSI's contract. The only concrete work performed by CSSI was the pipe support at the upstream end of the low level outlet.

3. *How was stream diversion accomplished?*

The stream was initially diverted through a temporary culvert installed downstream of the location of the chimney drain. The stream was later diverted through the low level outlet pipe and the temporary culvert was removed. The temporary culvert and the low level outlet pipe were never overtopped.

4. *How was the foundation for the dam prepared? Was there any flow into the foundation after preparation?*

Loam, stumps and other vegetation, and boulders were removed from the footprint area of the dam using a large excavator (CAT 225-size) and a D8 bulldozer. A few very large boulders that couldn't be moved with this equipment were left in place. One of the boulders left in place was located about 20 to 25 feet west of the low level outlet. The portion of this boulder that was exposed (above the ground surface) covered an area of about 10 feet by 10 feet and was shaped like a dome with shallow sideslopes. Fill was placed and compacted around the boulders that were left in place.

Ground water seepage into the foundation soils west of the stream occurred in the spring of 1994, when saturated core material upstream of the chimney drain alignment (core material placed in the fall of 1993) was removed (see response to Question 10). As directed by Mr. Bergeron, the seepage was controlled using a network of trenches and a sump installed at the north side of the dam footprint, west of the stream.

5. *How was the bedding for the low level outlet pipe prepared?*

The low level outlet pipe was placed in a trench excavated in fill. Upstream of the antiseep collar, the pipe was placed in a trench excavated in the core fill material. Downstream of the antiseep collar, the pipe was placed in a trench excavated in the blanket drain (filter sand or sand & gravel).

6. *How was the concrete for the spillway slab and cutoff wall poured? Any cold joints?*

CSSI did not perform the concrete work.

7. *How was the chimney drain constructed?*

The chimney drain was constructed by excavating trenches in the embankment fill (core material and blanket drain materials) and backfilling the trenches with filter sand. The trenches were excavated after the embankment fill reached about 1/3 of its full height, 2/3 of its full height, and full height. Connection of the lowest segment of the trench with the blanket drain was verified by observing blanket drain materials (filter sand and/or sand & gravel) at the bottom of the trench. Connection of the middle and upper segments of the chimney drain with the previous segment was verified by observing filter sand at the bottom of the trench.

8. *Where were the various fill materials obtained?*

CSSI's original contract included the procurement of filter sand from Alton Sand & Gravel but all other materials were to be supplied by Mr. Bergeron. Mr. Bergeron later had CSSI procure the gravel blanket material for placement beneath the grouted riprap on the downstream face of the dam from Alton Sand & Gravel. Other fill materials were obtained at Mr. Bergeron's direction from the following on-site borrow sources:

- "Sand & gravel" for the blanket drain was obtained from the unpaved road located north of the Bergeron's residence. "Sand & gravel" placed on the lower portions of the upstream face of the embankment was obtained from a borrow area located northeast of the dam.

- "Core" material (silty sand with gravel) was obtained from a borrow area located northwest of the dam (next to the pond). The originally proposed borrow area located just west of the dam was abandoned due to high soil water content.

9. *Where was the left end of the cutoff wall terminated?*

CSSI did not perform the concrete work.

10. *Construction start and completion dates.*

Construction start and stop dates are provided below:

Date	**Comment**
November, 1993	Construction started.
December 29, 1993	Construction stopped due to winter conditions.
March 16 to 23, 1994	Borrow materials excavated from on-site and stockpiled near dam.
May 20, 1994	Construction resumed. Core material placed upstream of chimney drain in fall was removed due to saturation and disturbance. Blanket drain and overlying core material were firm and were not removed.
July 12, 1994	CSSI demobilized.

11. Other Information provided by CSSI:

- As directed by Mr. Varney (the quality control engineer hired by Mr. Bergeron to inspect construction), construction stopped in December of 1993 when the weather became cold enough to pose problems with freezing fill and subgrades.

- CSSI placed riprap on the embankment. The riprap in the spillway channel was grouted by Putnam Concrete under Mr. Bergeron's observation. The riprap along the upstream face of the spillway was not grouted by the time CSSI demobilized.

- CSSI excavated the trench for the cutoff wall under Mr. Bergeron's direction.

- CSSI observed cracks in the concrete spillway (primarily on the right side of the spillway) and grouted riprap shortly after the concrete was poured (prior to CSSI's demobilization). Cracks were also observed in the concrete cutoff wall while CSSI was placing riprap against the upstream side of the spillway. When Mr. Costas Halvatzes returned to the dam site in July of 1995, the cracks in the spillway were still evident.

- CSSI also installed ductile iron pipe along the left abutment for a small hydroelectric generator. The pipe was placed primarily in natural ground.

GEI Consultants, Inc.

MEMORANDUM

53 Regional Drive
Concord, NH 03301-8500
Tel: 603 · 224 · 7979
Fax: 603 · 224 · 7990

TO: **FILE**

FROM: **Craig Ward** CW

DATE: **May 28, 1996**

RE: **Interview with the Bergerons**
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire

This memorandum was prepared to summarize the interview held with Mr. Robert Bergeron and Mrs. Virginia Bergeron (owners of the Meadow Pond Dam) on April 24, 1996. The interview was conducted at the offices of Bouchard & Mallory, P.A., and was attended by the following:

Mr. & Mrs. Bergeron	Dam Owners
Mark Mallory, Esquire	Bouchard & Mallory, P.A. (representing the Bergerons)
Allen Marr, Ph.D., P.E.	GeoTesting Express (representing the Bergerons)
Gonzalo Castro, Ph.D., P.E.	GEI Consultants, Inc. (GEI)
Craig Ward, P.E.	GEI

A draft copy of this memorandum was provided to the Bergerons for review and comment to insure that their responses are accurately represented. This memorandum has been revised to reflect comments provided on behalf of the Bergerons by Mr. Mallory in his letter to Mr. Ward, dated May 13, 1996.

At the beginning of the interview, Dr. Castro briefly described GEI's scope of work for the forensic evaluation: to determine the mechanism of failure; to determine if the design was adequate; and to determine if the dam was constructed in accordance with the design.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Mallory in a letter dated April 11, 1996. Each of GEI's preliminary questions is restated in italics below with a summary of Mr. and Mrs. Bergeron's responses. Although additional information may have been provided by Mr. and Mrs. Bergeron, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. Thus, the summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with the Bergerons.

1. *What was the latest revision date in the plans given to the contractor(s) to build the dam?*

   During the interview, Mr. and Mrs. Bergeron were advised by Mr. Mallory not to comment on this issue due to pending litigation. In his letter of May 13, 1996, Mr. Mallory provided the following information:

"It is presently our understanding that plans provided by Rivers to the Bergerons with a stamped date of December 4, 1992, and not marked "not for construction" or otherwise restricted, were the plans used by CSSI during construction. A later set of plans stamped "not for construction," as well as additional sketches, were apparently submitted to the State by Rivers. However, Mr. Bergeron understood from conversations with Mr. Dollard at Rivers that the earlier plans were the ones to be utilized."

2. *What was the involvement of the various parties (contractors, designers, inspectors) during dam construction?*

Mr. and Mrs. Bergeron were advised by Mr. Mallory not to comment on this issue due to the pending litigation. However, in his letter of May 13, 1996, Mr. Mallory provided the following general information regarding the respective roles of the various parties involved in the design and construction of the dam:

"...Rivers had been retained as the designer of the dam; Jaworski had been retained at the request of Rivers to do geotechnical engineering; CSSI, Inc. had been hired to build the project; and Mr. Varney had been hired as the professional engineer to inspect the ongoing construction."

3. *What maintenance, if any, was performed for the dam? Did it include patching of any cracks in the concrete structure?*

Mr. Bergeron indicated that maintenance of the dam included the following:

- Shortly after the pond was filled, three cracks formed in the concrete spillway. The cracks were of hairline width and were located on the flat portion of the spillway, near the right end (looking downstream). Mr. Bergeron pulled riprap away from the leading edge of the concrete to further expose the cracks and filled visible portions of the cracks with caulking in the spring of 1995. Filling of cracks is consistent with the maintenance procedures suggested by the State. A sketch of the spillway is shown on the attached figure.

- Mr. Bergeron leveled some of the flashboards by shimming and sealed the bottom of the flashboards using a sealing compound called coal dust that was suggested by Mr. Doyon.

- In the spring of 1995, Mr. Bergeron built concrete wingwalls at both ends of the spillway to protect the portions of the earthen embankment adjacent to the spillway from splashing water that could cause erosion. The wingwalls are about 4 feet long, and are flush with the tops of the parapet walls on either end of the spillway. The locations of the wingwalls are shown on the attached figure.

- In the spring of 1995, Mr. Bergeron also regrouted portions of the grouted riprap spillway, as was consistent with maintenance procedures suggested by the State. One concrete truck load of grout was used to fill holes and cracks along the upper approximately one-third of the grouted riprap (within reach of the concrete truck chutes) and to fill a space that was left after removal of a concrete form board from the downstream edge of the concrete spillway structure. Grout was also used to raise the sides of the grouted spillway to reduce the potential for overflow during high flow periods. Some grout was applied on the lower approximately two-thirds of the grouted riprap (beyond the reach of the concrete truck chutes) by transporting the grout in buckets.

Mr. Bergeron indicated that personnel from the New Hampshire Department of Environmental Services (NHDES) - Water Resources Division (WRD) had told Mr. Bergeron to look for soft areas along the downstream embankment and cracks/holes in the grouted riprap. Mr. Bergeron indicated that he observed shrinkage cracks in the grouted riprap after the pond was filled, but that no obvious or significant new cracks were observed after the regrouting performed in the spring of 1995. Mr. Bergeron also stated that no soft areas were observed in the embankment.

Dr. Castro asked Mr. Bergeron if he has ever observed seepage through cracks in the grouted riprap. Mr. Bergeron indicated that he has not observed anything he could identify as seepage from within the riprap. He further indicated that the grouted riprap is typically dry (except for minor rivulets from water seeping through the flashboard area as anticipated) since the water level in the pond was usually maintained just below the top of the flashboards.

4. *Was there any water flowing over the flashboards immediately prior to the failure?*

Mr. Bergeron indicated that the water level in the pond was just below the top of the flashboards immediately prior to the failure. Mr. Bergeron typically maintained the pond at this level during the winter so that snow would remain on the top of the spillway for snowmobiling.

Mr. Bergeron also indicated that water first overtopped the flashboards in April, 1995. The water level in the pond has never been more than about 1/4-inch above the tops of the flashboards.

5. *Observations prior to and during the failure, such as seepage out of the downstream face of the dam and/or spillway, cracks, erosion at downstream toe of spillway, etc. Approximate times at which various observations were made.*

Mr. and Mrs. Bergeron described the sequence of events prior to and during the failure as follows:

- Sunday, March 3, 1996:

  Mr. Bergeron inspected the dam, which had little or no snow cover. The toe drains, outlet flow and grouted riprap were inspected without observing anything unusual or amiss.

- Sunday, March 10, 1996:

  Additional snow had fallen since the previous Sunday and Mr. Bergeron snowmobiled across the dam. Most of the snow had melted from the grouted riprap, including in the area of the subsequent failure. Mr. Bergeron noticed nothing unusual or amiss.

- Monday, March 11, 1996:

  On Monday night, Mr. Bergeron snowmobiled across the concrete spillway. No unusual conditions were observed. However, only the upper portion of the dam was visible in the light of the snowmobile.

- Wednesday, March 13, 1996:

  Mr. Bergeron arrived home at about 6:10 pm. When crossing the bridge spanning the stream downstream of the spillway (location of culvert installed after the failure), Mr. Bergeron did not notice any obvious changes in the flow.

  At about 6:35 pm, Mrs. Bergeron left the house to attend a town meeting. She came back almost immediately and told Mr. Bergeron that the water level in the stream had risen to the level of the bridge deck.

  Mr. Bergeron checked the dam to determine if water was flowing over the flashboards or from the low level outlet. He saw an approximately 3-foot-diameter plume of water flowing from the face of the grouted riprap spillway channel. The area of flow was located near the top of the grouted riprap, about 15 to 20 feet right of the left end of the flat portion of the concrete spillway (see sketch on attached figure).

  At about 6:40-6:45 pm, Mrs. Bergeron dialled 911, while Mr. Bergeron located the Emergency Action Plan. Mr. Bergeron reported the condition of the dam to the 911 dispatcher. While Mr. Bergeron was on the telephone, Mrs. Bergeron went out to look at the dam and saw that a vortex had formed in an area of the pond from which the ice had disappeared. The vortex was located about 10 to 15 feet right of the left end of the flat section of the spillway, just upstream of the dam.

  A few minutes after his telephone call to the 911 dispatcher, Mr. Bergeron again checked on the condition of the dam. By this time, the area of flow from the face of the spillway channel had increased to approximately 5 feet in diameter. Ice had disappeared from a horseshoe-shaped area of the pond, located opposite the area of flow from the face of the spillway channel (see sketch on attached figure).

  Mr. Bergeron drove to the bridge to examine the stream. The water level in the stream at that time was approximately 6 inches above the bridge deck and roadway area.

Mr. Bergeron returned to the dam. In the approximately 15 minutes since he had last seen the dam, the horseshoe-shaped area without ice had increased in diameter to about 20 feet, and water was cascading down into a void formed in the upstream embankment (similar to a horseshoe-shaped waterfall). Mr. Bergeron observed the portion of the concrete spillway located between the area of flow from the spillway channel and the horseshoe-shaped area of the pond without ice collapse to form a "V". Water continued to flow beneath the collapsed concrete spillway.

At approximately 6:55 pm, Mr. Bergeron telephoned 911 again.

Mr. Bergeron returned to the bridge. The water level had risen to about 1.5 feet above the bridge deck and roadway area.

When Mr. Bergeron returned to the dam, water was flowing over the portion of the concrete spillway that had collapsed to form a "V".

6. *Was the low level outlet open periodically, and if so at what times?*

Mr. Bergeron indicated that he periodically opened the low level outlet to keep it from seizing. During the winter, he also kept the low level outlet flowing slightly to prevent water from flowing over the flashboards so that he could maintain snow on the concrete spillway structure for snowmobiling. Once the low level outlet was used to lower the pond for removal of the upper dam.

GEI Consultants, Inc.

Client NHDES

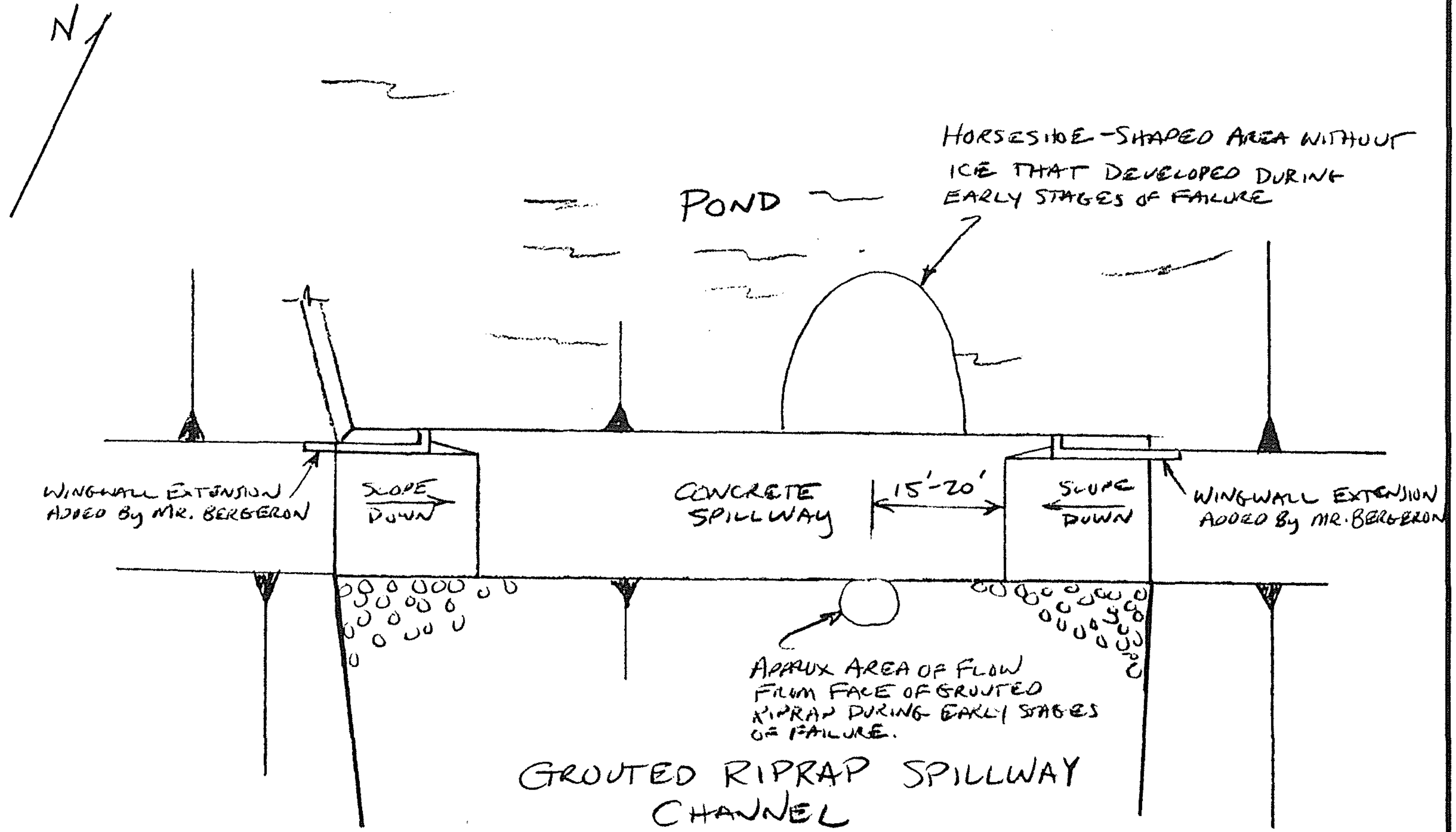
Subject MEADOW POND DAM, ALTON, NH

Project 96069 Page 1

Date 4/30/96 By CW

Checked By

Approved By



SKETCH OF SPILLWAY

0 20'

APPROX. SCALE

GEI Consultants, Inc.

MEMORANDUM

53 Regional Drive
Concord, NH 03301-8500
Tel: 603 · 224 · 7979
Fax: 603 · 224 · 7990

TO: **FILE**

FROM: **Craig Ward**

DATE: **June 17, 1996**

RE: **Interview with Roger Putnam**
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire

This memorandum was prepared to summarize an interview with Mr. Roger Putnam of Putnam Concrete. Mr. Putnam was hired by Mr. Bergeron (owner) for concrete work during the construction of the Meadow Pond Dam. The interview was conducted by telephone conference call on June 11, 1996, and was attended by the following:

Roger Putnam	Putnam Concrete
Richard Mitchell, Esquire	Sullivan and Gregg (representing Farm Family Insurance)
Craig Ward, P.E.	GEI Consultants, Inc. (GEI)

A draft copy of this memorandum was provided to Mr. Mitchell for review and comment to insure that Mr. Putnam's responses are accurately represented. This memorandum has been revised to reflect comments provided by Mr. Mitchell.

At the beginning of the interview, Mr. Ward briefly described GEI's scope of work for the forensic evaluation: to determine the mechanism of failure; to determine if the design was adequate; and to determine if the dam was constructed in accordance with the design.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Mitchell in a letter dated June 4, 1996. Each of GEI's preliminary questions is restated in italics below with a summary of Mr. Putnam's responses. Although additional information may have been provided by Mr. Putnam, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. The summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with Mr. Putnam.

1. *What was the latest revision date in the plans used to build the spillway? Were there any other design documents (sketches, letters, reports) given to the contractor containing instructions pertaining to the construction of the spillway? Any changes to the design made during construction? Any communications with the dam designers?*

   Mr. Putnam indicated that he was not provided a set of design drawings for his files. He and Mr. Bergeron used the plans on-site to layout and set forms for the various concrete structures. Mr. Putnam does not recall the revision number or date that was on the drawings used for the layout. No documents other than the design drawings were used in constructing the concrete structures. Mr. Putnam had no communications with the dam designers.

2. *What work were you hired to perform?*

Mr. Putnam said he was hired by Mr. Bergeron to grout the riprap downstream of the spillway and to form and cast concrete for the spillway slabs, cutoff wall, abutment walls, low level outlet valve stem guide, and baffle wall. Mr. Putnam and Mr. Bergeron layed out the spillway relative to a baseline stakes along the crest of the dam and the trench for the cutoff wall, both of which were in place prior to Mr. Putnam's involvement.

The concrete structures were built in the following order:

- Baffle wall - Two days were required for casting: one day for footings, and one day for the wall.

- Grouted riprap - One day was required for grouting the riprap.

- Spillway slabs and cutoff wall - One day was required for casting. Mr. Putnam indicated that the slabs and cutoff wall were cast monolithically.

- Valve stem guide - One day was required for casting.

- Concrete abutment walls - One day was required for casting. Mr. Putnam indicated that the abutment walls were built about two weeks after the spillway slabs were poured.

3. *Did anyone inspect your work for conformance with the design documents?*

Mr. Putnam indicated that no inspection of his work was performed while he was on-site.

GEI Consultants, Inc.

53 Regional Drive
Concord, NH 03301-8500
Tel: 603·224·7979
Fax: 603·224·7990

MEMORANDUM

TO: **FILE**

FROM: **Craig Ward**

DATE: **June 17, 1996**

RE: **Interview with Thomas Varney**
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire

This memorandum was prepared to summarize an interview with Mr. Thomas Varney of Varney Engineering. Mr. Varney was hired by Mr. Bergeron (owner) to provide quality control during the construction of the Meadow Pond Dam. The interview was conducted by telephone conference call on May 22, 1996, and was attended by the following:

Thomas Varney, P.E.	Varney Engineering
Gonzalo Castro, Ph.D., P.E.	GEI Consultants, Inc. (GEI)
Craig Ward, P.E.	GEI

A draft copy of this memorandum was provided to Mr. Varney for review and comment to insure that his responses are accurately represented. This memorandum has been revised to reflect comments provided by Mr. Varney.

At the beginning of the interview, Dr. Castro briefly described GEI's scope of work for the forensic evaluation: to determine the mechanism of failure; to determine if the design was adequate; and to determine if the dam was constructed in accordance with the design.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Varney in a letter dated May 14, 1996. Each of GEI's preliminary questions is restated in italics below with a summary of Mr. Varney's responses. Although additional information may have been provided by Mr. Varney, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. The summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with Mr. Varney.

1. *What was the latest revision date in the plans used to build the dam? Were there any other design documents (sketches, letters, reports) given to you containing instructions pertaining to the construction of the dam? Any changes to the design made during construction that you are aware of? Any communications with the dam designers?*

Mr. Varney indicated that the design drawings provided by Mr. Bergeron were "Bergeron Lake Dam", sheets C1 through C3, prepared by Rivers Engineering Corporation, Revision 3, dated December 3, 1992. Mr. Varney was not aware of the existence of Revision 4 of the drawings, dated December 17, 1992, until after the failure of the dam. No other documents showing design information (except low level outlet design change discussed below) were provided to Mr. Varney.

The only design change made during construction that Mr. Varney is aware of was the use of corrugated polyethylene pipe with a Ripley's Dam antiseep collar for the low level outlet instead of the 14 gauge corrugated metal pipe with a cast-in-place concrete cutoff specified in the design.

Mr. Varney did not have any communications with the dam designers. Mr. Varney's communications were limited to Mr. Bergeron and the Contractors.

2. *For what aspects of the construction did you provide quality control?*

   Mr. Varney indicated that he provided quality control for overall construction. He was on-site for soil testing and to monitor construction. Most of his work involved monitoring earthwork, but he monitored all aspects of the construction.

3. *How often did you visit the site?*

   Mr. Varney indicated that the frequency of his site visits varied over the duration of the project. Early in the project, Mr. Varney visited the site daily. After the embankment was more than half completed, the Contractor had established a routine for fill placement and compaction, and Mr. Varney reduced the frequency of site visits to about one visit every 3 to 5 working days.

   Mr. Varney was not on-site when forms were set for the spillway structure and the concrete was poured. He did, however, observe subgrade preparation for the spillway structure.

4. *Were any permeability tests conducted on borrow soils?*

   Mr. Varney indicated that no permeability tests were performed.

5. *Was any concrete testing performed?*

   Mr. Varney said that no concrete testing was performed.

6. *How many grain size, compaction and field density tests were conducted? How was retesting of densities tracked?*

   Mr. Varney stated that the following soil testing was performed:

Tests	Quantity
Field Density Tests	18
Grain Size Analyses:	6 (on soils used in the construction)
Compaction tests	2

An additional six grain size analyses were conducted during the search for a suitable borrow source for the filter sand. The results of these additional grain size analyses where not submitted to the Water Resources Division of NHDES since these materials were not used in construction of the dam.

Dr. Castro asked what criteria was used to evaluate the suitability of the gravel blanket material since there was no gradation specified in the design documents. Mr. Varney stated that the gradation requirements for sand and gravel were used for the gravel blanket material.

7. *To whom did you report items not conforming to the design documents? Who made decisions regarding acceptance or rejection of items not conforming to the design documents?*

Mr. Varney said that nonconforming items were reported to Mr. Bergeron and/or the Contractor.

Dr. Castro asked if any in place materials were found to be nonconforming. Mr. Varney indicated that some of the core fill placed in the fall of 1993 was found not to meet density requirements when construction resumed in the spring of 1994. Due to difficulties in compacting these materials, they were removed by the Contractor.

8. *How was the concrete for the spillway slab and cutoff wall poured? Any cold joints?*

Mr. Varney indicated that he was not on-site when the concrete was formed and poured.

9. *Where there any problems associated with cold weather during construction? Freezing subgrades or fill?*

Mr. Varney stated that construction stopped due to cold weather on December 28, 1993. Prior to stopping construction, some core materials had been removed due to freezing.

10. *How was the chimney drain constructed?*

Mr. Varney indicated that the chimney drain was constructed by trenching the in place core materials and backfilling with filter sand. Trenching and backfilling were done in two lifts.

11. *Where were the various fill materials obtained?*

Mr. Varney indicated that while he was on-site, fill material sources were as follows:

- Sand filter, gravel blanket material (for beneath spillway, grouted riprap and upstream riprap) and sand and gravel placed along the lower portions of the upstream slope were obtained from Alton Sand and Gravel.

- Sand and gravel used in the blanket drain was obtained from the gravel road.

- Core material was obtained from an on-site borrow area on the other side of the pond from the dam.

12. *Where was the left end of the cutoff wall terminated?*

Mr. Varney observed the trench for the cutoff wall but not the forming and pouring of the remaining portions of the spillway structure. Therefore, he could not know the position of the left end of the cutoff wall relative to the spillway structure.

13. *Construction start and completion dates.*

Mr. Varney provided the following:

- Mr. Varney met Mr. Connie Halvatzes of CSSI on November 28, 1993, and construction began in earnest. One operator from CSSI had been clearing the site with a D8 dozer for the previous approximately two weeks.

- Construction stopped for the winter on December 28, 1993.

- Construction resumed around the first of May 1994.

- Construction was completed around the first of July 1994.

Dr. Castro asked if Mr. Varney returned to the dam site after construction. Mr. Varney said that he returned to the site in the first or second week in July 1994. At that time, the pond had filled to about 2 feet below the spillway, the embankment had been seeded, and a sprinkler was operating.

At the conclusion of the interview, Dr. Castro asked if Mr. Varney had anything to add.

Mr. Varney indicated that no significant problems had been encountered during construction: the Contractor was agreeable and the fill materials seemed to be uniform in quality.

Mr. Varney also offered the following ideas on the cause of the failure:

- Frost susceptible core materials placed beneath the spillway were within the depth of frost penetration. Frost heaving of the core materials could have lifted and damaged the spillway. Upon melting of ice lenses in the core material (note that it was 60 degrees F on the day of the failure), the core material would become weakened and disturbed, creating a pathway for the development of piping.

- Other factors that may have contributed to the failure include the lack of steel reinforcement in the cutoff wall and the shorter than designed cutoff wall.

GEI Consultants, Inc.

MEMORANDUM

53 Regional Drive
Concord, NH 03301-8500
Tel: 603 · 224 · 7979
Fax: 603 · 224 · 7990

TO: **FILE**

FROM: **Craig Ward**

DATE: **June 17, 1996**

RE: **Interview with Rivers Engineering Corp.
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire**

This memorandum was prepared to summarize an interview with personnel from Rivers Engineering Corp. (Rivers). Rivers was hired by Mr. Bergeron (owner) to assist in the preparation of a permit application for the Meadow Pond Dam. The interview was conducted by telephone conference call on May 16, 1996, and was attended by the following:

John Lavigne, P.E.	Rivers
George Rief, P.E.	Rivers
Rod Stark, Esquire	Stark Law Firm (representing Rivers)
Gonzalo Castro, Ph.D., P.E.	GEI Consultants, Inc. (GEI)
Craig Ward, P.E.	GEI

A draft copy of this memorandum was provided to Rivers for review and comment to insure that their responses are accurately represented. This memorandum has been revised to reflect comments provided by Rivers.

At the beginning of the interview, Dr. Castro briefly described GEI's scope of work for the forensic evaluation: to determine the mechanism of failure; to determine if the design was adequate; and to determine if the dam was constructed in accordance with the design.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Lavigne in a letter dated May 10, 1996. Each of GEI's preliminary questions is restated in italics below with a summary of Rivers' responses. Although additional information may have been provided by Rivers, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. The summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with Rivers.

1. *What was the latest revision date in the plans and design reports provided to the Bergerons and to the Water Resources Division of NHDES? Where any other design documents (sketches, letters, reports) given to the Bergerons or NHDES?*

Mr. Lavigne indicated that the latest revision of the permit drawings was dated December 17, 1992, and stamped "Not for Construction". Other documents considered by Rivers to be part of the permit application included the geotechnical report prepared by Jaworski Geotech, the hydraulics report prepared by Rivers, and key correspondence between Rivers and the Water Resources Division (WRD) of NHDES. Each of these documents is included in the WRD files, except for the geotechnical report.

Mr. Lavigne said that Mr. Bergeron controlled most communications with the WRD. The permit application was prepared and submitted to the WRD by Mr. Bergeron. WRD did direct some design questions and recommendations to Rivers, which were addressed in correspondence between Rivers and the WRD and revisions to the permit drawings. Mr. Bergeron was copied on all of Rivers' correspondence with the WRD, and hand delivered the final permit drawings revised December 17, 1992, to the WRD.

Rivers prepared a letter to the WRD, dated December 17, 1992, in response to concerns raised by the WRD regarding the effects of frost penetration on seepage in the vicinity of the spillway. In this letter, Rivers indicated that WRD's concerns were addressed in the December 17, 1992 revision of the permit drawings by increasing the length of the seepage cutoff and specifying finer material for the gravel blanket base to the riprap. Dr. Castro indicated that since the gradation requirements for the gravel blanket had not been specified on the previous revision of the permit drawings (the December 3, 1992 revision), it was not clear whether the change to the gravel blanket gradation had been incorporated into the December 17, 1992 revision. Mr. Lavigne indicated that this change had been incorporated as shown on the December 17, 1992 revision of the permit drawings on file with the WRD.

2. *Did Rivers Engineering have any communications with the Bergerons, NHDES, CSSI, or Varney Engineering during construction of the dam?*

   Mr. Lavigne stated that, prior to the failure, Rivers had no communications regarding design or construction issues with anyone after the December 17, 1992 revision of the permit drawings were submitted to Mr. Bergeron.

At the conclusion of the interview, Dr. Castro asked if Rivers had anything to add. Mr. Lavigne pointed out that the December 17, 1992 design drawings were intended to support the permit application and were not issued for construction.

GEI Consultants, Inc.

53 Regional Drive
Concord, NH 03301-8500
Tel: 603 · 224 · 7979
Fax: 603 · 224 · 7990

MEMORANDUM

TO: **FILE**

FROM: **Craig Ward**

DATE: **June 17, 1996**

RE: **Interview with Steve Doyon of the Water Resources Division,
New Hampshire Department of Environmental Services
Meadow Pond Dam Forensic Evaluation
Alton, New Hampshire**

This memorandum was prepared to summarize an interview with Steve Doyon of the Water Resources Division (WRD) of the New Hampshire Department of Environmental Services (NHDES). The interview was conducted on April 25, 1996, and was attended by the following:

Steve Doyon, P.E.	WRD
Gonzalo Castro, Ph.D., P.E.	GEI Consultants, Inc. (GEI)
Craig Ward, P.E.	GEI

A draft copy of this memorandum was provided to Mr. Doyon for review and comment to insure that his responses are accurately represented. Mr. Doyon had no comments on the draft memorandum.

Prior to the interview, GEI provided a preliminary list of interview questions to Mr. Doyon. Each of GEI's preliminary questions is restated in italics below with a summary of Mr. Doyon's responses. Although additional information may have been provided by Mr. Doyon, only information considered by GEI to be relevant to our forensic evaluation is presented in this memorandum. The summary provided in this memorandum is not intended to be a complete or verbatim account of GEI's discussions with Mr. Doyon.

1. *What was the latest revision date of the plans provided to the Water Resources Division (WRD) of NHDES? Where any other design documents (sketches, letters, reports) given to the WRD? Where there any design changes made during construction?*

   Mr. Doyon indicated that the latest revision of the design drawings submitted to the WRD were dated December 17, 1992, which were approved by WRD. Other documents considered by the WRD to be part of the approved design include key correspondence in the WRD files, most notably letters from Rivers Engineering Corp. (Rivers) dated December 11, 1992, and December 17, 1992. The letter from Rivers dated December 17, 1992 was referenced in the permit.

The only design change made during construction was the use of corrugated polyethylene pipe with a Ripley's Dam antiseep collar for the low level outlet instead of the 14 gauge corrugated metal pipe with a cast-in-place concrete cutoff specified in the design. This design change was requested by Mr. Bergeron in his letter to the WRD dated October 14, 1993, and approved by WRD in a letter to Mr. Bergeron dated October 28, 1993.

2. *Did WRD have any communications with the design engineers, the Bergerons, CSSI, or Varney Engineering during construction of the dam?*

Mr. Doyon indicated that WRD had no communications with the design engineers (Rivers) or the quality control engineer (Varney Engineering) during construction. The only contact with Mr. Bergeron during construction (other than site visits) was correspondence related to the low level outlet pipe design change. Mr. Doyon had contact with Mr. Bergeron and CSSI during the following site visits:

- December 23, 1993: Mr. Doyon visited the site to observe installation of the low level outlet pipe.

- July 1994: Mr. Doyon conducted the final inspection required prior to filling the pond. At the time of Mr. Doyon's visit, contractors were placing the riprap along the upstream face of the embankment and forming the concrete abutment walls on the spillway slabs. Mr. Doyon told Mr. Bergeron the following:

    - Cracking of the grouted riprap may occur due to embankment settlement. Mr. Bergeron should repair grouted riprap as necessary.

    - The downstream face of the embankment should be inspected periodically for soft spots. Soft spots may be indicated by variations in vegetation.

    - The lip along the left and right edges of the grouted riprap channel downstream of the spillway should be maintained to avoid overflow and embankment erosion.

Except for review and approval of the Emergency Action Plan for the dam, WRD had no other communications with Mr. Bergeron after the July 1994 site visit.

Left side of breach (looking upstream) after failure. (3/19/96)

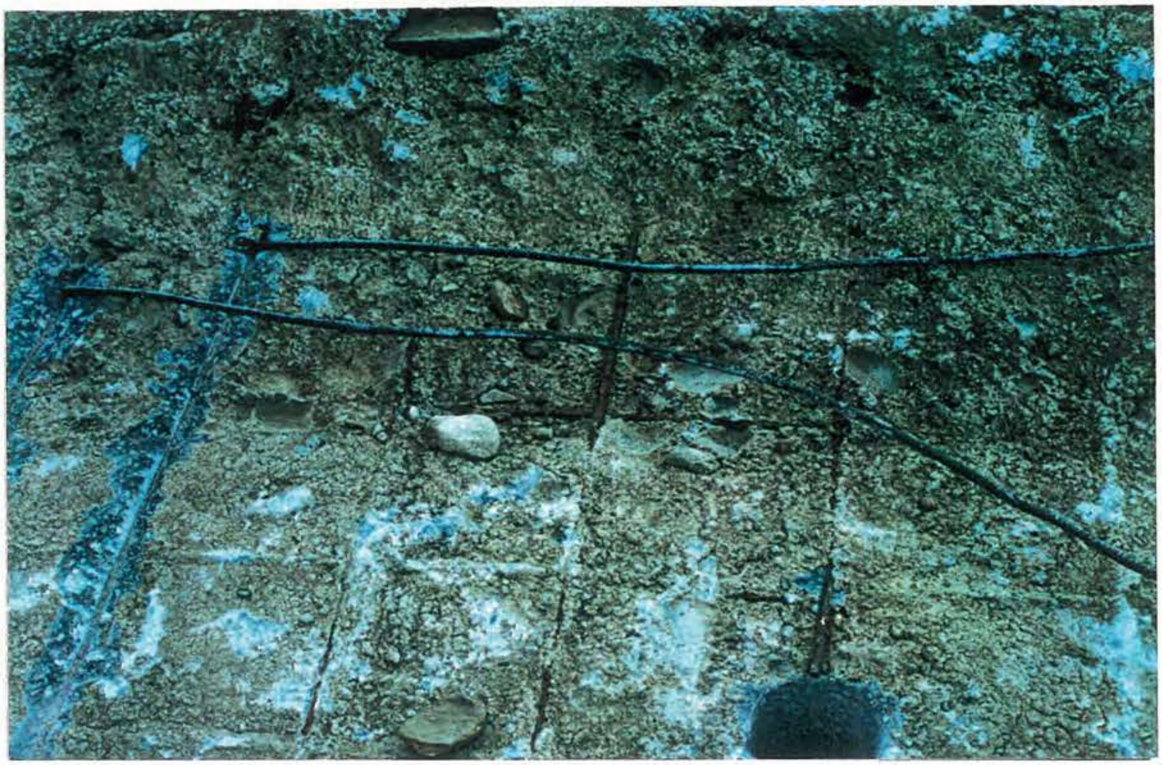
Left side of breach (looking downstream) after failure. (3/19/96)

Void at right end of cutoff wall (looking downstream). Stem guide and cutoff wall on left side of photo. (4/1/96)

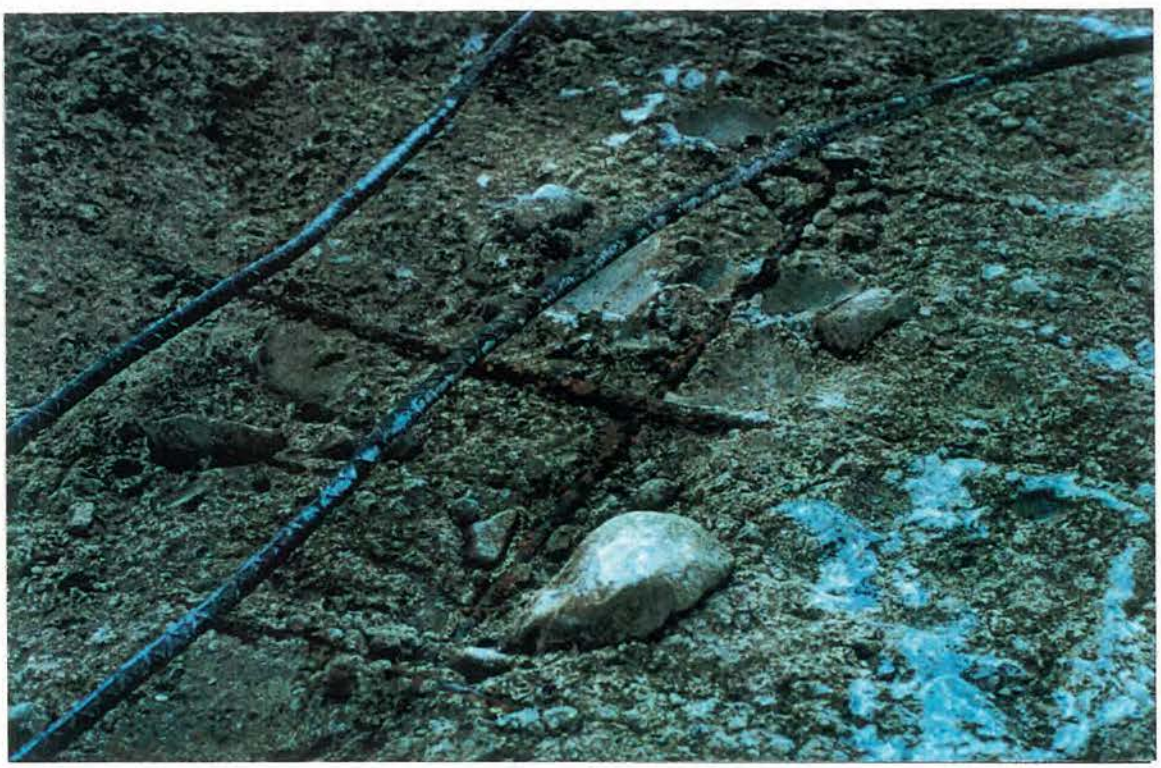
Concrete spillway section in dam breach. Note cold joint between slab and cutoff wall at lower left of photo. (3/20/96)

Right side of breach (looking upstream) after failure. (3/19/96)

Left side of breach after the first day of field investigations. (3/20/96)



Rusted reinforcing steel and staining of concrete on underside of sloping spillway slab from left side of spillway. (4/5/96)

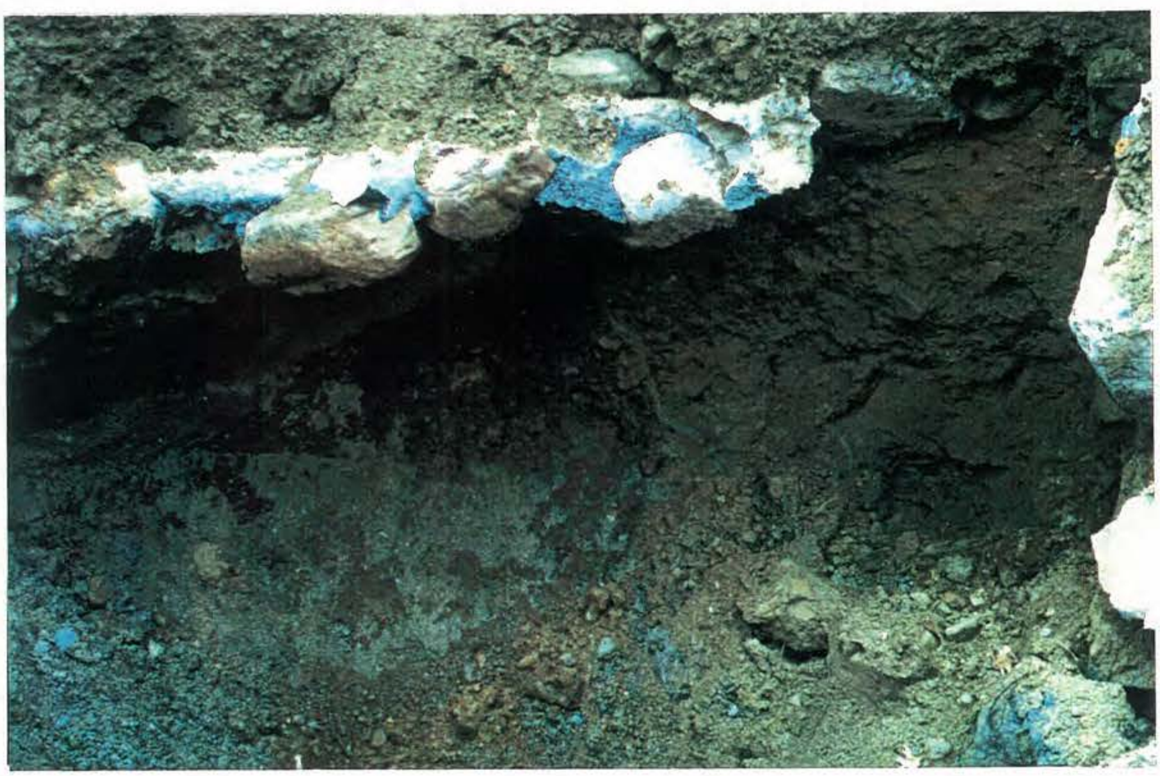


Rusted reinforcing steel and staining of concrete on underside of sloping spillway slab from left side of spillway. (4/5/96)

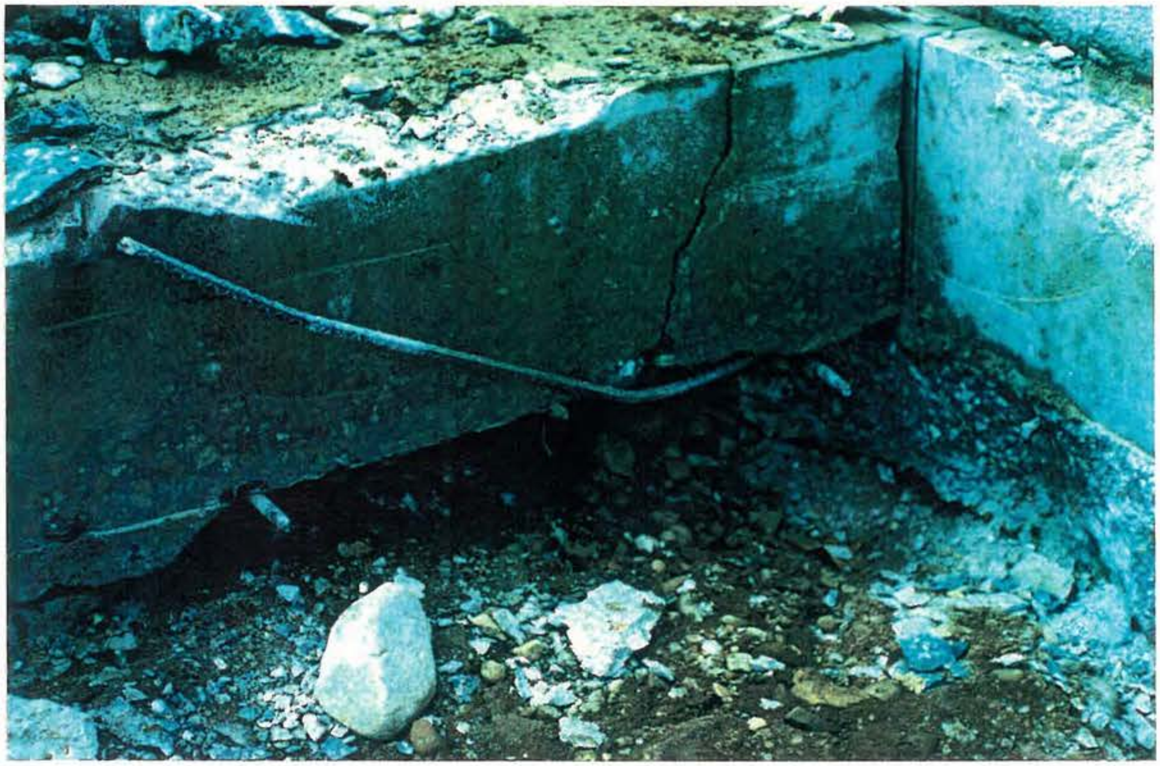
Underside of spillway slab section in breach of dam. Note limited cover over reinforcing steel. (3/20/96)

Crack in cutoff wall and spillway slab. Note repair material at top of crack. (3/20/96)

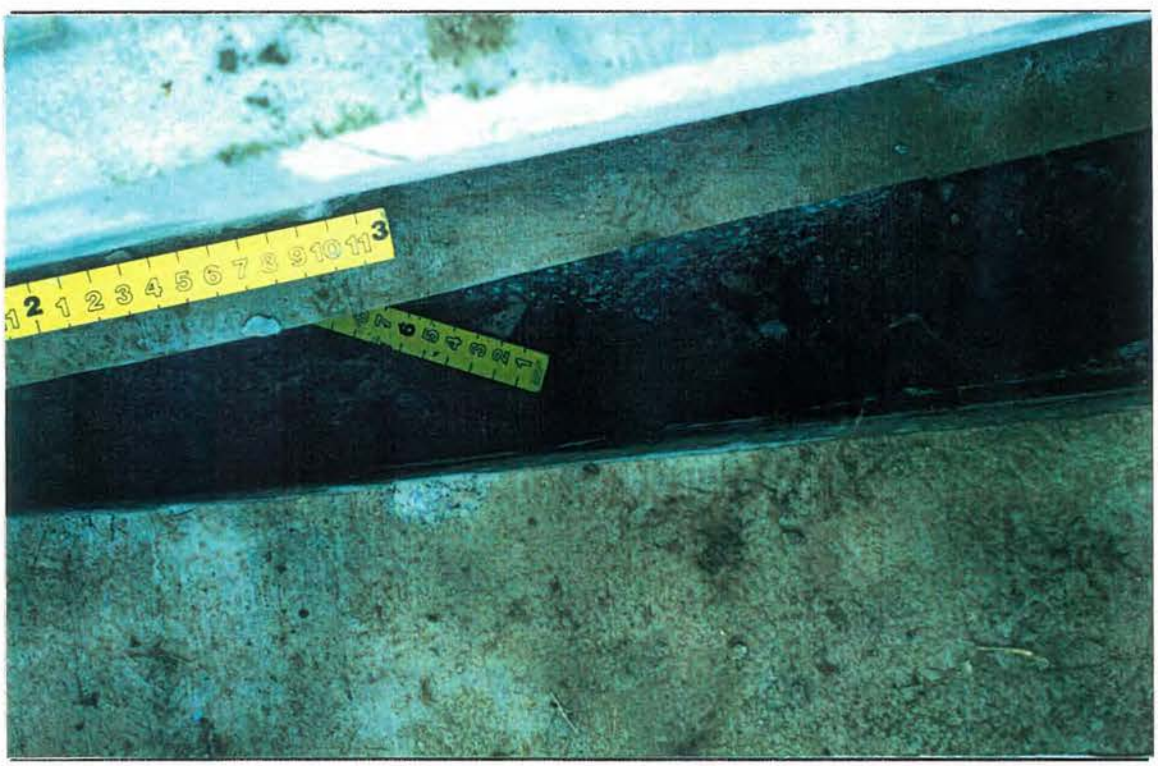
End of spillway cutoff wall and slab. Note the absence of longitudinal reinforcement in the cutoff wall. (3/20/96)



Soil beneath grouted riprap on downstream side of spillway. (4/5/96)



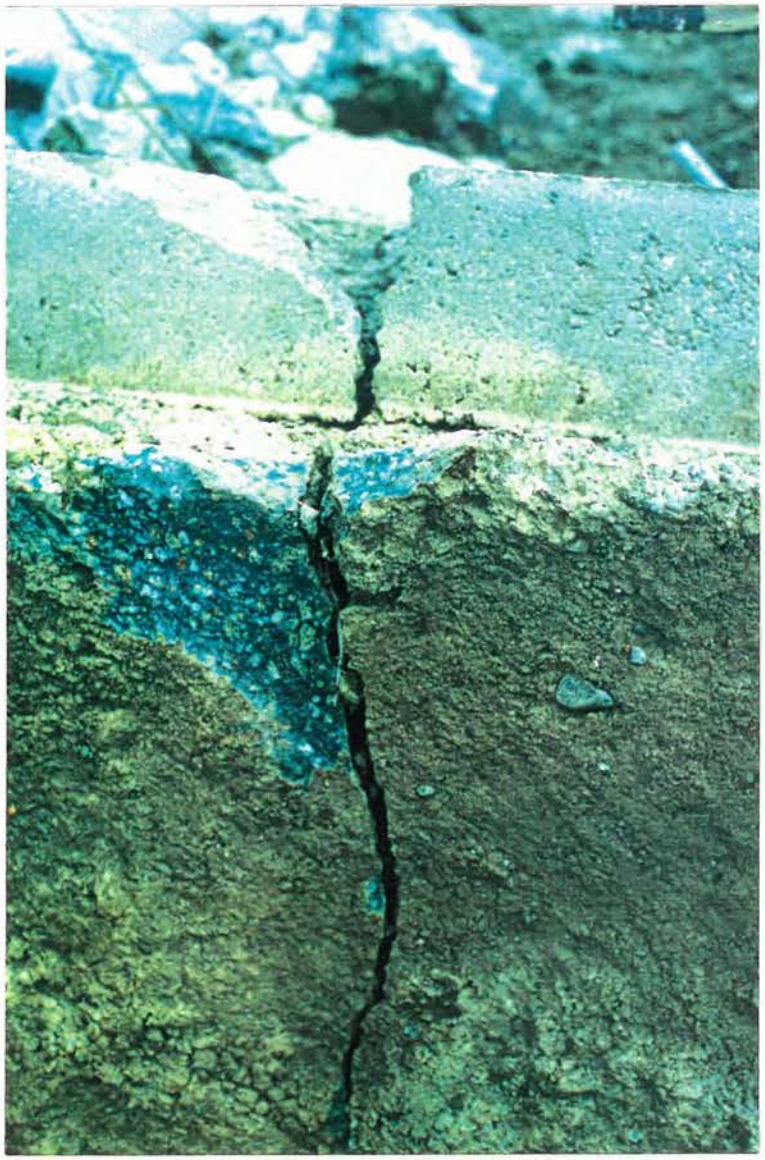
Void beneath spillway slab. (4/2/96)



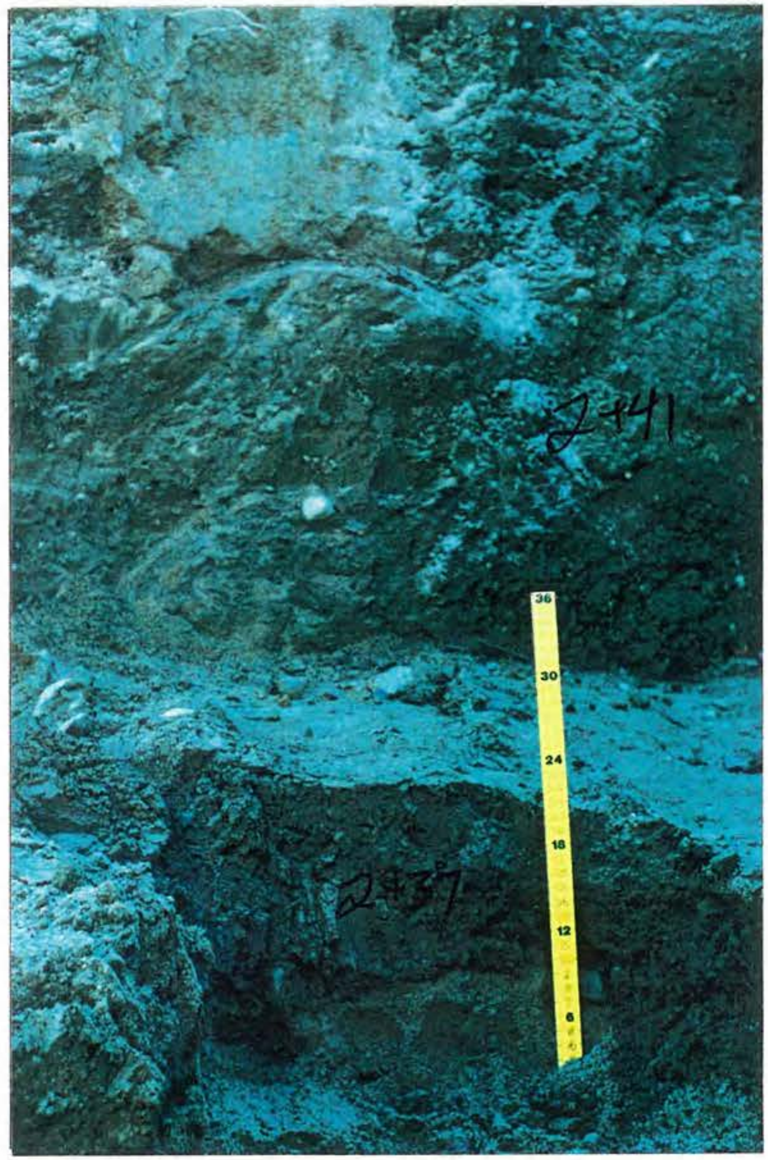
Saw cut slab moved away from abutment wall. Ruler on slab subgrade inserted from upstream side of void at right end of cutoff wall. (4/2/96)

Left: Subgrade beneath sloped portion of spillway slab. Note void at far edge of subgrade, area of protruding gravel on subgrade (indicating errosion) and corresponding dry area on bottom of slab. (4/2/96)

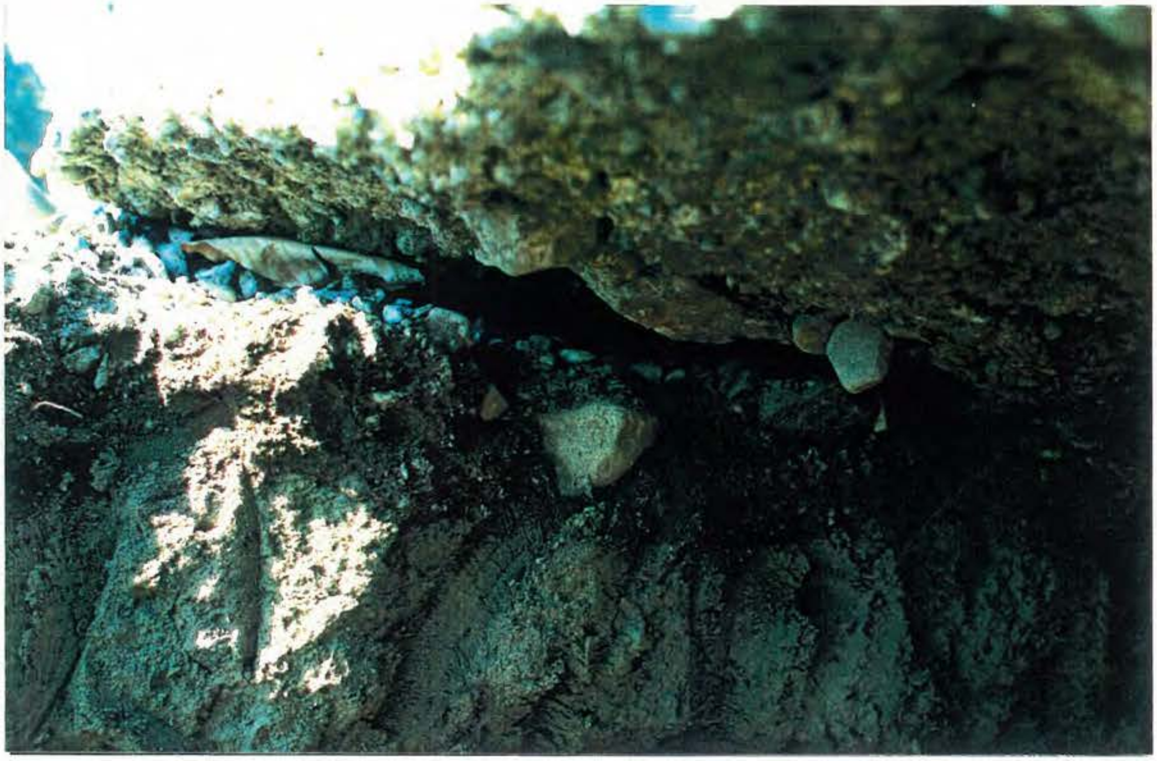
Below: Void beneath spillway slab. (4/2/96)



Crack in cutoff wall and spillway slab. Note cold joint between cutoff wall and spillway slab. (3/20/96)



Chimney drain contaminated with core materials. (4/4/96)



Void beneath spillway slab. (4/2/96)

Right side of breach after field investigations. (4/5/96)