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REPORT OF
GEOTECHNICAL INVESTIGATION

KETCHUM SEWAGE TREATMENT PLANT ADDITION
KETCHUM, IDAHO

Chen Northern, Inc.

Consulting Engineers and Scientists

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February 7, 1990

Bell Walker Engineers, Inc.
827 La Cassia Drive
Boise, Idaho 83705

ATTENTION: Mr. Gilbert Walker, P. E.

SUBJECT: Report of Geotechnical Investigations
Ketchum Sewage Treatment Plant Additions
Ketchum, Idaho

Ladies and Gentlemen:

At your request, we have investigated the subsurface foundation soil conditions at the site of proposed additions to the sewage treatment plant in Ketchum, Idaho.

Subsoils at the proposed pump station site consist of fill overlying silty sand, which in turn overlies dense poorly graded gravel with sand. At the proposed thickener location, the subsurface profile consists of a thin surface layer of silty sand or sandy silt overlying the same dense poorly graded gravel deposit.

Existing fill soils are not suitable for support of foundations or floor slabs, and must be replaced with structural fill. Conventional spread footings founded on natural soils at the site, or on structural fill placed on the natural soils are recommended for support of structural loads. A relatively low allowable bearing pressure is recommended for design of footings for the pump station to reduce potential for differential settlement between portions of the structure bearing on soils of differing compressibility.

Groundwater levels are relatively deep at this time of year, but have been observed at much shallower depths during previous investigations at the site performed in early summer. We understand that dewatering presented significant difficulties during previous construction. New construction should be performed when groundwater levels are expected to be lowest to minimize dewatering requirements. Even during low ground water periods, some dewatering may be necessary for deeper portions of the thickener.

The report which follows describes in detail our investigations, summarizes our findings, and presents our recommendations. It is important that we provide consultation during design, and field services during construction to review and monitor the implementation of the geotechnical recommendations.

In order for you to better understand this report and the limitations of geotechnical studies with respect to findings, opinions, and recommendations, we have included an information sheet on this topic in the Appendix.

If you have any questions regarding this report, please contact us.

Respectfully submitted,

Jerry A. Peterson, P.E.

Enclosures
In quadruplicate

REPORT OF GEOTECHNICAL INVESTIGATION

KETCHUM SEWAGE TREATMENT PLANT ADDITION
KETCHUM, IDAHO

To:
BELL WALKER ENGINEERS
BOISE, IDAHO

From:
CHEN-NORTHERN, INC.
BOISE, IDAHO

February, 1990

PURPOSE AND SCOPE OF STUDY

This report presents the results of a subsurface study for additions to the existing sewage treatment plant in Ketchum, Idaho. These additions include a thickener to be located near the southwest corner of the plant, and a pump station and grit chamber near the northeast corner. The project site is shown on Drawing No. 90-1303-1 in the Appendix. The investigation was conducted for the purpose of developing foundation recommendations for design and construction, and was performed in accordance with our proposal to Bell Walker Engineers, Inc., dated December 15, 1989.

A field exploration program consisting of four exploratory borings along with appropriate sampling of subsurface materials was conducted to obtain information about subsurface conditions. Samples obtained during the field investigation were tested in the laboratory to determine physical and engineering characteristics of the on-site soil. Results of the field exploration and laboratory tests were analyzed to develop recommendations for foundations of the additions. The results of the field exploration and laboratory testing are presented herein and in the Appendix.

A previous investigation was performed by our firm for existing facilities at the plant in June of 1982. Findings and recommendations of that investigation were submitted in our "Report of Geotechnical Investigation", addressed to Bell-Walker Engineers and dated June 28, 1982.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

PROPOSED CONSTRUCTION

The thickener will be a circular reinforced concrete tank about 30 feet in diameter and extending almost entirely below grade. Side walls of the tank will extend 13.5 feet vertically downward to attach to the conical shaped bottom. The floor of the tank will slope downward toward the center at an inclination of 2 inches vertically to 12 inches horizontally. The lowest point at the center of the floor will be approximately elevation 5713.5 (USGS datum).

The pump station will consist of a below grade concrete box at one end, which will extend to a depth of about 10 feet below the proposed main floor elevation, which we understand will be approximately elevation 5734 (USGS datum). From this deep end, the bottom of the pump station will slope upward at an inclination of about 30 degrees. The grit chamber will be located at the opposite end of the pump station, and will consist of a narrow concrete receptacle extending about 10 to 12 feet below the floor level, or to an elevation of about 5722 (USGS datum). This configuration will result in foundations placed deep in the profile at the ends of the structure, and shallow in the center.

Structural loads of both of these facilities are expected to be relatively light. Because both structures will be largely below grade, net increases of load to the foundation soils will be low. The weight of the structures will be largely displacing the weight of soil presently in place. If the loadings, locations or conditions relating to the structures are significantly different from those described above, then we should be notified to reevaluate the recommendations contained in this report.

FIELD EXPLORATIONS

The field exploration was conducted on January 22 and 23, 1990, during which four exploratory borings were drilled to depths ranging from 5.4 to 26.2 feet to observe subsoil and ground water conditions. Locations of the borings were determined by measurement from existing on site features. Elevations were determined by a level survey referenced to an assumed elevation of 5728.0 for the finished floor of the control building at its back door. This reference elevation was also used in previous investigations at the site.

The borings were advanced through the soils with 7 inch diameter hollowstem augers. Borings were logged by a representative of Chen Northern, Inc.

Samples of the subsurface materials were taken with 2 inch and 1-3/8 inch I.D. split spoon samplers. The samplers were driven into the various strata using a 140-pound hammer falling 30 inches. The number of blows required to advance the samplers each successive six-inch increment was recorded and the total number of blows required to advance the samplers the second and third 6-inch increments has been reported as the penetration resistance ("N value"). For the smaller sampler, this test is the standard penetration test described by ASTM Method D1586.

Measurements of the water level were made in the borings by lowering a weighted tape into the augers at the completion of drilling. Depths to the water level where encountered are recorded on the Logs of Exploratory Borings.

LABORATORY TESTING

Samples obtained during the field exploration were taken to the laboratory where they were observed and visually classified in accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils in general accordance with ASTM or other approved procedures.

Tests Conducted:	To determine:
Grain-size Distribution	Size and distribution of soil particles; that is, clay, silt, sand and gravel.
Natural Moisture Content	Moisture content representative of field conditions at the time samples were taken.

Tests Conducted:	To determine:
Atterberg Limits	The consistency and stickiness, as well as the range of moisture content within which the material is workable.
Consolidation	The amount that a soil compresses with loading and the influence of wetting on its behavior. For use in settlement analysis for footing design.

Results of all field and other laboratory tests are summarized on Figures 1 through 3 in the Appendix. These data, along with the field information, were used to prepare the exploratory boring logs shown in the Appendix.

SITE CONDITIONS

The existing treatment plant is located on the east bank of the Big Wood River just south of the City of Ketchum. The proposed thickener site is a relatively level area located just outside the existing perimeter fence at the southwest corner of the plant. The ground surface drops abruptly about 15 feet into the present river channel. Old concrete pipe sections and other parts or equipment are presently stored on the site.

The proposed pump station will be located just east of the northeast corner of the existing plant. This area, including a strip of land along the entire east side of the plant, was formerly railroad right of way which was purchased by the city for expansion and separation from adjacent property. The site was covered with snow at the time of our investigations, but it appeared that the old railroad tracks and ties have been removed. A paved recreation trail has been constructed along the east side of the old right of way. This strip of land is generally higher in the center at the north, apparently having been filled to achieve railroad grade. Shallow drainages or borrow ditches are located along either side of the old right of way. Comparison of existing contours to those available during previous investigations indicates that some grading of the site has taken place recently, probably in conjunction with removal of the tracks and construction of the paved trail.

SUBSURFACE CONDITIONS

The subsurface profile encountered in the exploratory borings at the thickener site consists of a thin surface layer of silty sand or sandy silt overlying dense poorly graded gravel with sand. At the pump station site, the profile consists of fill overlying a layer of silty sand which in turn overlies the same deposit of poorly graded gravel. These soils are described in greater detail on the attached logs. Physical and engineering properties of the soils are discussed in the following paragraphs.

<u>Fill</u>--Fill extending to depths of 3.7 and 5.7 feet was encountered in Borings 1 and 2, respectively, at the pump station site. The fill consists mostly of clayey or silty gravel with sand and cobbles. Approximately the upper 2.5 feet of fill in Boring 2, however, consists of lean clay with sand and some gravel. Standard penetration test results in the fill range from 60 blows per foot to refusal of the sampling equipment. In finer grained soils, such high blows would indicate high density. However, in this instance, they are likely a result of the sampler encountering large cobble size particles. The fill was probably placed to support the old railroad subgrade. Information concerning the placement and density of the fill are not available. Therefore, the potential compressibility of the fill is uncertain. Due the variability in composition, it is concluded that the compressibility will probably be nonuniform.

<u>Silty SAND</u>--A layer of silty sand was encountered beneath the fill at the pump station site extending to depths ranging from 6.5 to 9.5 feet in Borings 1 and 2, respectively. At the thickener site, the silty sand or sandy silt is present only as a thin surface layer ranging from 0.5 to 1.5 feet thick. The sand is poorly graded, fine to medium grained, and nonplastic. Standard penetration test results in this soil range from 7 to 12 blows per foot, indicating loose to medium dense consistency. Natural moisture contents range from 11 to 13 percent. The in-place dry unit weight of an undisturbed sample of this soil was 92 pounds per cubic

foot. A consolidation test on this same sample shows that the silty sand has low to moderate compressibility under light foundation loads, and increases slightly in compressibility when saturated.

Poorly to Well Graded GRAVEL with Sand, Clay and Cobbles--This deposit of granular, alluvial soil was encountered in all borings and extends though the depths explored. The specific composition of the soil varies within the deposit, containing clay or silt fines and interbedded sand or gravelly sand at some locations. The plant operator reports that large boulders (rocks larger than 12 inches in size) were encountered in the deposit during excavation for construction of existing facilities at the plant. Standard penetration test results range from 31 blows per foot to refusal of the sampling equipment. These values generally indicate that the soil is dense. Higher values are likely a result of encountering large cobbles or boulders. Natural moisture contents above the ground water level are relatively low, ranging from 4 to 9 percent. Our experience with this soil at this and other sites in the area is that it has high strength and low compressibility. It is expected that this soil will have relatively high permeability, especially portions of the deposit which contain very few clay or silt fines. This property indicates that the soil will readily transmit water, which could result in large pumping volumes to dewater excavations below the water table.

Ground Water

Ground water was encountered at depths ranging from 15.9 to 20.0 feet at the time of our recent investigations. It is expected that the ground water level is strongly influenced by the adjacent river, and is near its lowest level at this time of year. Ground water levels were encountered at depths as shallow as 3.3 feet during our previous investigations at the site, which were performed in the early summer. It is also reported that extensive dewatering was required for construction of existing below grade facilities. Numerous factors may contribute to fluctuations in the ground water levels, and evaluation of such factors is beyond the scope of this project.

ENGINEERING ANALYSIS

SITE GRADING

Large excavations will be required for construction of below grade structures. Except for these excavations and replacement of the existing fill, site grading is expected to be minimal. It is anticipated that conventional earth moving equipment should be suitable for most of the proposed excavation. However, contractors should be aware that some large boulders will likely be encountered in the gravel deposit which may require extra time or equipment for removal.

Sloped excavations must be kept far enough from facilities to avoid undermining shallow existing foundations. The proposed excavations could interfere with existing site features or facilities if very flat construction slopes are required to maintain stability, which could be the case for excavations below ground water which are dewatered internally. If it appears that the flat slopes will interfere, braced excavations or methods of excavation and dewatering which will allow steeper slopes will be necessary.

FOUNDATIONS

The dense, poorly to well graded gravel will provide excellent foundation support for the proposed thickener using conventional spread footings. Settlement of footings designed for an allowable net bearing pressure of 4,000 pounds per square foot are expected to be less than 1/4 inch. Since this facility is to be mostly below grade, net changes in pressure in the underlying foundation soils will be the difference between the weight of the structure and its contents, and that of the soil which presently occupies this space. This difference is expected to be small. Consequently, actual settlements of the thickener are expected to be negligible.

Due to the variability and lack of information concerning placement of the existing fill at the pump station site, it is considered unsuitable for support of foundations or floor slabs. The existing fill should be removed and replaced with structural fill.

At the proposed elevations and design configuration, deeper chambers at each end of the pump station would bear on the dense gravel layer, while shallower portions of the structure in between would be supported on the overlying silty sand or structural fill to replace the existing fill. A low allowable bearing pressure of 1,500 pounds per square foot appropriate for the silty sand is recommended to minimize the potential differential settlement due to differing compressibilities of these materials. Portions of the structure bearing on the gravel are expected to experience negligible settlement. Footings on the silty sand and designed for the recommended allowable bearing pressure are expected to settle less than 1/4 inch. This settlement may increase slightly if the foundation soil becomes saturated.

FLOOR SLABS

Floor slabs may be supported on natural soil or on structural fill used to achieve finished grade elevation. The use of a leveling course of small gravel and/or sand will be important where the slab is placed on the dense gravel to prevent the slab from bearing directly on a large cobble or boulder. These large particles in direct contact with the slab could intrude into the design thickness during concrete placement, or cause stress concentrations in the slab. Either of these could result in premature cracking of the concrete.

LATERAL LOADS

Below grade walls of all new structures will be subjected to horizontal loading due to lateral earth pressure from backfilled soil. The lateral pressures are a function of the properties of the adjacent natural soil and the backfill, ground water conditions, and the amount of movement the wall can accommodate. Lateral pressures have been recommended for design both above and below the static ground water level assuming the use of on site gravel or sand soil for back fill. Because the below grade walls will be rigidly connected to other adjacent structural elements which will make them unyielding, the "at rest" condition of lateral earth pressure was used in determining the design pressures.

DEWATERING

Construction dewatering will be required for any excavation which extends below the ground water level. Dewatering requirements can be reduced by constructing below grade facilities during low ground water periods, generally late fall through winter months. Based on available information, it appears that dewatering may be avoided altogether at the pump station site if it is built during the time of lowest ground water.

The proposed bottom elevation of the thickener is about the same as the present water surface of the adjacent river. Therefore, even at times of lowest ground water, some dewatering of the excavation for this structure may still be required. However, the volume of water to be pumped will be reduced significantly by scheduling the work for low water.

Although specific methods and design of dewatering systems are the responsibility of others, the following comments are given for your consideration. Based on previous experience at the site, general characteristics of the foundation soil types, and proximity to the river, it is expected that the quantities of water to be pumped during dewatering will be large. Large flows into the excavation will adversely affect stability of side slopes, especially in these granular soils. Deep sumps or wells around the perimeter to intercept water before it enters the excavations will improve construction slope stability, but are often more expensive to install than sumps inside the excavation. Trade offs between these dewatering methods include the need for flatter slopes to maintain stability when dewatering from sumps inside the excavation, as opposed to potentially more expensive external dewatering methods which may allow steeper slopes.

Structures which extend below the high ground water level must be designed to resist buoyancy if they are ever to be emptied when water levels are high. Alternatively, the ground water would have to be drawn down when the structures are emptied.

RECOMMENDATIONS

Site Preparation and Grading

1. Below grade earthwork should be performed during periods of low ground water, generally late fall through winter months.

2. All topsoil, fill or and disturbed soil should be removed from the beneath and within five feet of the proposed structures. Existing fill soil is not suitable for use as structural fill or backfill.

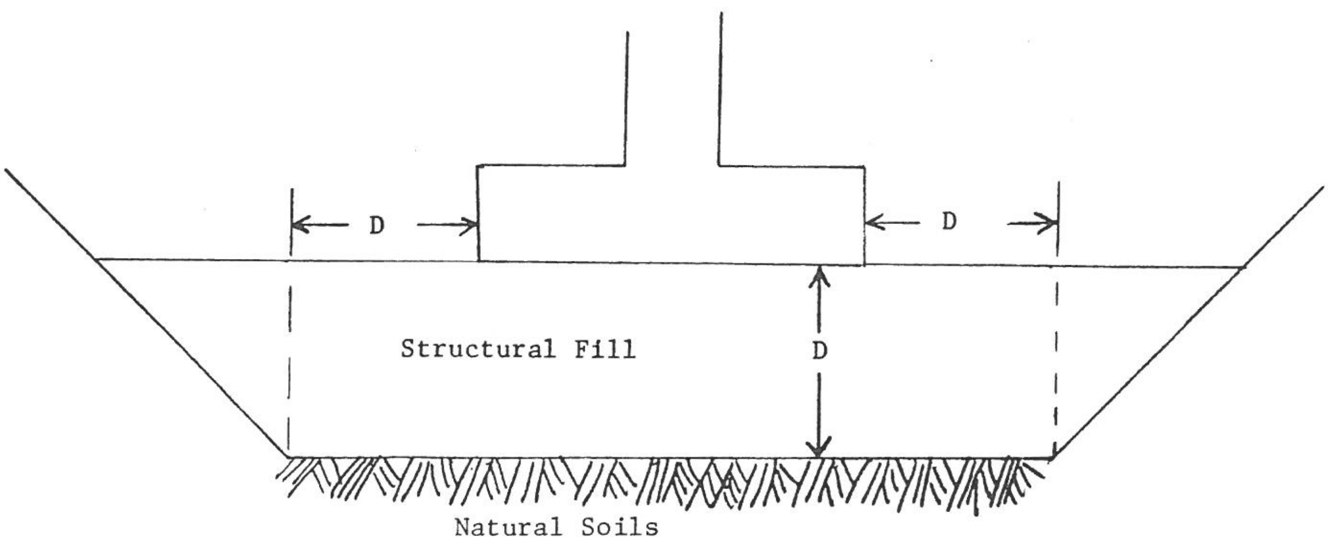
3. All fill and backfill should consist of clean (less than 10 percent passing the number 200 size sieve) 4 inch minus gravel with sand or other material approved by the soils engineer. On site poorly to well graded gravel which is free of organics or debris or oversized particles may be used for structural fill. Some screening or raking to remove very large particles may be necessary to use the onsite gravel for fill. All fill and backfill beneath structures should be placed in loose lifts 8 inches or less in thickness, moisture conditioned to near optimum, and compacted to at least 70 percent of relative density. Backfill against walls above the footing elevation should be compacted to 65 percent of relative density. Only hand operated compaction equipment should be used within 5 feet of backfilled walls. Maximum and minimum densities of gravel for determining relative density of structural fill should be determined in accordance with ASTM D4253 and D4254. If finer grained soil is approved for use as fill, it should be compacted to 98 percent of maximum dry density beneath footings or 95 percent of maximum dry density when placed against walls above footing level. Maximum dry density should be determined in accordance with ASTM D698.

Foundations

4. Spread footings founded on the dense poorly to well graded gravel, natural silty sand, or on structural fill may be used to support structural loads. Footings for the thickener which will be supported entirely on the gravel may be designed for an allowable bearing pressure of 4,000 pounds per square foot. Footings for the pump station, which will bear partially on the silty sand, should be designed for an allowable bearing pressure of 1,500 pounds per square foot. Settlements as described in the Engineering Analysis section of this report should be anticipated.

5. Footings should be placed at least 3.5 feet below adjacent unheated finished grade. Interior footings should be placed at least 1.5 feet below adjacent floor slabs of the pump station, or 2.0 feet below the thickener floor. Minimum recommended footing width is 1.5 feet.

6. Structural fill beneath footings should extend laterally from the edges of footings for a distance equal to the depth of fill beneath the footing, as illustrated below.



Floor Slabs

7. Floor slabs may be supported on natural soils or on structural fill used to achieve the desired subgrade elevation. A leveling course consisting of 4 inches of clean (less than 10 percent passing the number 200 sieve) 1 inch minus gravel or sand should be used immediately beneath the slabs, including the floor of the thickener.

Lateral Loads

8. Lateral loads may be resisted by friction between the footing base and the supporting soil and by lateral bearing pressure against the sides of footings. At the pump station, a friction coefficient of 0.4 and a lateral bearing pressure of 150 pounds per square foot per foot of depth are appropriate for design. For design of the thickener, a coefficient of friction of 0.50 and a lateral bearing pressure of 400 pounds per square foot per foot of depth may be used.

9. Below grade walls should be designed to resist equivalent fluid pressures of 50 and 90 pounds per cubic foot for above and below the ground water level, respectively. In addition, below grade walls should be designed to resist a uniform pressure of 0.4 times any surcharge load that may be placed on adjacent backfill.

Dewatering

10. Dewatering should be anticipated for construction of deep, below grade structures. Issues discussed relative to dewatering in the Engineering Analysis section of this report should be considered in design of systems to dewater the site. A dewatering system should be designed by the contractor or independent consultant selected by the owner. Plans for the system should be submitted to the engineer for review prior to any excavation below the water table.

11. Below grade structures should be designed to resist buoyancy as necessary.

Site Grading

12. Develop and maintain site grades which rapidly drain surface and roof runoff away from foundation soils, both during and after construction.

Plan Review

13. Our geotechnical engineer should review plans and specifications prior to construction to insure that the intentions of our recommendations are properly incorporated into the design and that any changes in the design concept properly consider geotechnical aspects.

Footing Observation and Testing

14. A geotechnical engineer from our firm should observe the excavation, earthwork, and foundation phases of the work to determine that subsurface conditions are compatible with those used in the analysis and design. These observations will be important to confirm that all fill has been removed from beneath structures where required.

15. During site grading, placement of structural fill should be observed and tested to confirm that proper density has been achieved.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on the attached drawing, and the proposed site grading and construction discussed in this report. The nature and extent of subsurface variations across the site may not become evident until construction. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so re-evaluation of the recommendations can be made.

Reviewed by:

Steven A. Narkiewicz, P. E.

Respectfully submitted,

Clair A. Waite, P. E.

EXPLORATION
AND
TESTING

Exploration

Field exploration was performed using a truck-mounted rotary drilling machine equipped with hollowstem augers. Standard penetration testing was performed through our hollowstem auger, which serves as casing. The soils were continuously logged by an engineer or geologist and classified by visual examination in accordance with ASTM D2487, which is a modified version of the Unified Soil Classification System.

Samples of soils were taken at frequent intervals in the boring excavation. Disturbed samples were normally taken by the standard penetration test. This test is made by driving a 2 inch O.D. split-spoon sampler 18 inches into the soil by striking it with a 140 pound hammer dropping 30 inches. The total number of blows required to advance the sampler the second and third 6-inch increments is the standard penetration resistance.

Laboratory Classification and Physical Properties Testing

All samples taken during the field investigation were reclassified in the laboratory by an experienced person other than the one who made the field classification. Representative samples were then selected for moisture content, grain size distribution and Atterberg Limit tests to aid confirmation of both the field and laboratory visual classifications. These physical properties tests can also provide useful empirical information about the engineering properties of the materials when the nature of the soils or the size of the project do not warrant additional complicated testing. Typically, the results of these tests are used to select additional samples for strength, compressibility, or permeability tests.

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/ The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage,* to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

Chen-Northern, Inc.
A member of the HIH group of companies

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 - 83
(Based on Unified Soil Classification System)

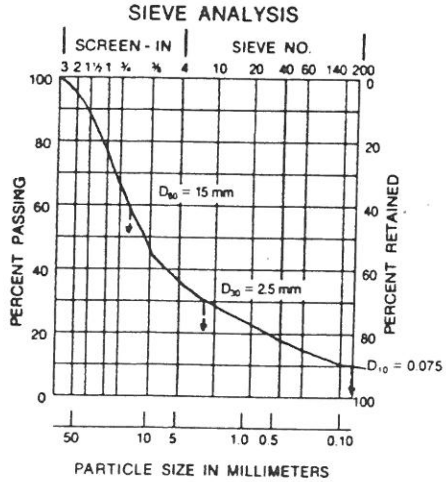
Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well graded gravel[F]
			Cu<4 and/or 1>Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and/or 1>Cc>3[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

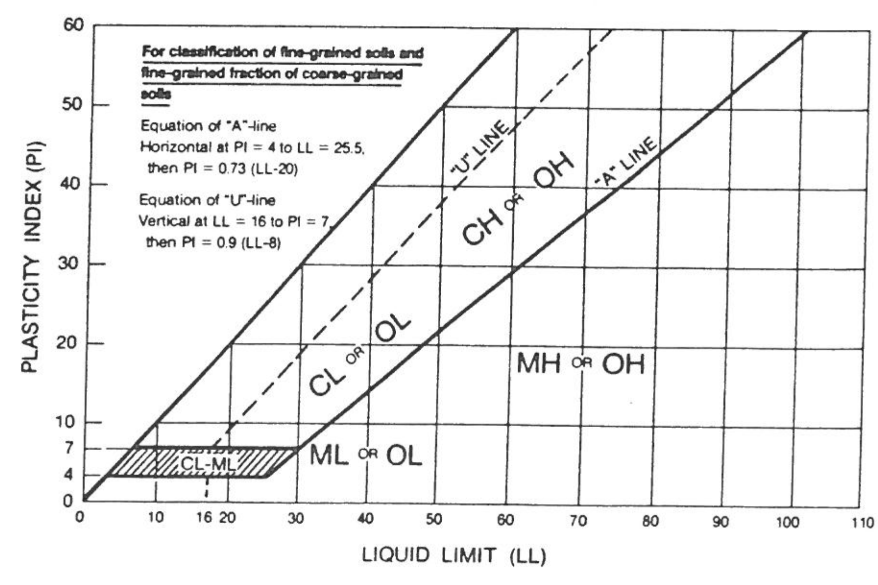
[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI≥4 and plots on or above "A" line.
[O] PI<4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



$C_U = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$



Chen-Northern, Inc.

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LOG OF EXPLORATION BORING

PROJECT: Ketchum Sewage Treatment Plant Addition
Ketchum, Idaho

JOB NO.: 90-1303

DRILL TYPE: SOIL CME 75 - hollowstem augers

ROCK

DRILLED BY: E. Kelly

LOGGED BY: C. Waite

REMARKS: *Referenced to TBM, floor elevation at back of control building, assumed elevation = 5728.0

HOLE NO. B-1

SHEET 1 OF 1

LOCATION: NE corner, proposed pump station
See Drawing No. 90-1303-1

ELEVATION: TOP OF HOLE 5733.3*

GROUNDWATER None

DATE: HOLE STARTED 1/23/90

COMPLETED 1/23/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	LL %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		FILL, silty GRAVEL with sand; medium dense to dense, moist, brown with cobbles.	LSS	30/.0								
3.7		Silty SAND; medium dense, moist, poorly graded, fine grained, scattered small gravels in upper part, nonplastic, brown, (SM).	LSS	12	13							
			SSS	80/.8								
6.5		Poorly to well graded GRAVEL with clay, sand, and cobbles; very dense, moist, subrounded, percentage of fines varies, brown, (GP-GC).										
10			LSS	64	9				48	40	12	
				See Figure 1 for additional test data								
			LSS	104								
			SSS	93/.8								
18.8		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT: Ketchum Sewage Treatment Plant Addition, Ketchum, Idaho
JOB NO.: 90-1303
DRILL TYPE: SOIL CME 75 - hollowstem augers
ROCK
DRILLED BY: E. Kelly
LOGGED BY: C. Waite
REMARKS: *Referenced to TBM, floor elevation at back of control building, assumed elevation = 5728.0

HOLE NO. B-2
SHEET 1 OF 2
LOCATION: SE corner, proposed pump station
See Drawing No. 90-1303-1
ELEVATION: TOP OF HOLE 5733.0*
GROUNDWATER 5713.0
DATE: HOLE STARTED 1/23/90
COMPLETED 1/23/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		FILL, lean CLAY with sand; stiff, moist to slightly moist, low to moderate plasticity, brown, with gravel.	Bag									
			LSS	78/.8								
2.5		FILL, clayey GRAVEL with sand and cobbles; very dense, slightly moist, brown.										
			LSS	60								
5.7		Silty SAND; loose, slightly moist, poorly graded, fine to medium grained, scattered small gravels (1" minus) in upper part of layer, nonplastic, brown, (SM).	SSS	7	11							
			STS		12		G	NP	4	55	4	1
			See Figures 2 and 3 for additional test data									
9.5		Poorly graded GRAVEL with sand and cobbles; very dense, slightly moist, with some clay fines, brown, (GP).	LSS	76								
15			SSS	76/.8								
20.0		GWL: (1/23/90)										

LOG OF EXPLORATION BORING

JOB NO. 90-1303 HOLE NO. B-2 SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
20.0		Poorly graded GRAVEL with sand and cobbles; very dense, saturated, with some clay fines, brown, (GP).	SSS	50								
			SSS	24								
26.2		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT: Ketchum Sewage Treatment Plant Addition
Ketchum, Idaho
JOB NO.: 90-1303
DRILL TYPE: SOIL CME 75 - hollowstem augers
ROCK
DRILLED BY: E. Kelly
LOGGED BY: C. Waite
REMARKS:

HOLE NO. B-3
SHEET 1 OF 1
LOCATION: West of proposed thickener
See Drawing No. 90-1303-1
ELEVATION: TOP OF HOLE 5725.2
GROUNDWATER None
DATE: HOLE STARTED 1/22/90
COMPLETED 1/22/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		Sandy SILT with gravel; (ML).										
0.5		Poorly graded GRAVEL with silt and sand; dense, slightly moist, (GM).										
1.5		Poorly graded GRAVEL with sand and cobbles; very dense, slightly moist, with some clay fines, brown, (GP).	LSS	50/.4								
5.4		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT:	Ketchum Sewage Treatment Plant Addition Ketchum, Idaho	HOLE NO.	B-4
JOB NO.:	90-1303	SHEET	1 OF 2
DRILL TYPE: SOIL	CME 75 - hollowstem augers	LOCATION:	S side of proposed thickener See Drawing No. 90-1303-1
ROCK		ELEVATION: TOP OF HOLE	5725.4
DRILLED BY:	E. Kelly	GROUNDWATER	5709.5
LOGGED BY:	C. Waite	DATE: HOLE STARTED	1/22/90
REMARKS:		COMPLETED	1/22/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		Silty SAND with gravel; medium dense, moist, (SM).	Bag									
1.5		Poorly graded GRAVEL with sand and cobbles; dense to very dense, slightly moist to saturated, brown, (GP).	LSS	51/.5	4							
10		Fewer large cobbles below approximately 11.0 feet, maybe interbedded gravelly sand layers.	LSS	84	6							
			LSS	49								
15.9		GWL: (1-22-90)										
20												

LOG OF EXPLORATION BORING

JOB NO. 90-1303 HOLE NO. B-4

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
20		Poorly graded GRAVEL with sand; medium dense to very dense, saturated, less dense and easier drilling than above, brown, (GP).	SSS	31								
			LSS	62								
26.0		BOTTOM OF HOLE										

Chen-Northern, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Ketchum Sewage Treatment Plant Add

Location: B-1, 9.5 - 11.0 feet

Classification (ASTM D2488) Well graded GRAVEL with silt and sand

Moisture Content 9 %

Liquid Limit ______ %

Sample No. ______

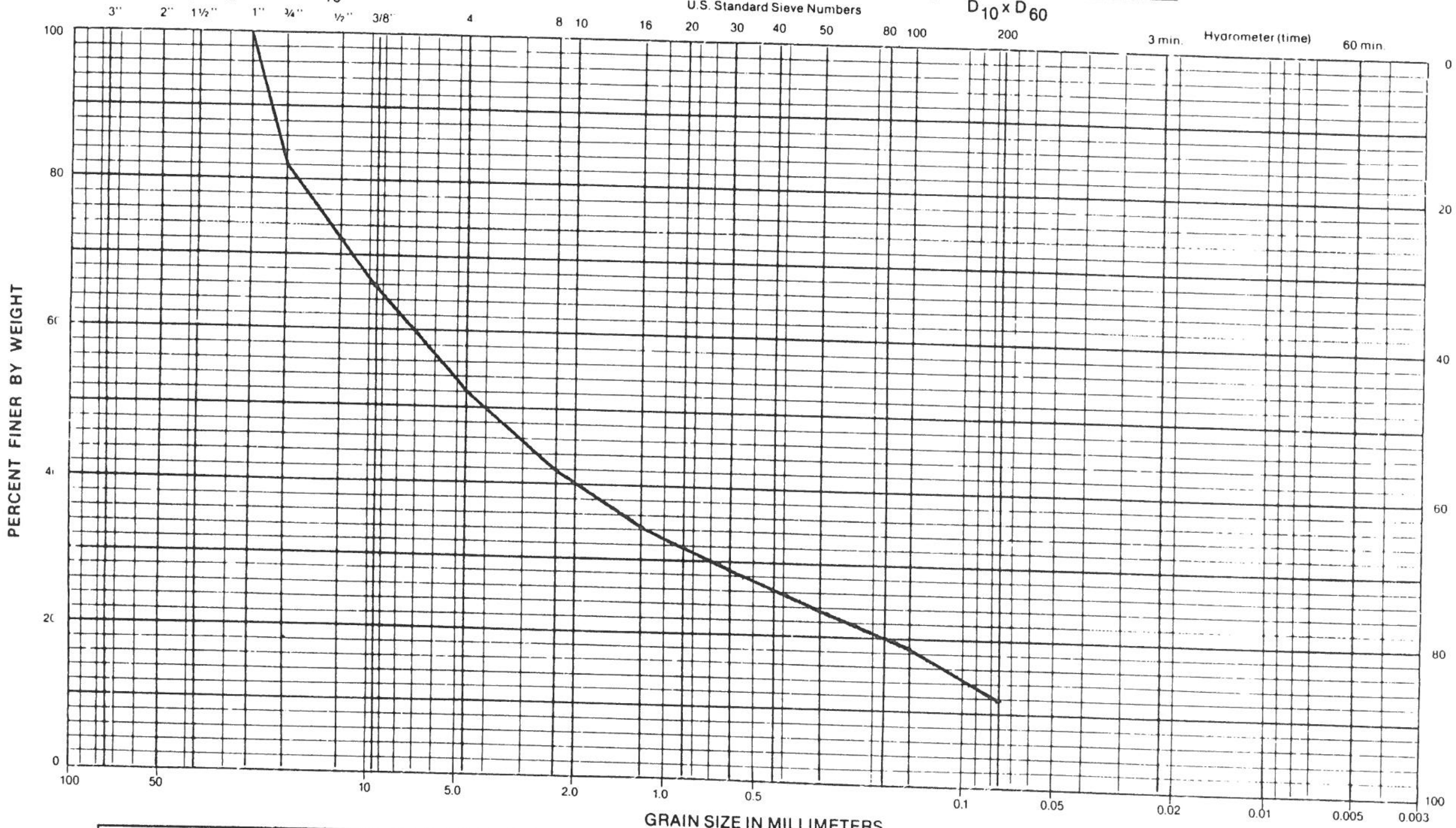
Job No. 90-1303

Date 1-29-90

Plasticity Index ______ %

Coefficient of Uniformity $= C_U = \frac{D_{60}}{D_{10}} =$ ______

Coefficient of Curvature $= C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}} =$ ______



Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Figure 1

(Rev. 1/89) CNI-105

Chen-Northern, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Ketchum Sewage Treatment Plant Add

Location: B-2, 7.0 - 9.0 feet

Classification (ASTM D2487) Silty SAND

Moisture Content 12 %

Liquid Limit -- %

Sample No. ______

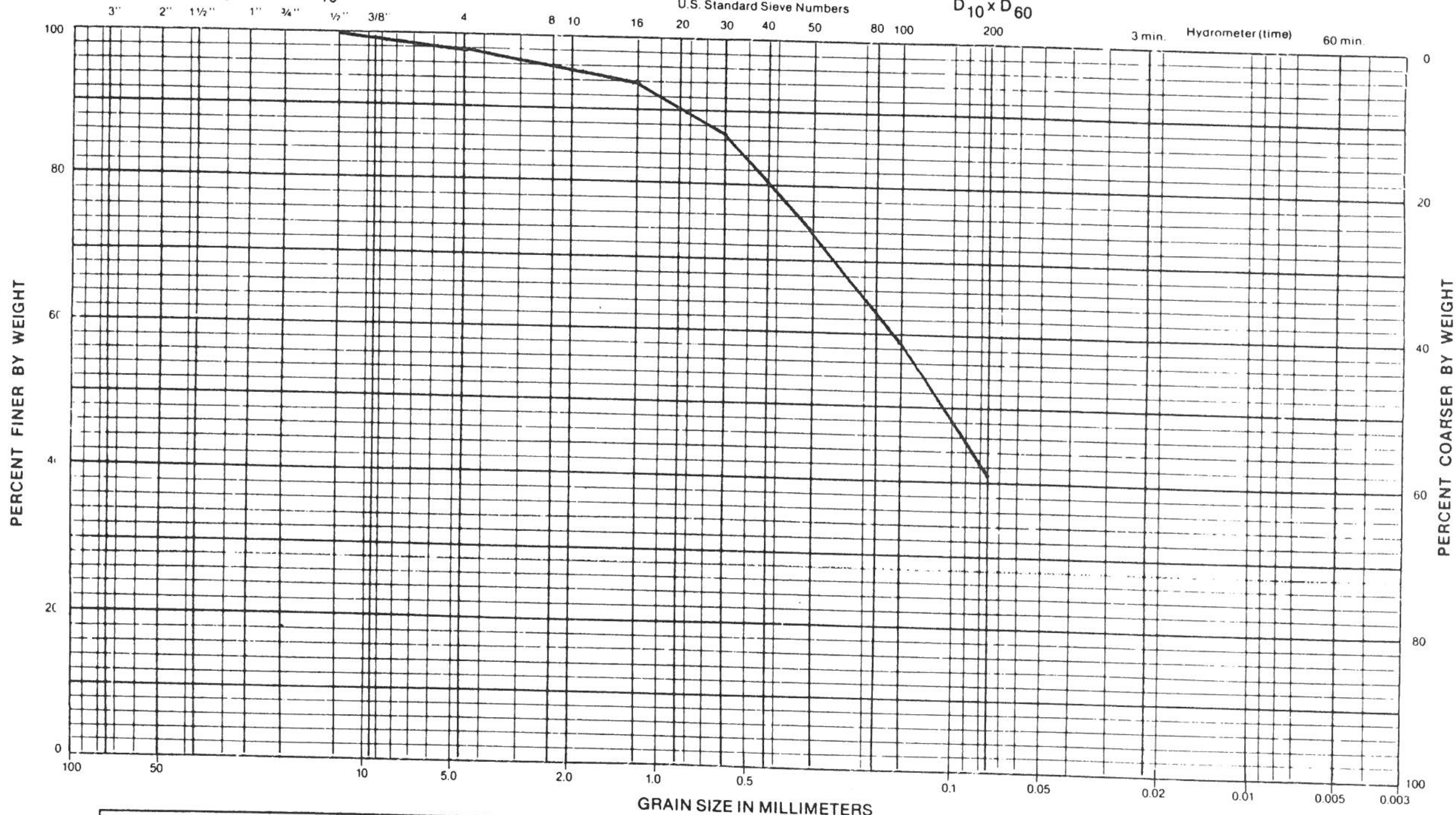
Job No. 90-1303

Date 1-29-90

Plasticity Index Nonplastic %

Coefficient of Uniformity $= C_U = \frac{D_{60}}{D_{10}} =$ ______

Coefficient of Curvature $= C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}} =$ ______



Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

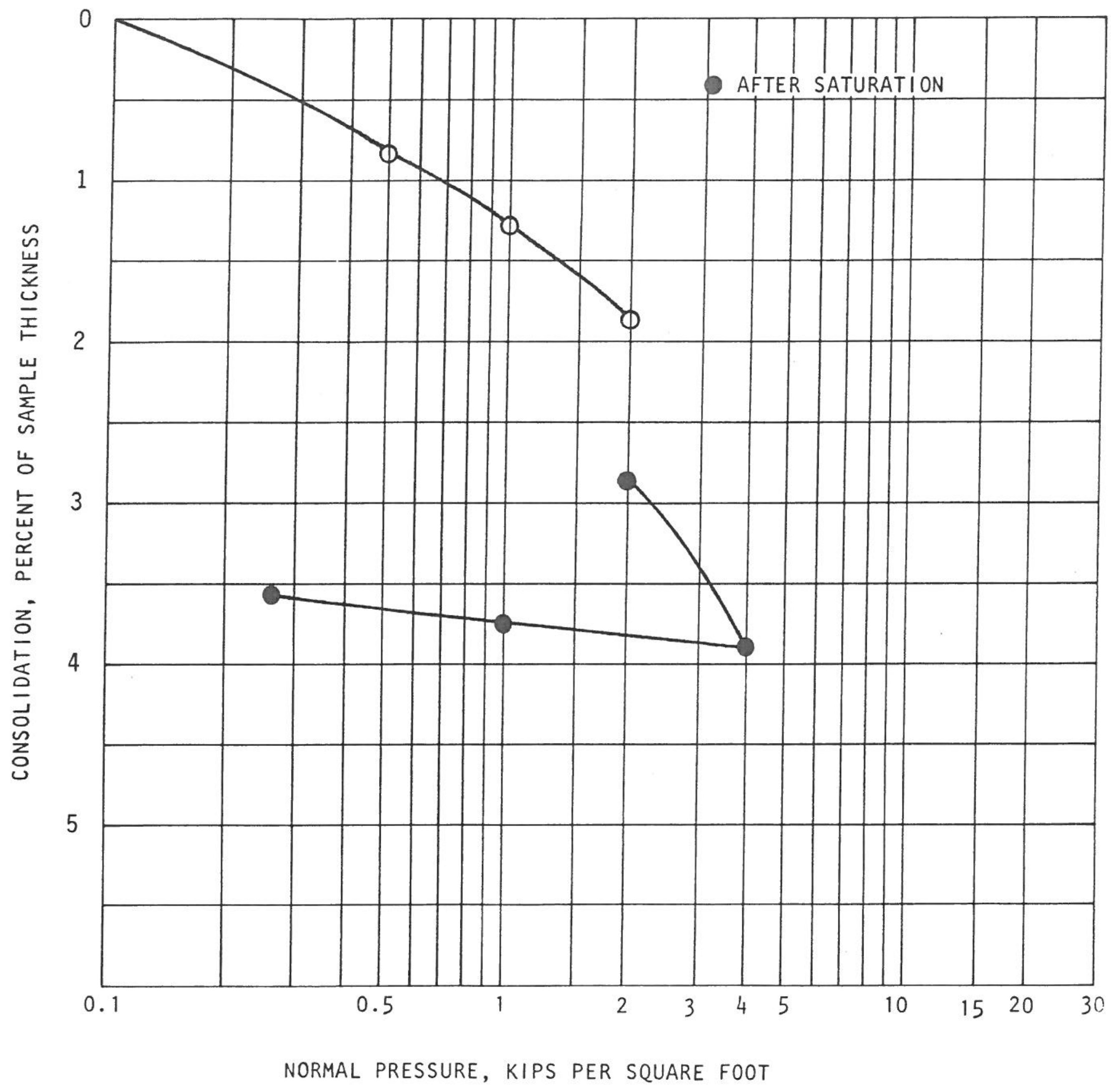
Figure 2

(Rev. 1/89) CNI-105

CONSOLIDATION TEST

DRILL HOLE B-2
DEPTH 7.0 - 9.0 feet
SAMPLE NO.
TRIMMED UNDISTURBED SAMPLE

MOIST UNIT WEIGHT : 103 pcf
DRY UNIT WEIGHT : 92 pcf
INITIAL MOISTURE CONTENT: 12%
FINAL MOISTURE CONTENT : 18%
CLASSIFICATION : Silty SAND



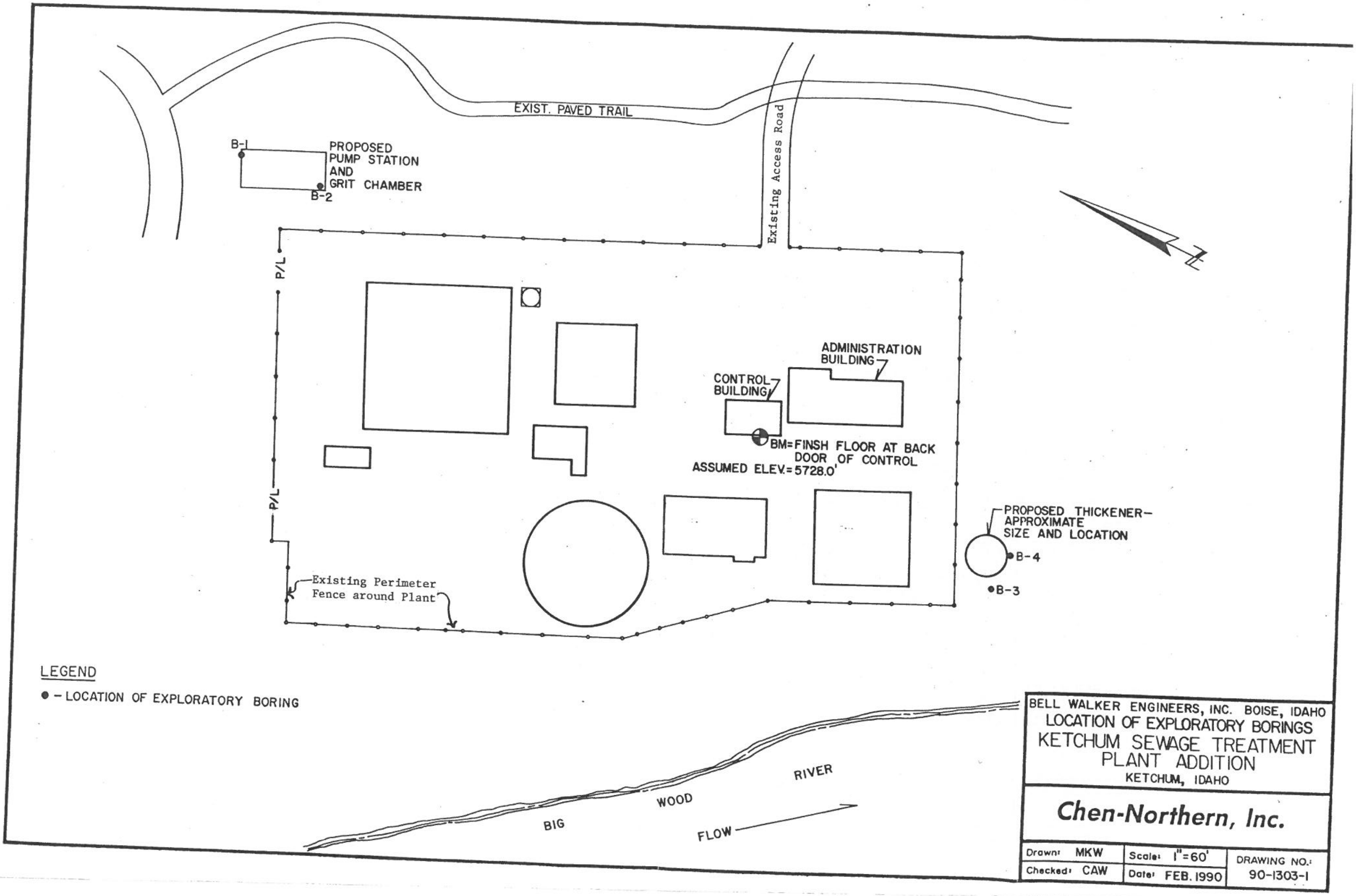
Bell Walker Engineers
Boise, Idaho

Ketchum Sewage Treatment Plant Additions
Ketchum, Idaho

Northern Engineering and Testing, Inc.

Job No. 90-1303 Figure 3

NET 156


EXIST. PAVED TRAIL
Existing Access Road
B-1
PROPOSED PUMP STATION AND GRIT CHAMBER
B-2
P/L
P/L
ADMINISTRATION BUILDING
CONTROL BUILDING
BM=FINSH FLOOR AT BACK DOOR OF CONTROL
ASSUMED ELEV.=5728.0'
PROPOSED THICKENER– APPROXIMATE SIZE AND LOCATION
B-4
B-3
Existing Perimeter Fence around Plant
LEGEND
● – LOCATION OF EXPLORATORY BORING
BIG WOOD RIVER
FLOW
BELL WALKER ENGINEERS, INC. BOISE, IDAHO
LOCATION OF EXPLORATORY BORINGS
KETCHUM SEWAGE TREATMENT PLANT ADDITION
KETCHUM, IDAHO
Chen-Northern, Inc.
Drawn: MKW
Checked: CAW
Scale: 1"=60'
Date: FEB. 1990
DRAWING NO.: 90-1303-1