GEOTECHNICAL EVALUATION

BRIDGE N214 REPLACEMENT
ROAD N5001
TOADLENA, NEW MEXICO
JOB NO. 3121JC100

Western Technologies Inc.
The Quality People
Since 1955

FARMINGTON – NEW MEXICO
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Prepared for:

BIA ROADS

March 6, 2002

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BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS
State of New Mexico
7864
Lawrence E. Cynova
3-6-02

Lawrence E. Cynova, P.E.
Geotechnical Engineer

Candice Mumm for
Craig P. Wiedeman, P.E.
Principal

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March 6, 2006

Bureau of Indian Affairs, Navajo Area Office
Branch of Contracts and Property Management
P.O. Box 1060
Gallup, New Mexico 87305

Attn: Mr. Corwyn Henry, P.E.

Re: Geotechnical Evaluation
Bridge N214 Replacement
Toadlena, New Mexico

Job No. 3121JC100

Western Technologies Inc. has completed the geotechnical evaluation for the proposed replacement of the existing bridge located southeast of Toadlena, New Mexico. This study was performed in general accordance with our proposal number 3121PC041 dated April 26, 2001 and with Indefinite Quantity Contract No. CMN00001100. The results of our study, including the boring location diagram, laboratory test results, boring logs, and the geotechnical recommendations are attached.

We have appreciated being of service to you in the geotechnical engineering phase of this project and are prepared to assist you during the construction phases as well. If design conditions change, or if you have any questions concerning this report or any of our testing, inspection, design and consulting services, please do not hesitate to contact us. We look forward to working with you on future projects.

Sincerely,
WESTERN TECHNOLOGIES INC.
Geotechnical Engineering Services

Lawrence E. Cynova, P.E.

Copies to: Addressee (3)

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GEOTECHNICAL EVALUATION
BRIDGE N214 REPLACEMENT
TOADLENA, NEW MEXICO
JOB NO. 3121JC100

1.0 PURPOSE

This report contains the results of our geotechnical exploration for the proposed replacement of the existing bridge over Captain Tom Wash which is located southeast of Toadlena, New Mexico. The purpose of these services is to provide information and recommendations relative to foundation design, lateral earth pressures and site preparation.

2.0 PROJECT DESCRIPTION

Project information supplied by Mr. Corwyn Henry on November 26, 2001, indicates the proposed bridge will be 35.878 meters (117.7 feet) long and 7.6 meters (26.1 feet) wide. The bridge will be two span with prestressed concrete Type 45 AASHTO beams, made continuous for live load, with a 210 mm thick cast in place concrete deck. It is understood that the bridge grade will be located about 6 meters (19.68 feet) above the existing wash bottom. The new structure centerline is to be constructed slightly less than 1 meter north of the existing wood bridge centerline. The preliminary scour analysis performed by others indicated that the maximum scour depths at each abutment and the center pier will extend down to the rock. The abutment and pier loads are as follows:

Imperial Units									
	DL	LL - Case 1				LL - Case 2			
	P	P	I_p	M_T	I_M	P	I_p	M_T	I_M
Abutments	285k	115.4k	34.6k	93.5k-ft	28.1 k-ft	57.7k	17.3k	392.9 k-ft	117.9 k-ft
Pier	422.8k	143.8k	43.1k	116.5 k-ft	35.0 k-ft	71.9k	21.6k	489.6 k-ft	146.9 k-ft
SI Units									
	DL	LL - Case 1				LL - Case 2			
	P	P	I_p	M_T	I_M	P	I_p	M_T	I_M
Abutments	1267.7 kN	513.3 kN	153.9 kN	126.7 kN-m	38.1 kN-m	256.6 kN	77.0 kN	532.7 kN-m	159.8 kN-m
Pier	1880.6 kN	639.6 kN	191.9 kN	157.9 kN-m	47.4 kN-m	319.8 kN	96.1 kN	663.4 kN-m	199.0 kN-m

Legend:

DL: Dead Load
LL: Vehicular live load (HS-20-44/MS-18)
I_r Impact for vertical load, P (30%)
I_M Impact for transverse moment, M_T (30%)
F_I Vertical reaction for entire substructure unit.
M_T: Moment about transverse axis of structure (strong axis of substructure unit).
Case 1: Vehicle loading for maximum vertical reaction.
Case 2: Vehicle loading for maximum transverse moment.

Conversion Factors:

1kN = 4.448k
1KN-m = 1.355 k-ft

3.0 SCOPE OF SERVICES

3.1 Field Exploration

Six borings were drilled to depths ranging from about 9.2 to 13.8 meters (30 to 45 feet) below existing site grades in proposed pier and abutment areas. The borings were at the approximate locations shown on the attached boring location diagram. Final logs, included in Appendix A, represent our interpretation of the field logs and include modifications based on laboratory observations and tests of the field samples. The final logs describe the materials encountered, their thicknesses, and the locations where samples were obtained.

The Unified Soil Classification System was used to classify soils. The soil classification symbols appear on the boring logs and are briefly described in Appendix A

3.2 Laboratory Analyses

Laboratory analyses were performed on representative samples to aid in material classification and to estimate pertinent engineering properties of the on-site materials for preparation of this report. Testing was performed in general accordance with applicable ASTM specifications. The following tests were performed and the results are presented in Appendix B.

- Water content
- Proctor (Maximum Density/Optimum Moisture)
- Shear strength

- Gradation
- Plasticity
- Resistivity & pH
- Rock compressive strength
- Soluble salts and sulfates

3.3 Analyses and Report

This report is for the exclusive purpose of providing geotechnical engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken. We are available to discuss the scope of such studies with you.

4.0 SITE CONDITIONS

4.1 Surface

The site has an existing old wood bridge located at the site of the proposed bridge. At the time of exploration, the wash was dry except for a pool of water located about 30 meters upstream. The site is located in a small valley which slopes downward to the east/northeast. Sandstone is outcropping at the east abutment. The existing road and bridge were built in the early 1970's. The existing bridge has been bypassed and a culvert is now used for the crossing. The Two Grey Hills Chapter House is located about 1-1/2 kilometers east of the site.

4.2 Subsurface

As presented on Logs of Borings, surface soils to depths of about 1.9 to 2.7 meters (6.2 to 9 feet) in all borings consisted of silty sand/cobbles and silty sand of low to medium density and none to low plasticity. The materials underlying the soils in all borings and extending to the full depths of exploration are soft to moderately hard coal, shale, siltstone and sandstone.

4.3 Groundwater

No groundwater was encountered in Borings 1, 5 and 6 at the time of exploration. Groundwater was encountered in Borings 2, 3 and 4 at depths of 0.6 to 1.5 meters (2 to 5 feet) below existing site grades. The groundwater levels presented represented only current condtions. Groundwater levels during and after construction may fluctuate due to seasonal variations, adjacent construction or development, flow conditions in the wash, and other factors.

4.4 Geology

The proposed roadway is located in alluvial deposits of soil, as well as the partially consolidated alluvial material at the bridge site. Underlying the soils, the rock consists of the Menefee Formation which is underlain by the Point Lookout Sandstone.

5.0 GEOTECHNICAL PROPERTIES AND ANALYSIS

Consolidation tests were not possible due to the amount of gravel in the soil, but past experience would indicate that the soils are low to moderately compressible at existing water contents. Low to moderate additional compression could occur when the water content is increased. Near surface soils are of low plasticity. Test results are presented on Plates B-1 through B-3.

Based on the results of laboratory testing, design values utilized in the analysis were:

BORING No.	DEPTH (Meters)	TOTAL UNIT WEIGHT (Kg/m^3)	ANGLE OF INTERNAL FRICTION (Degrees)	COHESION (kPa)
1	1.5-1.9	1826	31	9.58
4	0-0.9	1826	38	4.79

6.0 RECOMMENDATIONS

6.1 General

Recommendations contained in this report are based on our understanding of the project criteria described in Section 2.0, Project Description, and the assumption that the soil and subsurface conditions are those disclosed by the borings. Others may change the plans, final elevations, number and type of structures, foundation loads, and deck level during design or construction. Substantially different subsurface conditions from those described herein may be encountered or become know. Any changes in the project criteria or subsurface conditions shall be brought to our attention in writing.

6.2 Foundations

Because of variations in the nature and of the depth of bearing materials, preliminary scour depths, the presence of water in some of the borings, structural loads and possible final grades, we considered the following alternate foundation systems:

- Spread footings bearing on sandstone
- Driven H-piles into sandstone
- Drilled shafts designed for friction and end bearing into sandstone

The spread footings and deep foundation alternatives for support of the bridge abutments are comparable in terms of performance from a geotechnical standpoint. However, our services did not include a cost study. Therefore, we do not know which of the possible foundations alternatives would be most economical. We recommend that the client and his design consultant team evaluated the design criteria presented herein, discuss the various alternatives with a knowledgeable foundation contractor and then prepare a detailed cost study or receive bid alternates to determine which system would be the most appropriate.

6.2.1 Spread Foundations

Sandstone is located at a shallow depth below the existing bridge. Spread footings could be used to support the bridge abutments and center pier when the depth to sandstone is less than about 3 to 5 meters (10 to 16.5 feet). Spread footings should be founded a minimum of 1 meter (3 feet) into the existing undisturbed, dense sandstone/siltstone.

An allowable bearing capacity of 479 kPa (10,000 pounds per square foot) should be used in proportioning the footings. Footings should bear a minimum of 1 meter (3 feet) into dense sandstone.

Estimated movement for shallow spread footings bearing on undisturbed sandstone/siltstone are less than 1 centimeter (0.4 inch).

The allowable bearing capacity applies to dead loads plus design live load conditions. The allowable bearing capacity may be increased by one-third when considering total loads that include wind or seismic forces.

Dewatering may be required at abutment and pier locations.

6.2.2 H-piles

H-piles may be used to support the bridge (particularly the south abutment), with the piles extending down into dense sandstone encountered in the borings at depths ranging from about 6 to 10 meters (20 to 32 feet) below existing site grades. Where the rock is shallow, predrilling the pile locations will be required to obtain a minimum depth of about 1.5 meters into hard sandstone which is about 7 to 11 meters (23 to 36 feet) below existing grade.

The allowable bearing capacity of H-piles bearing in dense sandstone can be calculated as:

$$Pa = Ap\ Fs$$

Where:

Ap = cross-sectional area of pile

Fs = allowable steel stress, 0.25 fy of 36 ksi

Fy = yield strength of steel

Examples of axial capacities for three sizes of steel H-piles are presented on the following table:

Pile	Axial Capacity (kN)
HP 10x42	490
HP 12x53	620
HP 14x73	860

Final allowable capacities of pile foundations should be determined in the field during construction, using an appropriate dynamic driving formula and/or testing apparatus. A driving hammer compatible with the size and type of the specified piles should be used. We recommend a hammer delivering a minimum rated energy of 20,335 jules (15,000 foot-pounds). All pile driving equipment should be approved before use.

The group capacity of piles supported on sandstone is the number of piles times the Individual capacity of each pile.

Due to the presence of hard sandstone and uneven sandstone surfaces, the use of reinforced heavy-duty pile tips is recommended to properly embed the piles into the dense sandstone.

6.2.3 Drilled Shafts

Drilled shafts designed in side friction and end bearing in the sandstone could be used to support the bridge structure. The shafts should extend to a minimum of about 7 to 12 meters (23 to 39.5 feet), Boring 1 to a minimum of 9 meters (29.5 feet), Boring 2 to a minimum depth of 11.5 meters (38 feet), Boring 3 to a minimum of 7 meters (23 feet), Boring 4 to minimum depth of 9 meters (29.5 feet), Boring 5 to a minimum depth of 12 meters (39.5 feet) and Boring 6 to a minimum depth of 11 meters (36 feet), below the ground surface and to a minimum of 2.5 meters (8.2 feet) into dense rock. The ultimate capacities of drilled shafts having different areas are presented in Plate 4. The weight of the shaft should be considered as part of the total load. A minimum factor of safety of 2.5 was used during calculations. Due to the presence of hard sandstone and uneven sandstone surfaces, some difficulty may be encountered in keeping the shaft alignment vertical when encountering the top of the sandstone. Capacities of other pile types of sizes can be provided, if requested. The design capacity is for dead plus live loads. A one-third increase may be used when considering wind or seismic loads.

Estimated settlements for drilled shafts are 1 centimeter or less for maximum anticipated loads.

Shafts in groups should be spaced at least three diameters on centers. There will be no reduction in the downward capacities of the shafts due to group action if the shafts are spaced as recommended. Shafts in groups should be drilled and filled alternately, allowing the concrete to set at least eight hours before drilling an adjacent shaft. Shaft excavations should not be allowed to stand open overnight, concrete should be placed as soon as possible after inspection.

Protective steel casing will be required to hold the excavation open, particularly when ground water is encountered. The casing should be removed as the concrete is placed. However, the protective steel casing should not be removed until the concrete is above the groundwater level and any caving sandy soil. A minimum head of 3 meters (10 feet) of concrete should be maintained above the bottom of the casing during withdrawal and should prevent concrete from "hanging-up" inside the shell which can cause soil and water intrusion below the casing. A bentonite slurry may be required where water and sand are flowing into the shaft excavations.

We recommend that the concrete be placed into the drilled shaft through a tremie pipe. The concrete should be maintained above the bottom of the tremie pipe, so the water will be forced out the top of the hole during concrete placement.

Piles in groups at an abutment or pier should be spaced at least 3 diameters apart (3B). The individual capacity of each pile should be reduced by a factor of s times the total capacity for an individual pile, where s = 0.67 for a center-to-center (CTC) spacing of 3B and s = 1.0 for a CTC spacing of 7B or larger. For intermediate shaft spacing, the value of s may be determined by linear interpolation between the given values.

6.3 Lateral Design Criteria

Lateral load criteria was developed from data outlined in "Documentation of Computer Program COM624, Part 1, Analysis of Stresses and Deflection for Laterally-Loaded Piles including Generation of p-y Curves" August 1980, by Lymon C. Reese and W. Randall Sullivan. To satisfy forces in the horizontal direction, piles should be designed for lateral loads using the following parameters:

Location	Material Type	Unit Weight Kg/m^3	Horizontal Subgrade Reaction kPa/m
Abutments And Piers	Sand	1003	21,693
Abutments And Piers	Sandstone	1083	135,709

Due to potential scour of the subgrade materials, resistance to lateral loads should be neglected within the calculated scour zone. Once the final scour analysis has been performed and more detailed information regarding the type of foundations selected becomes available, a lateral analysis should be conducted. We are able to assist you in this matter, if requested.

The lateral pressures appropriate for design of the abutments and appurtenant structures will be a function of the type of material used as backfill, the type of undisturbed soils, and the magnitude of lateral movement permitted to occur in the abutments and appurtenant structures. For cantilevered walls above any free water surface with level backfill and no surcharge loads, recommended equivalent fluid pressures and coefficients of base friction for unrestrained elements are:

- Active:
  Undisturbed subsoil.. 5.5 kPa/m (35 psf/ft)
  Compacted granular backfill... 4.7 kPa/m (30 psf/ft)

Compacted site soils (non-clay) .... 5.5 kPa/m (35 psf/ft)

- Passive:
  Shallow wall footings .... 39 kPa/m (250 psf/ft)

- Coefficient of base friction 0.40*

  * The coefficient of base friction should be reduced to 0.30 when used in conjunction with passive pressure.

Where the design includes restrained elements, the following equivalent fluid pressures are recommended:

- At-rest:
  Undisturbed subsoil .... 9.4 kPa/m (60 psf/ft)
  Compacted granular backfill .... 8.6 kPa/m (55 psf/ft)

The equivalent fluid pressures presented herein do not include the lateral pressures arising from the presence of:

- hydrostatic conditions due to submergence or partial submergence
- positively or negatively sloping backfill
- permanent or temporary point surcharge loading
- seismic or dynamic conditions

In regard to the abutments, wheel loads transmitted to the backfill immediately behind the walls will result in increasing the lateral earth pressures. An allowance for this increase in earth pressure should be included in the analysis and design of the abutments. This can be accomplished by assuming that the wheel loads are equivalent to a uniformly distributed loads. The uniform surcharge is then converted to an additional thickness of backfill by dividing this value by the unit weight of the backfill. The unit weight of the undisturbed soils can be estimated as 1600 kg/m^3 (100 pounds per cubic foot). The unit weight of compacted granular backfill can be estimated to be 1698 kg/m^3 (106 pounds per cubic foot).

If heavily reinforced portland cement concrete approach slabs are constructed on and adjacent to the abutments, the allowance for additional lateral earth pressure caused by wheel loads may be neglected. These slabs should extend a minimum of 4.6 meters (15 feet) beyond the abutments. The principal purpose of such construction is to provide a slab with sufficient strength to transfer wheel loads to the abutments.

We recommend a free-draining soil layer or manufactured geosynthetic material be constructed adjacent to the back of the abutment walls. A filter may be required between the road embankment material and drainage material next to abutment wall. This drainage zone should help prevent development of hydrostatic water pressure on the wall. The vertical drainage zone should be tied into a gravity drainage system at the base of the wall. In lieu of a drainage layer, weep holes should be provided for draining any water that could accumulate in the backfill or native soils. Weep holes should have a maximum spacing of 3.1' meters (10 feet). It is important that all backfill be properly placed and compacted. Backfill should be mechanically compacted in layers. Flooding or jetting should not be permitted. Care should be taken not to damage the walls when placing the backfill. Backfill should be observed and tested during placement.

Fill against footings, stem walls, and retaining walls should be compacted to densities specified in the "Earthwork." Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors. Overcompaction may cause excessive lateral earth pressures which could result in wall movements.

6.4 Seismic Considerations

Seismic design criteria are based upon the 1996 AASHTO "Standard Specifications for Highway Bridges" with interims through 2000, Based upon the nature of the subsurface material and the horizontal acceleration map included in Section 3, we recommend using an Acceleration Coefficient (A) of 0.02. This value should be used in conjunction with Figure 3 in the 1996 AASHTO Standard Specifications for Highway Bridges. In addition, we recommend using a site coefficient (S) value of 1.0 and a Seismic Performance Category (SPC) of A.

6.5 Drainage

In order to maintain stability of the roadway and the approaches adjacent to the bridge structure, positive drainage should be provided during construction and maintained throughout the life of the proposed roadway. Water should not be allowed to pond at the base of the embankments.

6.6 Corrosivity

We recommend a Type II portland cement be used for all concrete on and below grade.

A minimum resistivity value of 730 ohm-cms, a pH value of 8.1 and sulfate value of 10 ppm were determined from laboratory testing of the on-site soils. These results indicate that the on-site soils are considered to exhibit a (moderate) corrosive potential to underground piping. A corrosion allowance is not required for the steel H-piles for current conditions. The information derived from the testing should be used as an aid in choosing the construction materials that will be contacted with these soils and that will need to be resistant to various corrosive forces. Air entrained concrete is used for concrete above ground level, which is less susceptible to freeze/thaw deterioration. It is our opinion that epoxy coated reinforcement is not necessary for the drilled shafts. Manufacturer's representatives should be contacted regarding the specific corrosivity resistance for their particular product.

6.7 Excavation Conditions

The excavations into the surficial soils should be successfully accomplished with conventional equipment. Excavation penetrating the underlying rock will require the use of heavy-duty, specialized equipment, possibly together with drilling and blasting, to facilitate removal. The individual contractors should be responsible for designing and construction of stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored following local and federal regulations, including current OSHA excavations safety standards. All vehicles and soil piles should be kept a minimum lateral distance from the top of the excavation equal to no less than the depth of the excavation.

6.8 Materials

1. Utilities to be moved, should be placed on a minimum of 6 inches of granular bedding materials. Pipe bedding material should conform to Section 209.09, class B of FP-92(96).

2. On-site soils are suitable for use as backfill provided all material over 7.6 centimeters (3 inches) in size is not used within 0.3 meters (1 foot) of the pipe or top of subgrade. Backfill should be compacted to a minimum of 90 percent of the maximum density in non-structural areas and 95 percent of the maximum density in structural areas as determined by AASHTO T-99. Compaction should be accomplished by mechanical methods.

3. Backfill should be constructed in horizontal lifts, using equipment and procedures that will produce recommended water contents and densities throughout the lift. Uncompacted lifts should not exceed 20 centimeters (8 inches).

7.0 EARTHWORK

7.1 General

The conclusions contained in this report for the proposed construction are contingent upon compliance with recommendations presented in this section. Any excavating, trenching, or disturbance which occurs after completion of the earthwork must be backfilled, compacted and tested in accordance with the recommendations contained herein. It is not reasonable to rely upon our conclusions and recommendations if any future unobserved and untested trenching, grading or backfilling occurs.

7.2 Clearing and Grubbing

Clearing and grubbing should be performed in accordance with Section 201 of the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-92(96)", referred hereafter as the "Standard Specifications".

7.3 Removal of Structures and Obstructions

Removal of all existing structures and obstructions should be performed in accordance with Section 203 of the Standard Specifications.

7.4 Excavation, Embankment, and Foundation Preparation

Excavation, bridge approach embankments and foundation preparation should be performed in accordance with Section 204 of the Standard Specifications.

7.5 Structural Excavation and Backfill

Structural excavation and backfill should be performed in accordance with Section 208 of the Standard Specifications.

7.6 Structural Concrete

Structural concrete should conform to Section 552 of the Standard Specifications.

7.7 Driven Piles

Installation of driven piles should be performed in accordance with Section 551 of the Standard Specifications.

7.8 Structural Backfill

Structural backfill should conform to Section 704.04 of the Standard Specificatons.

7.9 Piling

Driven piling materials should conform to Section 715 of the Standard Specificaitons.

7.10 Scour Countermeasures

Rock for scour countermeasures should conform to Section 705 of the Standard Specifications.

7.11 Linear Grading

Linear grading should confirm to Section 212 of the Standard Specifications.

7.12 Aggregate Base Course

Aggregate base course should conform to Section 301 of the Standard Specifications.

8.0 LIMITATIONS

This report has been prepared based on our understanding of the project criteria as described in Section 2.0. Others may make changes in the project criteria during design or construction, and substantially different subsurface conditions may be encountered or become know. The conclusions and recommendations presented herein shall not continue to be valid unless all variations are brought to our attention in writing, and we have has an opportunity to assess the effect such variations may have on our conclusions and recommendations and respond in writing.

The recommendations presented are based upon data derived from a limited number of samples obtained from widely spaced borings. The attached logs are indicators of subsurface conditions only at the specific locations and times noted. The geotechnical engineer necessarily makes assumptions as to the uniformity of the geology and soil structures between borings, but variations can exist. Accordingly, whenever any deviation or change is encountered or become known during design or construction, the conclusions and recommendations presented herein shall not continue to be valid unless WT is notified in writing, has actually reviewed the matter, and has issued a written response.

This report does not provide information relative to construction methods or sequences. Any person reviewing this report must draw his own conclusions regarding site conditions as they relate to the employment or development of construction techniques. This report is valid for one year after the date of issuance unless there is a change in circumstances or discovered variations justifying an earlier expiration of validity. After expiration, no person or entity has any right to rely on this report without further review and reporting by WT under a separate contract.

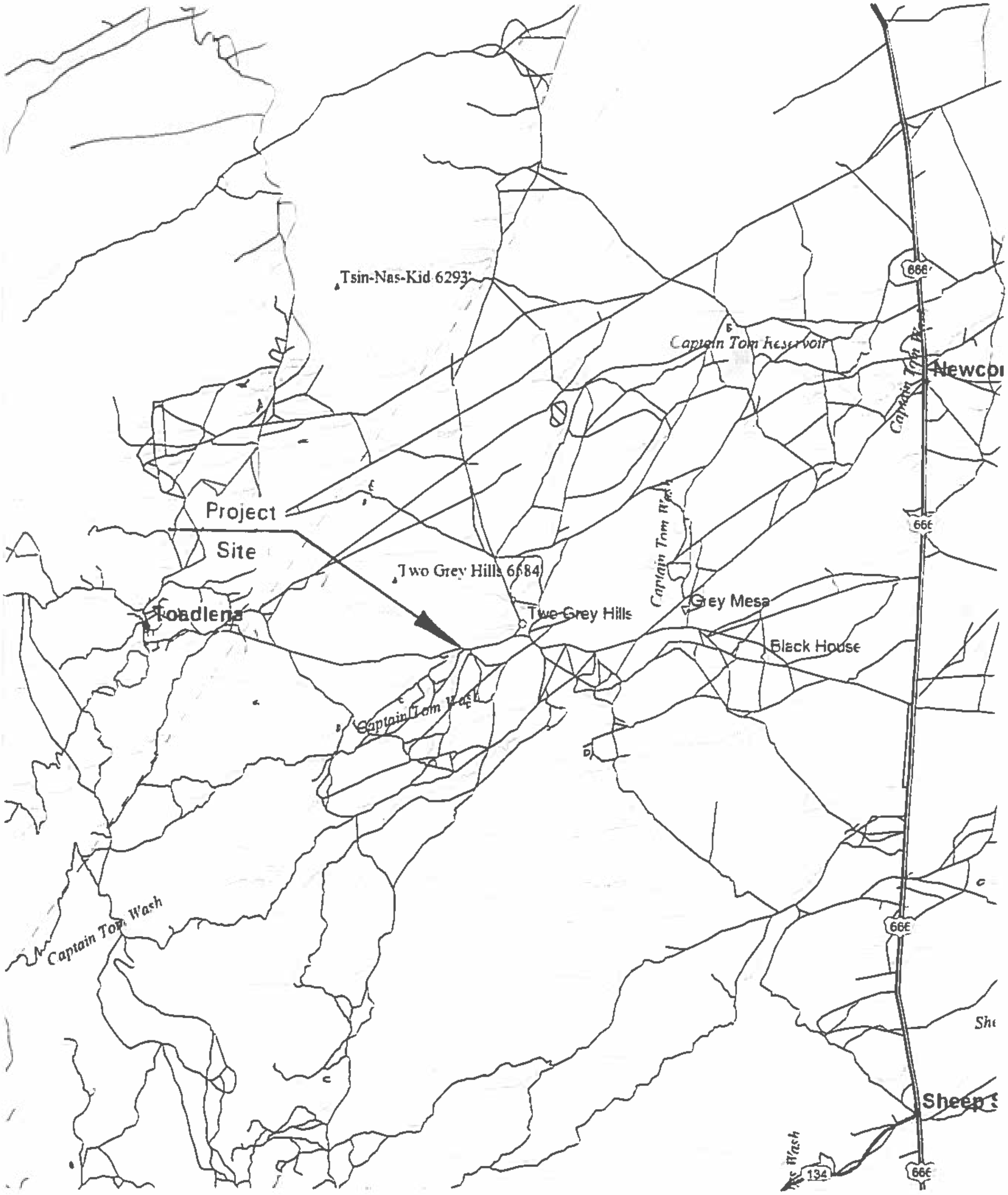
9.0 OTHER SERVICES

The geotechnical engineer should be retained for a general review of final plans and specifications to determine compliance with our recommendations.

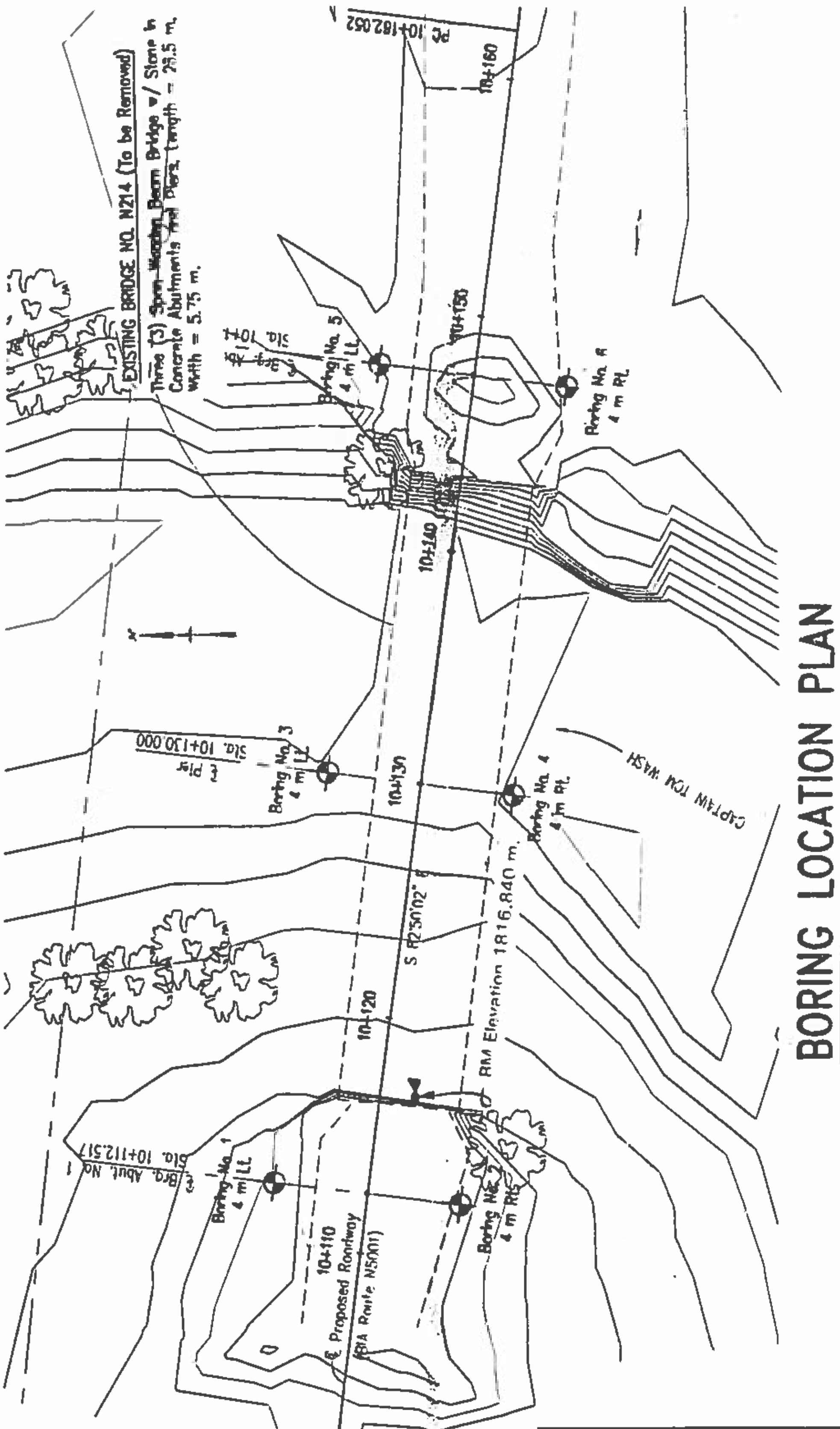
The geotechnical engineer should also be retained to provide observation and testing services during excavation, earthwork operations, and foundation construction phases of the project. Observation of footing excavations should be performed prior to placement of reinforcing and concrete to confirm that satisfactory bearing materials are present.

10.0 CLOSURE

We have prepared this report as an aid to the designers of the proposed project. The comments, statements, recommendations, and conclusions set forth in this report reflect the opinions of the authors. These opinions are based upon conditions at the location of specific tests and observations, and on the data developed to satisfy the scope of services defined by the contract documents. Work on your project was performed in accordance with generally accepted industry standards and practices by professionals providing similar services in this locality. No other warranty, express or implied, is made.



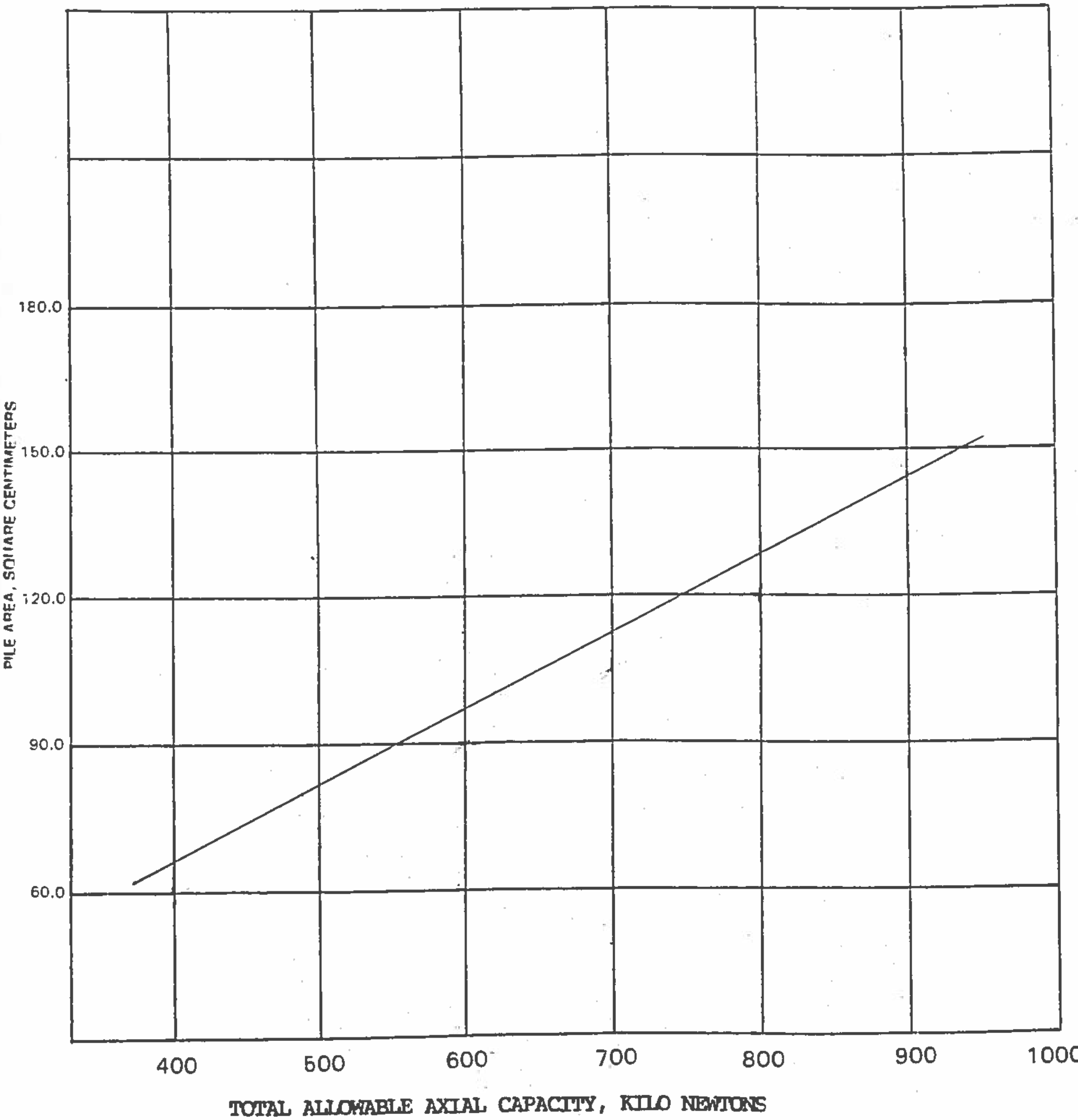
BRIDGE N214 REPLACEMENT	
Vicinity Map	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: 1



LEGEND

- Boring
- ▼ Bench Mark-BM

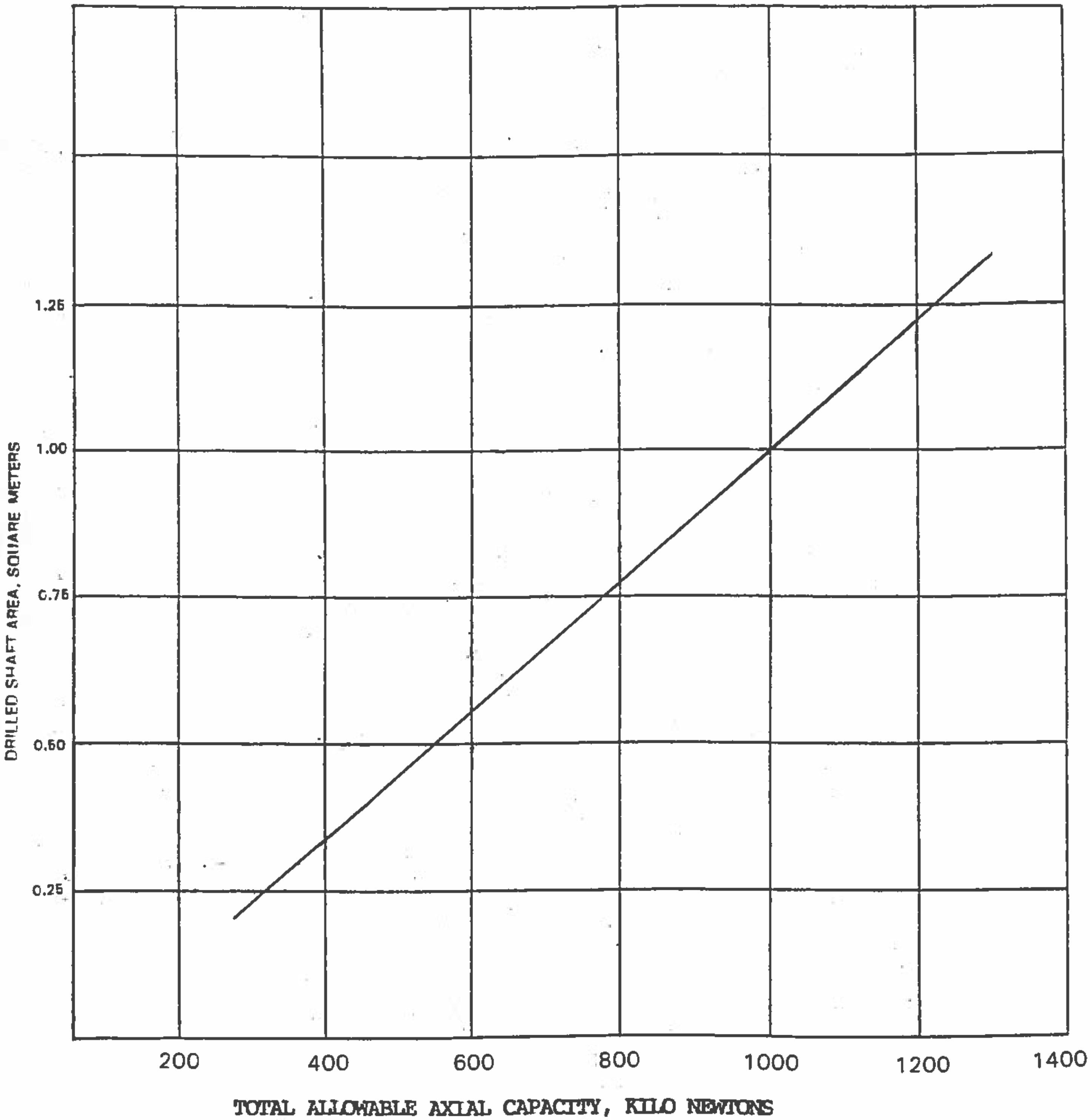
BRIDGE N214 REPLACEMENT	
Boring Location Diagram	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: 2



NOTES:

1. AXIAL CAPACITY BASED ON END BEARING.

BRIDGE N214 REPLACEMENT
H-Pile Design Capacity
Western Technologies Inc.
Job No.: 3121JC100 — Plate: 3



NOTES:

1. AXIAL CAPACITY BASED ON FRICTION AND END BEARING.
2. FACTOR OF SAFETY OF 2.5.
3. DRILLED SHAFT MINIMUM LENGTH OF 7 METERS ANTICIPATED MAXIMUM LENGTH 12 METERS

BRIDGE N214 REPLACEMENT	
Drilled Shaft Capacity	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: 4

A

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Backfill	A specified material placed and compacted in a confined area.
Base Course	A layer of specified material placed on a subgrade or subbase.
Base Course Grade	Top of base course.
Bench	A horizontal surface in a sloped deposit.
Caisson	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier.
Concrete Slabs-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade.
Crushed Rock Base Course	A base course composed of crushed rock of a specified gradation.
Differential Settlement	Unequal settlement between or within foundation elements of a structure.
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a soil engineer.
Existing Fill	Materials deposited through the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.
Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Fill	Materials deposited by the actions of man.
Finished Grade	The final grade created as a part of the project.
Gravel Base Course	A base course composed of naturally occurring gravel with a specified gradation.
Heave	Upward movement
Native Grade	The naturally occurring ground surface.
Native Soil	Naturally occurring on-site soil.
Rock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Sand & Gravel Base	A base course of sand and gravel of a specified gradation.
Sand Base Course	A base course composed primarily of sand of a specified gradation.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Soil	Any unconsolidated material composed of discrete solid particles, derived from the physical and/or chemical disintegration of vegetable or mineral matter, which can be separated by gentle mechanical means such as agitation in water.
Strip	To remove from present location.
Subbase	A layer of specified material placed to form a layer between the subgrade and base course.
Subbase Grade	Top of subbase.
Subgrade	Prepared native soil surface.

COARSE-GRAINED SOILS
LESS THAN 50% FINES*

GROUP SYMBOLS	DESCRIPTION	MAJOR DIVISIONS
GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LESS THAN 5% FINES	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size
GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES LESS THAN 5% FINES	
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, MORE THAN 12% FINES	
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, MORE THAN 12% FINES	
SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% FINES	SANDS More than half of coarse fraction is smaller than No. 4 sieve size
SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% FINES	
SM	SILTY SANDS, SAND-SILT MIXTURES, MORE THAN 12% FINES	
SC	CLAYEY SANDS, SAND-CLAY MIXTURES, MORE THAN 12% FINES	

NOTE: Coarse-grained soils receive dual symbols if they contain 5 to 12% fines (e.g. SW-SM, GP-GC, etc.)

FINE-GRAINED SOILS
MORE THAN 50% FINES

GROUP SYMBOLS	DESCRIPTION	MAJOR DIVISIONS
ML	INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS	SILTS AND CLAYS Liquid limits less than 50
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
OL	ORGANIC SILTS OR ORGANIC SILT-CLAYS OF LOW PLASTICITY	
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDS OR SILTS, ELASTIC SILTS	SILTS AND CLAYS Liquid limit more than 50
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY	
PT	PEAT, MUCK, AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS

NOTE: Fine-grained soils may receive dual classification based upon plasticity characteristics.

SOIL SIZES

COMPONENT	SIZE RANGE
BOULDERS	ABOVE 12 in.
COBBLES	3 in. to 12 in.
GRAVEL	No. 4 to 3 in.
Coarse	3/4 in. to 3 in.
Fine	No. 4 to 3/4 in.
SAND	No. 200 to No. 4
Coarse	No. 10 to No. 4
Medium	No. 40 to No. 10
Fine	No. 200 to No.40
*Fines (Silt or Clay)	BELOW No. 200

NOTE: Only sizes smaller than three inches are used to classify soils

CONSISTENCY

CLAYS & SILTS	BLOWS/FOOT*
VERY SOFT	0-2
SOFT	2-4
FIRM	4-8
STIFF	8-16
VERY STIFF	16-32
HARD	Over 32

RELATIVE DENSITY

SANDS & GRAVELS	BLOWS/FOOT*
VERY LOOSE	0-4
LOOSE	4-10
MEDIUM DENSE	10-30
DENSE	30-50
VERY DENSE	Over 50

*Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1 3/8" ID) split spoon (ASTM D1586)

PLASTICITY OF FINE GRAINED SOILS

PLASTICITY INDEX	TERM
0	Non-Plastic
1 - 7	Low
8 - 25	Medium
Over 25	High

DEFINITION OF MOISTURE CONTENT

DRY
SLIGHTLY DAMP
DAMP
MOIST
WET
SATURATED

BRIDGE N214 REPLACEMENT	
Method of Soil Classification	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: A-2

The number shown in **"BORING NO."** refers to the approximate location of the same number indicated on the "Boring Location Diagram" as positioned in the field by measurements from property lines and/or existing features.

"ELEVATION" refers to ground surface elevation at the boring location established by measurements with an engineer's level from a bench mark (BM) shown on the "Boring Location Diagram".

"TYPE SIZE BORING" refers to the exploratory equipment used in the boring wherein **HSA = hollow stem auger.**

"N" in Blows/Foot" refers to the number of blows of a 140-pound weight, dropped 30 inches, required to advance a two-inch-outside-diameter split-barrel sampler a distance of 1 foot, Standard Penetration Test (ASTM D1586). Refusal to penetration is defined as more tan 100 blows per foot.

"Sample Type" refers to the form of sample recovery, in which **N = Split-barrel sample, G = Grab Sample.**

"Water Content, %" refers to the laboratory-determined moisture content is percent (ASTM D2216).

"Unified Classification" refers to the soil type as defined by "Method of Soil Classification". The soils were classified visually in the field and, where appropriate, classifications were modified by visual examination of samples in the laboratory and/or by appropriate tests.

These notes and boring logs are intended for use in conjunction with the purposes of our services defined in the text. Boring log data should not be construed as part of the construction plans nor as defining construction conditions.

Boring logs depict our interpretations of subsurface conditions at the locations and on the date(s) noted. Variations in subsurface conditions and soil characteristics may occur between borings. Groundwater levels may fluctuate due to seasonal variations and other factors.

The stratification lines shown on the boring logs represent our interpretation of the approximate boundary between soil types based upon visual field classification. The transition between materials is approximate and may be far more or less gradual than indicated.

BRIDGE N214 REPLACEMENT	
Boring Log Notes	
Western Technologies Inc.	
Job No.: 3121JC100	Plate:A-3

BORING NO. 1

DATE DRILLED: 09-25-2001	LOCATION: See Boring Location Diagram
DRILL RIG TYPE: CME-75	ELEVATION: 1814.877 Meter
BORING TYPE/SIZE: HSA/7"	FIELD ENGR: J. Sandoval

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G					SM		SILTY SAND; tan, loose to medium dense, damp, some gravel, fine to medium grained sand, trace of cobbles.
		N		20		2			
		N		50/3"					COAL; black, soft, damp.
		N		50/2"		4			SANDSTONE; gray, soft to hard, damp, augered to 4.633 meters, start NX core with water at 4.633 meters, 3.048 meters 100 % recovery, 2.692 meters 88 % ROD, start second core 7.681 meters, 2.946 meters 96 % recovery, 2.845 meters 93 % ROD, first core fractures 1 to 31 inches, second core fractures 18 to 38 inches.
						6			
						8			
						10			
									Stopped at 10.728 meters
						12			
						14			
						16			
						18			

GROUNDWATER ENCOUNTERED NO: X YES:___ DEPTH:___ DATE: 09-25-2001

NOTES Station 10+112.517 meters, 4 meters left of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 | Plate: A-4

DATE DRILLED: 09-25-2001
DRILL RIG TYPE: CME-75
BORING TYPE/SIZE: HSA/7"

BORING NO. 2

LOCATION: See Boring Location Diagram
ELEVATION: 1814.822 Meter
FIELD ENGR: J. Sandoval

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G					SM		SILTY SAND; tan, loose to medium dense, damp to saturated, some gravel, fine to medium grained sand.
		N		5		2			Groundwater encountered at 1.5 meters.
		N		50/3"					SHALE; gray, soft to moderately hard, saturated.
		N		50/1"		4			SANDSTONE; gray, moderately hard to hard, moist to damp, augered to 4.603 meters, start NX core with water at 4.603 meters, 2.565 meters cored, 1.346 meters 52 % recovery 1.080 meters 42 % RQD, start second core 7.168 meters, 3.048 meters 100 % recovery, 2.896 meters 95 % RQD, start third core 10.217 meters, 2.946 meters 97 % recovery, 2.819 meters 93 % RQD, first core fractures 1 to 30 inches, second core fractures 1 to 44 inches, third core fractures 15 to 94 inches
						6			
						8			
						10			
						12			
									Stopped at 13.258 meters
						14			
						16			
						18			

GROUNDWATER ENCOUNTERED NO: ___ YES: X DEPTH: 1.5 m. DATE: 09-25-2001

NOTES Station 10+112.517 meters, 4 meters right of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 | Plate: A-5

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATE DRILLED: 09-27-2001

DRILL RIG TYPE: CME-75

BORING TYPE/SIZE: HSA/7"

BORING NO. 3

LOCATION: See Boring Location Diagram

ELEVATION: 1813.167 Meter

FIELD ENGR: J. Sandoval

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
						0			FILL 0 TO 0.6 METERS SILTY SAND; tan, loose.
		G					SM		SILTY SAND; tan, loose to medium dense, saturated, some gravel, some cobbles, trace of boulders. Groundwater encountered at 0.7 meters.
		N		50/4"		2			COAL; black, soft to moderately hard, saturated.
		N		50/2"					SANDSTONE; tan to white, moderately hard to hard, moist, augered to 3.109 meters, start NX core with water at 3.109 meters, 2.794 meters 92% recovery, 2.565 meters 84% RQD, start second core 6.157 meters, 2.870 meters 94% recovery, 2.870 meters 94% RQD, first core fractures 1 to 26 inches, second core fractures 113 inches solid.
						4			
						6			
						8			
									Stopped at 9.204 meters
						10			
						12			
						14			
						16			
						18			

GROUNDWATER ENCOUNTERED NO:___ YES: X DEPTH: 0.7 m. DATE: 09-27-2001

NOTES Station 10+130.000 meters, 4 meters left of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 | Plate: A-6

DATE DRILLED: 09-28-2001

DRILL RIG TYPE: CME-75

BORING TYPE/SIZE: HSA/17.7 cm

BORING NO. 4

LOCATION: See Boring Location Diagram

ELEVATION: 1813.243 Meter

FIELD ENGR.

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G							FILL 0 TO 0.457 METERS SILTY SAND; tan, loose, moist.
							SW		SAND; tan, loose to medium dense, saturated, some gravel, some cobbles, trace of boulders. Groundwater encountered at 0.6 meters.
		N		31					
						2			SHALE/SILTSTONE; gray, soft to moderately hard,
									SANDSTONE; tan, soft, saturated.
		N		50/5"					COAL; black, soft, saturated.
						4			SANDSTONE; gray to white, soft to hard, moist, augered to 4.633 meters, start NX core with water at 4.633 meters, 2.642 meters 87% recovery, 2.324 meters 76% RQD, start second core 7.681 meters, 3.048 meters 100% recovery, 3.048 meters 100% RQD, first core fractures 1 to 38 inches, second core no fractures.
		N		50/2"					
						6			
						8			
						10			
									Stopped at 10.759 meters
						12			
						14			
						16			
						18			

GROUNDWATER ENCOUNTERED NO:___ YES: X DEPTH: 0.6 m. DATE: 09-28-2001

NOTES Station 10+130.000 meters, 4 meters right of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 | Plate: A-7

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATE DRILLED: 09-26-2001

DRILL RIG TYPE: CME-75

BORING TYPE/SIZE: HSA/7"

BORING NO. 5

LOCATION: See Boring Location Diagram

ELEVATION: 1816.404 Meter

FIELD ENGR: J. Sandoval

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
							SM		SILTY SAND; tan, loose, slightly damp, some gravel.
		N		71			GM		COBBLES/GRAVEL; tan, loose to medium dense, slightly damp, some silty sand.
		N		50/6"		2			SANDSTONE/SILTSTONE; tan, soft to moderately hard, damp.
		N		50/6"		4			SHALE; gray, soft to moderately hard, damp.
									COAL; Black, soft, damp.
		N		50/4"		6			SHALE; gray, soft to moderately hard, damp.
		N		50/4"		8			COAL; black, soft to moderately hard, damp.
						10, 12			SANDSTONE; tan to white, moderately hard to hard, damp, augered to 7.742 meters, start NX core with water at 7.742 meters, 2.362 meters 78 % recovery, 1.461 meters 48 % RQD, start second core 10.790 meters, 2.794 meters 92 % recovery, 2.794 meters 92 % RQD, first core fractures 1 to 26 inches, second core fractures 37 to 72 inches. Shale 10.271 to 10.667 meters.
						14			Stopped at 13.837 meters
						16			
						18			

GROUNDWATER ENCOUNTERED NO: X YES: ___ DEPTH: ___ DATE: 09-26-2001

NOTES Station 10+147.483 meters, 4 meters left of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 Plate: A-8

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATE DRILLED: 09-27-2001
DRILL RIG TYPE: CME-75
BORING TYPE/SIZE: HSA/7"

BORING NO. 6

LOCATION: See Boring Location Diagram
ELEVATION: 1816.818 Meter
FIELD ENGR: J. Sandoval

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G					GM		GRAVEL; tan, loose to medium dense, damp, some silty sand.
		N		9					
		N		50/6"		2			SILTSTONE/SANDSTONE; tan, soft to moderately hard, damp to moist.
		N		50/3"		4			
		N		50/3"		6			SHALE; gray to black, soft to moderately hard, damp to moist.
									SHALE; gray to black, moderately hard to 6.492 meters, siltstone to 7.315 meters, sandstone to 7.620 meters, siltstone to 7.924 meters, coal/shale to 9.235 meters, start NX core with water at 6.187 meters, 2.286 meters 75 % recovery, 1.092 meters 36 % RQD, fractures 1 to 8 inches.
						8			
						10			SANDSTONE; tan, moderately hard to hard, damp, shale/coal 10.638 to 10.759 meters, start second core 9.235 meters, 3.048 meters 100 % recovery, 2.642 meters 87 % RQD, fractures 1 to 58 inches.
						12			Stopped at 12.283 meters
						14			
						16			
						18			

GROUNDWATER ENCOUNTERED NO: X YES:___ DEPTH:___ DATE: 09-27-2001

NOTES Station 10+147.483 meters, 4 meters right of centerline.

BRIDGE N214 REPLACEMENT

Boring Log

Western Technologies Inc.

Job No.: 3121JC100 Plate: A-9

B

SOIL PROPERTIES

Boring No.	Depth (m)	Soil Class.	Soil Property: Initial Dry Density kgs/m³	Soil Property: Initial Water Content (%)	Shear Strength: c (kPa)	Shear Strength: φ (Deg)	Resistivity ohm-cms	pH	Water Soluble Matter (ppm): Salts	Water Soluble Matter (ppm): Sulfates	Remarks
1	1.5-1.9	SM	1826	10.9	9.58	31					1,DS
4	0-0.9	SW	1826	10.9	4.79	38	730*	8.1	140	10	1,DS

NOTE: Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.

LEGEND
Shear Strength Test Method

DS Direct Shear
DS Direct Shear (Saturated)
UC Unconfined Compression
UU Unconsolidated Undrained
CU Consolidated Undrained w/pore pressure
CU Consolidated Undrained
CD Consolidated Drained
* **Arizona Method 236 B**

REMARKS
1. Compacted density (approximately 95% of ASTM D698 at moisture value slightly below optimum)
2. Visual Classification
3. Constant head
4. Falling head

BRIDGE N214 REPLACEMENT	
Soil Properties	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: B-1

PHYSICAL PROPERTIES

Boring No.	Depth (m)	Soil Class.	Particle Size Distribution (%) Passing by Weight					Atterberg Limits		Moisture-Density Relationship			R-Value	Remarks
			3"	#4	#10	#40	#200	LL	PI	Dry Density Kgs/m³	Optimum Moisture (%)	Method		
2	0-0.9	SM	100	98	91	75	18.4	-	NP	1922	10.9	C		2,4
4	0-0.9	SW	100	95	88	57	3.9	-	NP					2
6	0-0.9	SM	100	90	88	82	27.0	-	NP					2

REMARKS

Classification/Particle Size
1. Visual
2. Laboratory Tested
3. Minus #200 Only

Moisture-Density Relationship
4. Tested ASTM D698/AASHTO T99
5. Tested ASTM D1557/AASHTO T180

NOTE: NP - nonplastic

BRIDGE N214 REPLACEMENT	
Physical Properties	
Western Technologies Inc.	
Job No.: 3121JC100	Plate: B-2

UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORES

USE REPORT FORM NO. 451

Job No. 3121JC100 Date Required –

Procedure: ASTM D2938-95 Event/Invoice No. – Lab. No. –

Data: Mix Identification – Design Strength, psi – Respon. Tech. J. Sandoval Proj. Mgr. L.C.

Nominal Aggregate Size, in. – Date Placed – Reviewed By L.E.C. Date 11/12/01

TEST RESULTS

CORE IDENTIFICATION		Abutment	Pier	Abutment			
LOCATION OF CORE		Boring 1 8.8m	Boring 4 9.4m	Boring 5 12.5m			
DATE TESTED		11/12/01	11/12/01	11/12/01			
CONCRETE AGE, DAYS		-	-	-			
LENGTH OF CORE, AS RECEIVED		3 9/16"	3 5/8"	3 5/8"			
LENGTH BEFORE CAPPING, IN.							
LENGTH AFTER CAPPING, IN.	1	3.81	3.81	3.81			
DIAMETER, IN.	2	1.81	1.81	1.81			
LENGTH / DIAMETER RATIO	1 ÷ 2	2.1:1	2.1:1	2.1:1			
CROSS-SECTIONAL AREA, SQ. IN.	3	2.84	2.84	2.84			
MAXIMUM LOAD, LBF	4	10,480	12,330	11,520			
COMPRESSIVE STRENGTH, PSI	4 ÷ 3	3,690	4,341	4,056			
STRENGTH CORRELATION FACTOR		-	-	-			
CORRECTED COMPRESSIVE STRENGTH, PSI		-	-	-			
TYPE OF FRACTURE		cone/shear	cone/shear	cone/shear			
DIRECTION OF LOAD TO PLACEMENT PLANE		vert.	vert.	vert.			
MOISTURE CONDITION AT TIME OF TEST		-	-	-			
UNIT WEIGHT, LBF PER CU. FT.		-	-	-			
DEFECTS NOTED IN SPECIMENS OR CAPS, IF ANY		None	None	None			

COMMENTS

C

N 214 Bridge

Spread Foundations

Continuous footing, General Case

NAVFAC DM-7.2 Department of Navy

Figure 1 7.2 - page 131

sandstone

$C = 0.5$ ksf $\phi = 33°$ $N_c = 44$

$\gamma = 120$ pcf $\gamma_{submerged} = 57.6$ pcf

$N_q = 27$ $N_\gamma = 27$ $D = 3$ feet

Assume width footing 3 feet

Length footing 30 feet

$$q_{ult} = C N_c \left(1 + 0.3\frac{B}{L}\right) + \gamma D N_q + 0.4 \gamma B N_\gamma$$

$$= 0.5(44)\left(1 + 0.3\frac{3}{30}\right) + 0.057(3')(27) + 0.4(0.057)(3)(27)$$

$$= 22.7 + 4.6 + 1.85$$

$$= 29.2 \text{ kips}$$

$$q_{all} = \frac{29.2}{3} = 9.7 \text{ ksf}$$ use 10 ksf

H-piles in Sandstone

36 ksi × 0.25 f_y = 9,000 psi

HP 10 × 42 Area 12.4 in^2 or 111,600 pounds
or 55.8 tons
Tons to Newtons 8896.44 or 496 kN
use 490 kN

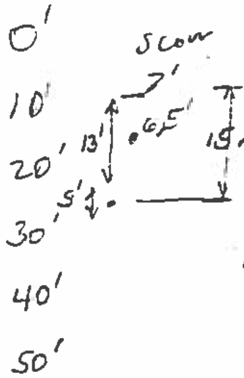
HP 12 × 53 Area 15.6 in^2. or 140,400 pounds
or 70.2 tons
Tons to Newtons 8896.44 or 624 kN
use 620 kN

HP 14 × 73 Area 21.5 in^2 or 193,500 pounds
or 96.7 tons
Tons to Newtons 8896.44 or 861 kN
use 860 kN

N 214 Bridge

AASHTO Method

Assume scour removes all sand at surface



For calculation purposes P. 62 column C (sandstone)

13 feet Poor Rock 0.019

5 feet Fair Rock 0.066

P. 81

$\beta_1 = 1.5 - 0.135\sqrt{z_i} = 1.5 - 0.135\sqrt{6.5} = 1.16$

$\beta_2 = 1.5 - 0.135\sqrt{15.5'} = 0.969$

2 ft dia.

$Q_{s_1} = \pi B \sum \alpha_i z_i \beta_i \Delta z_i$

$= \pi (2')(77.6)(6.5)(1.16)(13')$

$= 47,794$ lbs.

$Q_{s_2} = \pi (2') \, 77.6 \, (15.5)(0.969)(5')$

$= 36,617$ lbs

$Q_{all} = \dfrac{47.8 \text{ kips} + 36.6 \text{ kips}}{2.5} = 33.8$ kips

C_o = Average 4000 psi × 144 in²/ft² = 576,000 psf or 576 ksf

N_{ms} = 0.066

A_t = Area of tip shaft 3.14 ft²

$Q_{TR} = N_{ms} \, C_o \, A_t$

$= 0.066\,(576 \text{ ksf})(3.14 \text{ ft}^2)$

$= 119.4$ kips

$Q_{all} = \dfrac{119.4}{2.5} = 47.8$ kips + 33.8 kips = 81.5 kips

362.8 kN

N214 Bridge

3 ft dia.

$Q_{s_1} = \pi(3')(77.6)(6.5)(1.16)(13')$
$= 71,690$ lbs

$Q_{s_2} = \pi(3')(77.6)(15.5)(0.969)(5')$
$= 54,925$

$Q_{all} = \frac{71.69 \text{ kips} + 54.93 \text{ kips}}{2.5} = 50.6$ kips

$Q_{TR} = 0.066(576 \text{ ksf})(7.07 \text{ ft}^2)$
$= 268.8$

$Q_{all} = \frac{268.8}{2.5} = 107.5 \text{ kips} + 50.6 \text{ kips} = 158.2$ kips
703 kN

4 ft. dia

$Q_{s_1} = \pi(4')(77.6)(6.5')(1.16)(13')$
$= 95,588$ lbs

$Q_{s_2} = \pi(4')(77.6)(15.5)(0.969)(5')$
$= 73,234$

$Q_{all} = \frac{95.59 \text{ kips} + 73.23 \text{ kips}}{2.5} = 67.53$ kips

$Q_{TR} = 0.066(576 \text{ ksf})(12.57 \text{ ft}^2)$
$= 477.9$

$Q_{all} = \frac{477.9}{2.5} = 191.1 \text{ kips} + 67.5 = 258.6$ kips
1150.3 kN

PHYSICAL PROPERTIES OF AGGREGATES

Date of Report 12-17-01
Job No. 3121JC100
Event / Invoice No. 3121201-2 Lab No. 10012101
Authorized By CLIENT Date 12-10-01
Sampled By CLIENT Date 12-10-01
Submitted By CLIENT Date 12-10-01

Client BIA ROADS
PO BOX 1060
GALLUP, NM 87305
ATTN:CORWYN HENRY, P.E.

Project BRIDGE N214
Contractor BIA
Type / Use of Aggregate SILTY SAND W/GRAVEL
Sample Source / Location UPSTREAM
Special Instructions:

Location TOADLENA
Arch. / Engr. BIA
Supplier / Source N214 UPSTREAM
Source / Location Desig. By CLIENT Date 12-10-01

TEST RESULTS

SIEVE ANALYSIS ☐ ASTM C136 ☒ AASHTO T27

SIEVE SIZE U.S. - MM	ACCUMULATIVE % PASSING	SPECIFICATION
4 IN. - 100.0		
3 - 75.0		
1 1/2 - 37.5		
1 1/8 - 28.1		
1 - 25.0		
3/4 - 19.0	100	
1/2 - 12.5	97	
3/8 - 9.5	96	
1/4 - 6.3	92	
NO. 4 - 4.75	90	
8 - 2.36	87	
10 - 2.00	86	
16 - 1.18	83	
30 - .600	79	
40 - .425	70	
50 - .300	51	
100 - .150	15	
FINER THAN NO. 200 ☐ ASTM C117 ☐ AASHTO T11	4.8	

FINENESS MODULUS, ASTM C125 →

LIQUID & PLASTIC PROPERTIES
☐ ASTM D4318 ☐ AASHTO T89 & T90
METHOD ☐ A ☐ B

	RESULT	SPECIFICATION
LIQUID LIMIT		
PLASTIC LIMIT		
PLASTICITY INDEX		

SAMPLE AIR DRIED ☐ YES ☐ NO

CLEANNESS VALUE CA227 →

ORGANIC IMPURITIES ☐ ASTM C40 ☐ AASHTO T21
ORGANIC PLATE NO. →

CARBONATES IN AGGREGATE
☐ AZ 238 ☐ ASTM 3042 % →

PHYSICAL PROPERTIES		TEST RESULTS	SPECIFICATION
UNIT WEIGHT & VOIDS ☐ ASTM C29 ☐ AASHTO T19; ☐ RODDING ☐ JIGGING ☐ LOOSE	FINE AGGREGATE UNIT WEIGHT, PCF →		
	VOIDS, % →		
	COARSE AGGREGATE UNIT WEIGHT, PCF →		
	VOIDS, % →		
SPECIFIC GRAVITY & ABSORPTION — FINE AGGREGATE ☐ ASTM C128 ☐ AASHTO T84; AGGREGATE DRIED ☐ YES ☐ NO	BULK SPECIFIC GRAVITY →		
	BULK SPECIFIC GRAVITY (SSD) →		
	APPARENT SPECIFIC GRAVITY →		
	ABSORPTION, % →		
SPECIFIC GRAVITY & ABSORPTION — COARSE AGGREGATE ☐ ASTM C127 ☐ AASHTO T85; AGGREGATE DRIED ☐ YES ☐ NO	BULK SPECIFIC GRAVITY →		
	BULK SPECIFIC GRAVITY (SSD) →		
	APPARENT SPECIFIC GRAVITY →		
	ABSORPTION, % →		
SAND EQUIVALENT VALUE ☐ ASTM D2419 ☐ AASHTO T176	% →		
RESISTANCE TO DEGRADATION — SMALL COARSE AGGREGATE ☐ ASTM C131 ☐ AASHTO T96 GRADING B	100 REV., % LOSS →		
	500 REV., % LOSS →		
RESISTANCE TO DEGRADATION — LARGE COARSE AGGREGATE ☐ ASTM C535 GRADING	200 REV., % LOSS →		
	1000 REV., % LOSS →		
LIGHTWEIGHT PIECES ☐ ASTM C123 ☐ AASHTO T113	FINE AGGREGATE, % →		
	COARSE AGGREGATE, % →		
CLAY LUMPS & FRIABLE PARTICLES ☐ ASTM C142 ☐ AASHTO T112	FINE AGGREGATE, % →		
	COARSE AGGREGATE, % →		
FRACTURED FACES COARSE AGGREGATE BY WEIGHT ☐ AZ 212 ☐ FLH T507 ☐ FAA	ONE OR MORE FACES, % →		
	TWO OR MORE FACES, % →		
DURABILITY INDEX ☐ ASTM D3744 ☐ AASHTO T210; PROCEDURE: A ☐ COARSE B ☐ FINE C ☐ COARSE & FINE	D_c →		
	D_f →		
UNCOMPACTED VOID CONTENT ☐ AZ 247 ☐ ASTM C1252 METHOD	% →		
FLAT & ELONGATED PARTICLES ☐ ASTM D4791 ☐; DIMENSIONAL RATIO USED ☐ 1:2 ☐ 1:3 ☐ 1:5 ☐	BY WEIGHT, % →		
	BY NUMBER, % →		

Comments:

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THE SERVICES REFERRED TO HEREIN WERE PERFORMED IN ACCORDANCE WITH THE STANDARD OF CARE PRACTICED LOCALLY FOR THE REFERENCED METHOD(S) AND RELATE ONLY TO THE CONDITION(S) OF SAMPLE(S) TESTED AS STATED HEREIN. WESTERN TECHNOLOGIES INC. MAKES NO OTHER WARRANTY OR REPRESENTATION, EXPRESSED OR IMPLIED, AND HAS NOT CONFIRMED INFORMATION INCLUDING SOURCE OF MATERIALS SUBMITTED BY OTHERS.

REVIEWED BY ____________________

PHYSICAL PROPERTIES OF AGGREGATES

Date of Report 12-17-01
Job No. 3121JC100
Event / Invoice No. 3121201-1 Lab No. 10012102
Authorized By CLIENT Date 12-10-01
Sampled By CLIENT Date 12-10-01
Submitted By CLIENT Date 12-10-01

Client BIA ROADS
PO BOX 1060
GALLUP, NM 87305
ATTN:CORWYN HENRY, P.E.

Project BRIDGE N214
Location TOADLENA
Contractor BIA
Arch. / Engr. BIA
Type / Use of Aggregate SILTY SAND W/COBBLES
Supplier / Source N214 DOWNSTREAM
Sample Source / Location DOWNSTREAM
Source / Location Desig. By CLIENT Date 12-10-01
Special Instructions:

TEST RESULTS

SIEVE ANALYSIS ☐ ASTM C136 ☒ AASHTO T27

SIEVE SIZE U.S. - MM	ACCUMULATIVE % PASSING	SPECIFICATION
4 IN. - 100.0		
3 - 75.0		
1 1/2 - 37.5		
1 1/8 - 28.1	100	
1 - 25.0	95	
3/4 - 19.0	88	
1/2 - 12.5	79	
3/8 - 9.5	74	
1/4 - 6.3	68	
NO. 4 - 4.75	66	
8 - 2.36	64	
10 - 2.00	63	
16 - 1.18	63	
30 - .600	61	
40 - .425	58	
50 - .300	46	
100 - .150	18	
FINER THAN NO. 200 ☐ ASTM C117 ☐ AASHTO T11	6.9	

FINENESS MODULUS, ASTM C125 →

LIQUID & PLASTIC PROPERTIES
☐ ASTM D4318 ☐ AASHTO T89 & T90

METHOD ☐ A ☐ B	RESULT	SPECIFICATION
LIQUID LIMIT		
PLASTIC LIMIT		
PLASTICITY INDEX		
SAMPLE AIR DRIED ☐ YES ☐ NO		

CLEANNESS VALUE CA227 →

ORGANIC IMPURITIES ☐ ASTM C40 ☐ AASHTO T21
ORGANIC PLATE NO. →

CARBONATES IN AGGREGATE
☐ AZ 238 ☐ ASTM 3042 % →

PHYSICAL PROPERTIES		TEST RESULTS	SPECIFICATION
UNIT WEIGHT & VOIDS ☐ ASTM C29 ☐ AASHTO T19 ☐ RODDING ☐ JIGGING ☐ LOOSE — FINE AGGREGATE	UNIT WEIGHT, PCF →		
	VOIDS, % →		
COARSE AGGREGATE	UNIT WEIGHT, PCF →		
	VOIDS, % →		
SPECIFIC GRAVITY & ABSORPTION — FINE AGGREGATE ☐ ASTM C128 ☐ AASHTO T84; AGGREGATE DRIED ☐ YES ☐ NO	BULK SPECIFIC GRAVITY →		
	BULK SPECIFIC GRAVITY (SSD) →		
	APPARENT SPECIFIC GRAVITY →		
	ABSORPTION, % →		
COARSE AGGREGATE ☐ ASTM C127 ☐ AASHTO T85; AGGREGATE DRIED ☐ YES ☐ NO	BULK SPECIFIC GRAVITY →		
	BULK SPECIFIC GRAVITY (SSD) →		
	APPARENT SPECIFIC GRAVITY →		
	ABSORPTION, % →		
SAND EQUIVALENT VALUE ☐ ASTM D2419 ☐ AASHTO T176	% →		
RESISTANCE TO DEGRADATION — SMALL COARSE AGGREGATE ☐ ASTM C131 ☐ AASHTO T96 GRADING B	100 REV., % LOSS →		
	500 REV., % LOSS →		
LARGE COARSE AGGREGATE ☐ ASTM C535 GRADING	200 REV., % LOSS →		
	1000 REV., % LOSS →		
LIGHTWEIGHT PIECES ☐ ASTM C123 ☐ AASHTO T113	FINE AGGREGATE, % →		
	COARSE AGGREGATE, % →		
CLAY LUMPS & FRIABLE PARTICLES ☐ ASTM C142 ☐ AASHTO T112	FINE AGGREGATE, % →		
	COARSE AGGREGATE, % →		
FRACTURED FACES COARSE AGGREGATE BY WEIGHT ☐ AZ 212 ☐ FLH T507 ☐ FAA	ONE OR MORE FACES, % →		
	TWO OR MORE FACES, % →		
DURABILITY INDEX ☐ ASTM D3744 ☐ AASHTO T210 PROCEDURE: A ☐ COARSE B ☐ FINE C ☐ COARSE & FINE	D_c →		
	D_f →		
UNCOMPACTED VOID CONTENT ☐ AZ 247 ☐ ASTM C1252 METHOD	% →		
FLAT & ELONGATED PARTICLES ☐ ASTM D4791 ☐ DIMENSIONAL RATIO USED ☐ 1:2 ☐ 1:3 ☐ 1:5 ☐	BY WEIGHT, % →		
	BY NUMBER, % →		

Comments:

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